SYSTEM DYNAMICS CENTERS, ACTIVE

1 of 4

System Dynamics Center, Active

bcc: Charles J. Ryan

June 9, 1977

Dr. George P. Richardson
Simon's Rock
Gt. Barrington, MA 01230

Dear George:

Thank you for your letter of May 23 and the enclosed description of the system dynamics curriculum.

I found it interesting reading and it seems to be well organized. I would only question the possibility that it is understandable by those who already know system dynamics but may not create the desired images for one who knows nothing about the field. This comment depends on the target reader.

As far as the material is concerned, I like the arrangement. The new form strikes me as better than the form indicated by the early section III that you sent.

On your page 3 in the last paragraph, I question the precision of your terminology. You say "positive loops are shown to be responsible for unstable behavior." The term "unstable behavior" is most usually used for a negative feedback loop that produces a growing oscillation or a sustained oscillation that is limited by nonlinearities. The whole matter of the relationship between positive and negative loops needs to be handled very carefully. Quite often the growth created by a positive loop produces nonlinear interference that converts the positive loop into a negative loop. I suggest some caution and considerable discussion within your group on these points. The literature, including that from experienced system dynamics people, confuses the distinctions between positive and negative loops.

Thank you for letting me see the paper. I like it and am pleased to see good progress.

Sincerely yours,

JWF/nd

5-27-77

Simon's Rock
Gt. Barrington, MA.
01230

23 May 1977

Dear Professor Forrester,

The enclosed paper is a draft of a description of the pre-college curriculum in system dynamics being developed by Nancy Roberts' group. I wrote the description initially in March in an effort to help focus our group on five essential "learning packages" (appearing here as parts II-VI) rather than the ten or so we had been considering. Charlie asked me to rewrite that earlier draft for inclusion in the grant proposal we are preparing for funding the writing project.

No doubt you will see the grant proposal in its entirety before it's sent anywhere, and you may perhaps even want to contribute to its final form. I am sending you this little piece of it, with the blessings of the curriculum group, because I am very much interested in your reactions to the description of the curriculum itself, rather than the verbiage that will go into the rest of the grant proposal. From what you can tell of the enclosed attempt at a publication-pretty description, are we going in the right directions?

[In the earlier draft, Part IV "Understanding Dynamic Problems" focused not on themes of complex system behavior but on several real-world problems. I'm enclosing a page describing that version (called III in the earlier version) so that you can see the two approaches we talked about. Your reactions to both would be appreciated.]

Bill Shaffer has copies of the final papers of two of my systems students from their course-work this winter. He will be sharing them with you. I hope I'll get a chance to talk with you about

(over)

my year and their work. As I indicated in an earlier note, I will try to send you more detailed materials from the two semesters, as I get it rewritten.

Thank you for whatever time you can give to looking at these things and responding.

Yours sincerely,

George

George P. Richardson

A CURRICULUM IN SYSTEM DYNAMICS

The outline which follows describes a sequence of stages which forms the core of an introductory curriculum in system dynamics. The sequence can be tailored to a given audience, with different stages receiving greater or lesser emphasis, as appropriate. In one expression of this curriculum these stages may outline the sweep of lectures in a course or course sequence. In another, they may be chapters in a book, and in still another form they may appear as separate learning packages, emphasizing the thought that a student may exit from the sequence after any stage and still receive a meaningful part of the whole story.

I. Preconceptions: Dynamic Problems, Systems, and Models
II. Structure of Feedback Systems
III. Behavior of Feedback Systems
IV. Understanding Dynamic Problems
V. Introduction to Simulation
VI. The Dynamics of Complex Systems

I. Preconceptions: Dynamic Problems, Systems, and Models

Embarking on a course of study in system dynamics, a student may wish to have a vision of the preconceptions which underlie his work. Three are central: the focus is ultimately on <u>dynamic</u> problems; the intent is to consider the whole <u>system</u> of interacting parts from which a problem arises; and <u>models</u> are explicitly employed to carry the analyses. Each of these conceptions is explored briefly in Part I to provide a foundation for the study of feedback systems which follows.

A problem is dynamic if it involves change over time. Urban crime rates, for example, rise; the economy cycles, as do pendulums and people's feelings of depression and elation; central city populations decline, and so do reserves of natural resources.

A system is defined to be a collection of parts operating together for a common purpose, but the concept is sometimes better left undefined, to be inferred from examples. The notion should connote complexity, but it should also suggest a wholeness of perspective which we attempt to achieve and the feeling that the whole is greater in some sense than the sum of its parts.

A model is a representation -- usually a simplification -- of some slice of reality. Pictures, verbal descriptions, graphs, sets of equations, and laws all are models. Thinking could be characterized as the manipulation of mental models; the real system is never in one's head. Such a concept may seem too generalized to be useful, but realizing the central role models play in our thinking (especially in the scientific method) allows one to ask the proper questions -- not whether to develop a model, but what kind of model is most helpful.

System dynamics helps us to understand problems arising in dynamic systems, first by making our mental models explicit, second by incorporating into them feedback (II, III, and IV), and third by providing means for developing them into unambiguous mathematical models (V and VI) when the complexities become too great for mental models to handle.

II. Structure of Feedback Systems

The purpose of this part of the sequence is to introduce a way of thinking about cause and effect holistically. The principal tool employed to facilitate analysis of a system is the causal-loop diagram. Cause-and-effect relationships in a system are symbolized with arrows, forming chains of causal links. Loops result when analysis presses far enough to return some or all of these chains back to their starting points. These loops of causal influences are called feedback loops; they are the central focus and foundation of system dynamics.

Causal-loop diagrams are models of feedback systems. In this part of the curriculum they are used in a generally descriptive way to summarize the complex interactions in a variety of stories, problems, and systems with which the student is familiar.

The principal skills the student should develop and exercise in Part II are the ability to represent the essential influences in a problem or system in a causal-loop model, and the habit of searching for feedback influences which close causal loops. If a student completes this part of the curriculum but does not continue on in the sequence, he will have gained a powerful simplifying tool for understanding complicated interactions, but he will have only the beginnings of an understanding of the connection between feedback loops and dynamic behavior.

III. Behavior of Feedback Systems

Dynamic behavior of quantities in systems is the focus of this part of the curriculum. The purpose is to develop an understanding of how the structure of feedback loops in a system is responsible for how quantities in the system change over time. Graphs are introduced and used intuitively, often without specifying numerical scales. The shape of the graph of a variable over time is the concern.

Behavior characteristic of positive feedback loops and negative feedback loops is explored in simple situations and then exploited to analyze more complex multiple-loop structures. Positive loops are shown to be responsible for unstable behavior such as exponential growth, while negative loops are shown to produce goal-seeking behavior. S-shaped growth is shown in several apparently different systems to occur when a quantity is influenced by both a positive loop and a negative loop; a shift from dominance by the positive loop to dominance by the negative loop produces behavior which looks initially like unrestrained exponential growth but then becomes goal-seeking. An important principle will appear as different systems are explored: systems with the same feedback structure tend to behave the same over time, in the sense that the shapes of their graphs over time are essentially the same.

X

?

The role of delays in goal-seeking systems will be explored intuitively. Students will become familiar with the principle that delays can cause a quantity to overshoot its goal and to oscillate around it.

The approach in this part of the curriculum is essentially non-quantitative, with the exception that some quantitative graphing will be done to provide the tools required to graph intuitively without scales the behavior of quantities in causal-loop diagrams.

A student completing Part III will have a foundation for the principle that the behavior of a system is a consequence of its feedback structure. He will be ready to try to apply his understandings to more complex situations.

IV. Understanding Dynamic Problems

A number of recurring themes in real-world problems are uncovered in this part of the sequence. Each theme is explored in the context of several apparently different dynamic problems, making use of causal-loop models and the properties of feedback systems developed in Parts II and III. The structure of feedback loops responsible for the thematic behavior is exposed in each system, providing a common focus for understanding the different problems sharing that theme.

One of the themes explored here has been referred to elsewhere as the "counter-intuitive" behavior of complex systems: well-intentioned policies often tend not to produce the behavior expected, occasionally even producing results opposite to those intended. The phenomenon is traced initially to the distinctions between "Open-loop and Closed-loop Thinking"; the former overlooks feedback, in contrast to the latter which incorporates within the boundary of the system all the essential feedback influences. It appears again as the "Significance of Feedback Structure" is explored; feedback systems tend to resist certain kinds of change, unless the actual structure of the system is affected. Another theme is summarized by the phrase "Short-Term versus Long-Term Behavior"; in feedback systems the short-term effects of a policy may be different from, even opposite to, its long-term effects. The tendency of complex systems to become dependent upon external controls is explored under the theme of "Shifting the Burden to the Intervener." Finally, "Tradeoffs" are emphasized. In complex systems, policies rarely improve all aspects of the system at once; usually a policy improves some areas and is deleterious to others, requiring policy-makers to take explicit account of the tradeoffs.

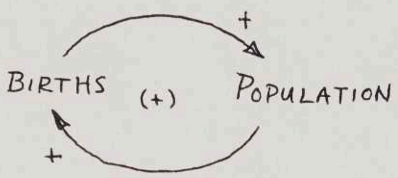
The problems explored in this part of the sequence range from peer pressure, cramming for a test, and mowing lawns, to criminal justice, pollution, urban growth-stagnation-decay, drug-related crime, and global population and food needs.

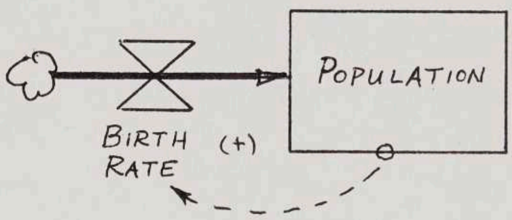
Part IV is the culmination of the essentially non-quantitative part of this system dynamics curriculum. Its purpose is to show the power of attempting to understand complex dynamic problems by focusing on feedback loops, to illustrate some themes which continue to recur in complex systems to the point that they may be called "principles," and to leave the student with a balanced view of the power and limitations of his understandings at this point. As Parts II, III, and IV have progressed, the need for knowing the relative strengths of feedback loops in a system will have arisen at various times, leading naturally (but not necessarily) to the next part of the sequence in which methods are developed for making the assumptions embodied in a causal-loop diagram unambiguous by quantifying them.

V. Introduction to Simulation

Computer simulation in system dynamics becomes necessary when the implications of a structure of feedback loops are in doubt. Greater precision than a causal-loop diagram can provide is required. Part V develops the skills needed to translate simple causal-loop models into quantitative models which a computer can trace through time, simulating the behavior of the actual system.

Two critical notions form the focus: the concept of a "level" (or "stock") and the concept of a "rate" (or "flow"). To aid understandings of these ideas and to facilitate translating from a causal-loop diagram to a quantitative model, level variables are pictured as rectangles and rates are pictured as stylized "faucets" pouring into the rectangles; the rate adjusts the flow of something into the level it is associated with, just as a faucet adjusts the flow of water into a tub, changing the water-level.





This part of the curriculum returns to the work of Parts II and III, developing quantitative understandings of positive and negative feedback loops and the behavior of simple systems. Students will expand their skills in understanding and interpreting graphs of variables over time. In addition, they will develop abilities to write general level equations and the elementary rate equations for exponential growth and decay and sigmoid growth. Exercises will include altering existing models by changing parameters, equations, and feedback structure. Familiarity with computers and programming is not required; the introduction to the simulation language DYNAMO is self-contained. The programming is presented as a means to an end: making assumptions sufficiently precise and suitably coded that a computer can trace out their implications over time.

At the close of Part V, the student is ready to understand more complex simulation models in DYNAMO, he will have begun to see the power of simulation, and he will have solidified his understandings of the behavior of feedback loops covered intuitively in Parts II and III.

VI. The Dynamics of Complex Systems

Several of the problems addressed in IV are reconsidered, most in greater detail. For each in turn a quantitative model is developed in DYNAMO, and explorations of the system are carried out by simulating different conditions in the model. The central focus, besides the significant problems themselves, is the understanding of complex system behavior. Where in a given system does intervention have the most effect? Why does the system behave as it does? What policies actually improve the behavior of the system? Why does one policy have a desirable effect while others which initially appear promising have little helpful effect or may even prove to be harmful?

Explorations of the behavior of a system are carried out, and alternative policies investigated, by changing numerical relationships in the model, altering or occasionally adding equations. The computer is shown as it really is — not an all-knowing intellect, but an obedient electrical servant, tracing out the implications of a modeler's assumptions over time. Each simulation model and each simulation run appear not as ends in themselves, but as means to understanding the dynamics of a certain problematic system. The goal is understanding, and feedback models help us to understand certain kinds of problems.

Part V completes this introduction to system dynamics. A student continuing through all six parts has a new understanding of the causes of dynamic problems, and he has the beginnings of a set of tools for analyzing and understanding them. He will have gained the habit of attempting to look at problems holistically and of searching for feedback loops responsible for the behavior of the system. He will understand the role of models in approaching problems, and in particular he will have an introduction to the meaningful role computer models and simulations can play in helping people to cope with the complex dynamic problems they face.

GPRichardson
12 May 1977.

structure. He will be ready to try to apply his understandings to more complex situations.

III. Understanding Dynamic Problems

Six real-world problems are addressed in this learning package, using causal diagrams and feedback loops to model the systems in which these problems arise. The problems, such as urban growth, stagnation, and decay, global population growth and food needs, and drug-related urban crime, will be selected to illustrate several important, recurring characteristics of the behavior of complex systems. In many ways, complex systems will be seen to behave "counter-intuitively": well-intentioned policies tend not to produce the behavior expected, and even when the feedback structure of a system is reasonably well understood ~~it~~ the system tends to defeat the purpose of most policy changes. The need for knowing the relative strengths of feedback loops will arise, leading, if desired, to the next learning package in which methods are developed for making the assumptions embodied in a causal-loop diagram unambiguous by quantifying them.

Package III is the culmination of the essentially non-quantitative part of the sequence of five learning packages. Its purpose is to show the power of attempting to understand complex dynamic problems by focusing on feedback loops, to illustrate some themes which continue to recur in complex systems to the point that they may be called "principles," and to leave the student with a balanced view of the power and limitations of his understandings at this point.

IV. Introduction to Simulation

Computer simulation in system dynamics becomes necessary when the implications of a structure of feedback loops are in doubt. Greater precision than a causal-loop diagram can provide is required. This learning package develops the skills needed to translate simple causal-loop models into quantitative models which a computer may trace through time, simulating

Univ - Oregon
[illegible] Centers
mailed
10/27
CJS

October 28, 1976

Dr. Richard Duncan
Assistant Professor
Systems Science Ph.D. Program
Portland State University
P.O. Box 751
Portland, OR 97207

Dear Dr. Duncan:

Thank you for the expression of interest in the National Model for your classwork. The National Model is probably too comprehensive and complicated to be a good vehicle for classwork. Also, detailed descriptions are only now starting to become available.

The book by Nat Mass on economic cycles describes an early, and by now somewhat obsolete, description of the standard production sector. Probably this book is the best place for you to start.

You might also be interested in the model on economic growth by my son, Nathan Forrester, in his text "The Life Cycle of Economic Development." Beyond these two books, I enclose papers that may be of interest.

If there develops some student reviews and working papers we would be pleased to see them.

Sincerely yours,

JWF/nd
Enclosures: "Business Structure, Economic Cycles, and National Policy."
"Moving Into the 21st Century: Dilemmas and Strategies for American Higher Education."
"The System Dynamics National Model: Understanding Socio-Economic Behavior and Policy Alternatives."

10/28/76

PORTLAND
STATE
UNIVERSITY
p.o. box 751
portland, oregon
97207
503/229-4961

systems science
ph.d. program

October 25, 1976

Professor Jay W. Forrester
The Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Mass. 02139

Dear Professor Forrester:

I am working with an NSF group to develop a curriculum and teaching materials on systems dynamics modeling techniques. Currently I am teaching a graduate course in modeling and simulation at Portland State University.

Last year you mentioned that a description of your model of the U.S. economy would be available for critical review. If so, I would like to obtain a copy and assign it to my class for study and written evaluation. Of course if you like, I will make sure that a summary of the student reviews be sent to you for further improvement of the model.

Again, your fine work continues to help guide us toward a better world.

I look forward to hearing from you at your earliest convenience.

Sincerely yours,

Richard Duncan /ko

Richard Duncan, Ph.D.
Asst. Professor

RD/ko

Ore-Univ.
SD-Active Centers

August 29, 1975

Professor Richard Duncan
Systems Science Ph.D. Program
Portland State University
P.O. Box 751
Portland, OR 97207

Dear Professor Duncan:

Thank you for your letter of August 20 and the helpful ideas in it.

At the present time the national economic model is still in the construction stage so we are not yet organized for working with a widening circle of collaborators on that particular effort. Please keep in touch with us and perhaps during the coming year we can have something available as a start.

I am asking Jack Pugh to respond to your inquiry about DYNAMO III.

Sincerely yours,

JWF/ndb

8/26/75

PORTLAND STATE UNIVERSITY
p.o. box 751
portland, oregon 97207
503/229-4961

systems science ph.d. program

August 20, 1975

Dr. Jay W. Forrester
Alfred P. Sloan School of Management
Massechusetts Institute of Technology
50 Memorial Drive
Cambridge, Mass. 02139

Dear Professor Forrester:

Your address to the Summer Computer Simulation Conference in Houston, Texas, July 10, 1974 entitled, "Understanding Social and Economic Change in the United States," brings up many new and important issues in economics, policy-making, and modeling. Hopefully, the modeling effort you describe will help change the whole social-economic-ecological decision making processes in America. I hope the following comments might help (in some small way) your formulation of causal factors effecting inflation.

1. Mr. Joel Schutz, former director of the Oregon State Office of Energy Research and Planning, attributes decreasing "net energy" as the prime driving factor for inflation. He elaborates on this concept first attributed to Prof. H. T. Odum in the enclosed paper (rather simplistic, but the idea should be clear).

2. You state (correctly) on page 16: "Present inflation arises from major imbalances in the economy. Some two-thirds of employment is outside of agriculture and direct production. This constitutes a very high overhead in government, education, and the service industry. Two-thirds of the working population in overhead is probably too great for the economy..."

Recently I encountered a specific example that strikingly supports this claim. The Department of Housing and Urban Development (HUD) is sponsoring a program to rehabilitate ("recycle") houses in run-down urban areas. In July 1975, a contractor (Mr. Philip Katsman, of Katsman Construction Company) told me his firm was awarded a $15,000 contract for rehabilitating a private house in Seattle, Washington. The administrative cost alone of this project was about $16,000 (i.e., more than 6% greater than the cost of actually doing the work)! Further, the owner got a subsidized 3%, 20 year loan and the taxpayer picked up the remaining 6%. (Mr. Katsman added, "The house will be in shambles before the loan is payed off.")

I have read most of Systems Dynamic/DYNAMO books and papers and used many of them as texts in modeling and simulation courses. This fall and winter I will teach graduate level courses in modeling and simulation to Urban Studies and Systems Science students at Portland State University. In addition, I am working with Dr. Dennis Meadows, and others, to develop a curriculum in System Dynamics. You mentioned on page 28 that a "widening circle of participants should become involved in a progression of discussions, model modifications, and publications on structure, behavior, and implications." I would gladly, and diligently, critique your current work. Kindly let me know on this at your earliest convenience.

Very best regards,

Rich Duncan

Richard Duncan, Ph.D.
Assistant Professor
of Systems Science

RD:kt
Encls

P.S. Is the DYNAMO III translator available for distribution? If so, please send particulars including cost, memory requirements, etc.

~~EAC~~

SD Centers – Calif – Univ.

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

System Dynamics Group
Building E40-253

MEMO: D-2226

TO: National Modeling Project Staff

FROM: Prof. Nathaniel J. Mass
Mr. Alan K. Graham
Mr. Peter M. Senge

RE: Visit with Willis Harman at Stanford

DATE: August 11, 1975

On July 21, 1975, we met for slightly over three hours with Willis Harman and other members of the staff of the Center for Social Policy at Stanford Research Institute. Members of the Center's staff in attendance included O. W. ("Mark") Markley, Duane Elgin, Tom Mandel, Egils Milbergs, David MacMichael, and Normal McEachron. The purpose of the meeting was to acquaint the Center's staff with the current National Modeling Project in the System Dynamics Group and to ascertain whether or not there might be some significant overlaps between the National Modeling Project and past work done at the Center on social value change. The meeting revealed that we are in fact interested in many of the same national issues. Much of the discussion focused on whether or not system dynamics, as a quantitative approach, in in fact capable of dealing with the less tangible social phenomena, such as changing perceptions, attitudes, and values. We feel that members of the Center's staff gained some feel for how such variables can be dealt with in a dynamic model. The following paragraphs outline some of the principal points covered in our discussion.

(1) Description of the National Model

We gave a brief presentation of the National Model, focusing on the social variables and attitudes that are included, or that we hope to include, in the model. The purpose of this presentation was, first, to apprise Harman's group of our current activities and interests; second, to solicit their comments on the range of social variables encompassed by the model; and third, to form a basis for the succeeding discussion about the representation of social variables in system dynamics models (see points (2) and (3) below).

(2) Representing Social Variables

Four general issues arose pertaining to the representation of social variables in system dynamics models. These issues are summarized briefly below.

(a) Representation of "soft" variables. Several members of Harman's group were doubtful that we could capture in a quantitative model many "soft" variables and factors of the kind that they deal with in their work. We responded that the primary source of structure and parameters for a system dynamics model is general knowledge and descriptive information of the kind that they would utilize. In particular, we argued that any concept which they could state precisely and unambiguously could be captures in a system dynamics model. In representing such factors, we would initially place more emphasis on precision--stating precisely the hypothesized linkages between variables--than on obtaining extreme accuracy in the measurement of all variables. Once a model were developed, dynamic tests could be conducted to assess the sensitivity of model behavior to specific numerical assumptions. If model behavior were found sensitive to a particular assumption, and if it were expected that the real system also exhibited such sensitivity, then a leverage point in the system would have been identified. Alternatively, if the sensitivity seemed spurious--not reflective of what occurs in real social systems--more precise measurements might be attempted and/or the model might be revised.

(b) "Discontinuous" changes in social structure. Several members of Harman's staff felt that many social movements represented a "discontinuous" break with the past, and, therefore, could not be captured or anticipated in a model. We argued, and by the end of the meeting some consensus seemed to have been reached, that such movements do not arise spontaneously or without motivation, and that the pressures that give rise to a particular social attitude usually develop in a continuous and cumulative manner. We also discussed how if structure of a social system were defined broadly enough, as we would in a system dynamics model, changing social attitudes would represent a shift in the mode of behavior of the social system with the underlying social system structure unchanged.

(c) Procedures for Representing Social Responses. We outlined two procedures for incorporating social responses and attitudes in a system dynamics model. The first procedure is to identify the pressures that underlie the social response and build those into the model as endogenous elements; this procedure would be applied wherever possible. A second procedure would be to test in the model the effects of social response taken as an exogenous variable. Testing of this kind would address questions of the form: "Suppose this social response occurred. What would be its impact?" Such testing could be helpful in identifying social attitudes of social responses which are sufficiently important to motivate building them endogenously into the model.

(d) Relation between Physical and Social Variables. At the meeting we offered the proposition that a useful perspective for understanding social attitude changes is to analyze how conditions in the physical environment condition changes in the social realm. For example, declining birth rates and family sizes seem to be caused, to a large extent, by factors such as rising per capita incomes, and concerns about crowding and environmental deterioration. Harman's group generally agreed that this was a useful perspective for understanding social change. In fact, many of the attitude changes identified in their Changing Images of Man study appear to rise from the declining contribution of material standard of living to well-being, concerns about the environment, and other "physical" causes.

(3) Central focus of the National Model Apparently on "Productive," rather than "Human," Elements

Several members of the SRI group felt that a significant difference in viewpoint and approach between their and our work was that their work centers primarily around "human" factors whereas our National Model appears to center about "productive" elements. We stated that the central "productive" core of the model provides a framework within which other elements could be incorporated, and the framework in no way implies an exclusion or subordination of social variables. In the model, such variables would interface with the model at the point where they affect the productive system. For example, in the model, attitudes toward pollution control would affect the allocation of capital equipment by the various industrial sectors to pollution control. Analogously, attitudes toward public support of individuals would affect the well-being of unemployed workers in the labor sector of the model, thereby influencing labor flows between sectors and willingness to work. Overall, the central "productive" core of the model appears to provide a mechanism, which is largely missing in Harman's work, for assessing the implications of a particular social change and judging whether or not a particular social or attitude change is likely to have important impacts on major policy concerns such as inflation rate and the rate of unemployment. For example, we tend to regard attitudes toward public support as an important factor to include in the National Model because of its likely impact of labor mobility, wage settlements, and the rate of inflation. Such issues about procedures for assessing the importance of a given social variable merit further discussion between the two groups.

To summarize the thrust of our meeting with Harman and his staff, there appear to be many issues of common interest between the two groups, and a good basis for mutual interchange. Harman, and others like him, should be very helpful in identifying important social factors to be included in the National Model and in reviewing and commenting on specific formulations of social variables. Likewise, Harman's group seems to have come out of the meeting with a better appreciation of the system dynamics modeling process and how modeling might contribute to their own work.

NJM,AKG,PMS/mt

cc: J. Miller

✓SD-Teaching
Calif-univ.
Miller, J.

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

March 31, 1975

Jay W. Forrester
Germeshausen Professor

Mr. Michael P. Hansen, Director
Science Computer Center
Department of Engineering
College of Marin
Kentfield, California 94904

Dear Mr. Hansen:

In response to your letter of March 7, I am enclosing two brochures. The Pugh-Roberts data will answer your questions on DYNAMO; The Wright-Allen Press Catalogue will bring you up-to-date on the system dynamics publications of the MIT and Dartmouth College Groups.

The two papers accompanying this letter give an overview of our current study, the national socio-economic model.

At present no member of our Group plans to be on the West Coast before end of the academic year. Dr. John Stanley-Miller, who did his doctoral work with me, is on the faculty of USC. While I do not know whether it would be possible for him to schedule a trip to Kentfield, you may wish to contact him at the following address:

Professor John Stanley-Miller
Environmental Engineering Programs
School of Engineering
University of Southern California
University Park
Los Angeles, California 90007

Best wishes in your endeavors.

Sincerely yours,

Jay W Forrester

eac
Encls: "DYNAMO II & III"
System Dynamics Publications, Spring 1975
"The National Socio-Economic Model--An Overview of Structure" by Gilbert W. Low
"Understanding Social and Economic Change in the United States" by Jay W. Forrester

3/31/75

COLLEGE OF MARIN

March 7, 1975

Professor Jay W. Forrester
Massachusetts Institute of Technology
Cambridge, MA 02142

Dear Professor Forester:

I am the one member of our four-man engineering department at the College of Marin (the community college serving the county at the "other end" of the Golden Gate Bridge) who has become our computer science "specialist" (as differentiated from data processing, offered by our business department.) I teach a limited variety of introductory lower-division courses for science, math, engineering, and technology majors, and manage a totally "hands-on" type center which features an IBM 1130 (due for replacement) and several analog computers, the largest of which is an EAI PACE 221R. We have limited access also to the IBM 370/135 used by data processing and for administrative production.

Although we are one of the older California community colleges, we have managed to be fairly innovative in some respects. One example is a course originated six years ago in our communications department called "Inventing the Future", which has been such a success that an entire futures-oriented program was developed last year, reorganizing the several courses that the original had become, and adding a variety of "follow-on" courses, which feature special topics pursued in depth from a futures perspective. (Descriptive materials are attached.)

I participate as a member of the volunteer committee which guides the overall development of that program, and as a member of the team which teaches the course I developed, Computer Science 21, "Computers in Our Futures". It is that course, currently in progress, for which I seek your help. If you will read the course description now, you will see why. (at back of this letter)

(Pause)

As you see, the project selected for the first offering of the course is the Dynamic World Model you published in 1971. That book is the "text" for the course, supplemented by "Limits to Growth" and "Prophets of Doom". The faculty members who volunteered to teach it with me are both economists from our business department, one primarily interested in the social aspects of the model and in its eventual adaptability to national systems, and

KENTFIELD
CALIFORNIA 94904
TEL (415) 454-3962

the other interested in natural resources aspects and the out-moded status of growth concepts in prevailing economics doctrine. My bias is the belief that computers are an indispensable tool for the informed, intelligent decisions that must be understood and supported by the world's citizenry to minimize future catastrophes ("maximize future prospects?"). It is my first experience with interdisciplinary team-teaching (a time-consuming but worthwhile arrangement), and with imparting functional computer skills to students without the usual background (conclusion pending.)

It is our good fortune that the analog computer program for your model published by Lee and Adams in the October, 1973 issue of COED (attached) fits neatly on our big old EAI, which has a large x-y plotter for output. I'm an analog enthusiast to start with, especially for continuous interactive programs of this nature. Thus, I am emphasizing most the concepts and skills necessary for programming and operating the analog computer version of the model.

I realize that there are advantages to the digital version also, and we intend to use one. We have the analog "simulation languages" of CSMP and LEANS for our IBM 1130, but I know we will not have time to become proficient enough with them to squeeze this large model into our smallish system. Therefore, we will need to use the IBM 370/135 on campus. Now, the question is: 1) whether DYNAMO is compatible with the 370 [who owns it, how much would it cost, and how quickly can it be acquired and made operational] so that we can use your programs directly; or, should we buy the FØRTRAN version of it from the University of Pittsburgh? That's my first question to you.

Now that I've started the questions, I could unleash dozens that have arisen in class discussions alone, but I'll try to restrict them to essentials.

2) We are basing our work on the three books cited above, published around 1970 with their references, etc. What has been published since, that we should know about? [Aside from periodicals, which we are reviewing]. In particular, where will we find the most recent full status report on the Club of Rome project?

3) Has a successful U.S. national version of your model been developed? If so, where can we get all the necessary information to do the same?

Professor Jay W. Forrester
Massachusetts Institute of Technology

March 7, 1975
College of Marin

4) Are you aware of, in communication with, etc., anywhere else in Northern California where your model is being used, or a project like ours is underway? Has an interest group developed, formal or informal, in which we might participate?

5) Have you or any of your colleagues embarked on speaking tours or other appearances, which might bring any of you into the Bay Area between now and June, so that we might impose on you during this semester? Who might we lobby for, to be included in next year's guest speaker program of the college? As you can see, it is our intention to provide ourselves and the results of this semester's work (the functioning models, analog and digital) as community-wide resources next year. Might it be possible to enhance that with the appearance of a qualified expert or two?

6) Finally, the usual kind of request. What more, lying so easily at your fingertips, might you send us or tell us, to eliminate our floundering about and give us the shortcut to instant expertise? Seriously, though, we will be grateful for anything more you might provide or suggest. While we all, staff and students, are quite enthusiastic and ambitious, our experience and resources are quite meager. We want to do this as competently as we possibly can. We know we are five years late at starting this, but that puts us many years ahead of most. Your help would greatly improve the quality of our results. We already appreciate what your work has done for all of us.

Sincerely yours
COLLEGE OF MARIN

Michael Hansen

MICHAEL HANSEN, Director
Science Computer Center
Department of Engineering

Note the unfortunate delay in mailing. We have only six weeks left in the semester. Hopefully, it will be possible for you to respond, at least in part, before we overlook too much more. My apologies.

MH/il

COLLEGE OF MARIN

COMP. SCI. 21 - Computers and the Future. (3 units) Spring Only.

Prerequisites: Future Studies (Core Course) and elementary algebra. Three lecture/project development hours weekly, plus additional use of Science Computer Center facilities.

Built around a specific application essential to future studies, selected each year by the Inter-Departmental Futures Education Program Committee, this course will involve two (or more) instructors, one from Computer Science and the other(s) from the discipline(s) most closely related to the application. It will begin with a presentation of the purposes for the application selected, followed by familiarization with the resources available, including equipment, staff assistance, and information sources. Then, a tentative program will be developed, identifying objectives, individual and group tasks, required instructional input, and a schedule. An organized information gathering system shall be designed for individual input by all participants, who subsequently, will be doing library research while formal instruction is presented in such topics as computer hardware and softward and their capabilities information , processing, elementary programming, documentation and the basic skills for computer use, such as preparation of imput, equipment operation, and comprehension of users' manuals. Special emphasis will be given to formalized process design and flowcharting.

A particular application may require concentration on the use of either analog or digital computer systems, although both types will be used to some extent in the course.

One objective will be to demonstrate throughout the course, the roles that "laymen" can and should have in deciding the extent of future use of computers as "servants of mankind".

Students will learn to operate all equipment themselves, and become resource persons to assist in the subsequent use of the course results anywhere they may be of service throughout the College community.

Proposed application for Spring, 1975: fully-operational world systems simulation models on analog and digital computer systems, documented for subsequent use throughout the College. (See COED Transactions, October, 1973, pp 155-165.

COLLEGE OF MARIN

Edited

Application for a [X] New Course
[ ] Change of Course

(To be submitted to Office of Instruction)

Initiated by Mike Hansen (name) 12/1973 (date)

Approved by ______ (dept. chairman)

Intended Date of Implementation: Spring '75

I. NEW COURSE:

Course Name and Number:	Course Title:	Office of Instruction Code No:
Comp.Sci.21	Computers ~~and~~ in Our FutureS	

Units for Students: 3 Lecture Hrs./Wk: 3 Laboratory Hrs./Wk: open

Teaching Units: 3 Prerequisite: IFEP Core Course (Futures Perspectives) and elementary algebra.

Will be Offered in: Fall ______ Spring X Summer ______ Anticipated WSCH/FTE: 300 (hrs./wk. x no. students X 15 ÷ number teaching units)

Max. Class Size At Registration: 22 Anticipated Enrollment: 20

Grading System: A, B, C. NC ______ CR, NC X Both ______

Budget implications, in terms of salary, equipment, supplies, and other expenses, both for initiating the course and for continued operations (Attach extra sheet if necessary) Equitable distribution of three teaching units between the two or more instructors to be resolved (equitably by IFEP Committee).
Equipment and supply costs can be absorbed within the Science Computer Center (Engineering Department) budget. No new equipment required. As a creative course with content dependent on adopted applications, and an objective being to produce documentation facilitating subsequent use of results, an unusual amount of duplicating supplies and services may be required. Users' manuals and documents which are produced may thereafter be sold through the bookstore to subsequent users.

THIS COURSE:

See notes below

- [ ] Is a lower division course at other institutions
- [1] Will be accepted toward the major at U.C. campuses
- [1] Will be accepted toward the major at State colleges
- [2] Will be accepted as an elective at U.C. campuses
- [2] Will be accepted as an elective at State colleges
- [2] Will satisfy a state college general education requirement in ______
- [3] Will satisfy COM graduation requirement in ______
- [ ] Will be part of the COM vocational program in ______
- [ ] Has been recommended by the ______ advisory committee (if it is a vocational course)
- [ ] Replaces the following COM course ______
- [X] Is described on attached COM form

NOTE: A listing of other institutions at which similar courses are offered and at what level, articulation agreements, evidence of need, and additional comments, if any, should be attached. See next page.

II. CHANGE OF COURSE: ______ (name and number)

List desired changes: ______

[ ] Revised course description attached. What are the budget implications of this proposed change? ______

ACTION:

Curriculum Comm.	Date	College Cabinet	Date
Dean of Instruction	Date	Board of Trustees	Date
Instructional Council	Date		

1. Too new to be an undergraduate major, except in rare cases.
2. To be formally explored through the Office of Instruction
3. Recommended to Curriculum Committee to satisfy Basic Subject, Group B requirement.

Offerings at Other Institutions

Future Studies Programs are appearing at many colleges. Many Computer Science departments offer a general education introductory course which includes a presentation of prospective roles for computers, etc; and also offer project courses.

But we are not aware of any college which integrates all of these into a single course like this one.

Articulation Agreements

Articulation agreements with UC and CSCU are to be formally processed through the Office of Instruction for acceptance as an elective toward general education requirements (Group B, Basic Subject) or in satisfaction of specific lower division courses with similar basic content.

Evidence of Need

(See IFEPC Prospectus, pgs. 1 through 6)

Additional Comments

A fuller understanding of the origins of this proposal can be gained by a careful reading of the IFEPC Program Development Prospectus. It is an integral part of what has surely been the most productive interdisciplinary educational effort in COM history. In ~~it,~~ this course students and teachers with various backgrounds are to be brought together for purposes including on-going curriculum development with a distinct "futures perspective", to have continuing value to themselves and the college overall.

COLLEGE OF MARIN – COURSE DESCRIPTION

Comp. Sci. 21
COURSE NAME & NUMBER

Computers ~~and~~ in Our Futures
COURSE TITLE

CODE NUMBER

CATALOG DESCRIPTION: (Attached - see Next Page)

Mike Hansen
SUBMITTED BY

APPROVED BY DEPART. CHAIRMAN

DATE

PLEASE ANSWER THOSE QUESTIONS WHICH APPLY TO THIS COURSE, ATTACHING EXTRA SHEETS IF NECESSARY.

A. What are the objectives or purposes of the course in terms of:

1. subject matter to be covered by the instructor? At least 75% retention of such information as computer hardware and software fundamentals, their capabilities, information processing, elementary programming, documentation, input coding, process design, and flow charting as are required for the particular application development project adopted for the current semester.

2. mental skills to be developed by the student? (e.g., reasoning, problem solving, writing, memory, creativity, analysis, synthesis of ideas.) Improved ability to cope with large, complex problems by systematically analyzing their parts and their interrelationships, gradually comprehending an integrated whole, which involves all of the examples above. In addition, it will be necessary to successfully quantify variables and to formulate abstract or physical analogies of relationships in order to "computerize" solutions.

3. attitudes to be developed by the student? (e.g., interpersonal, emotional, aesthetic)
Strengthened appreciations of:
a) Potential of computers as servants of mankind.
b) Importance of the role of average citizens in deciding how computers should be used - responsibilities.
c) Willingness to make the necessary efforts to become qualified to participate in such uses.

Comp. Sci. 21
COURSE NAME AND NUMBER

4. physical skills to be developed by the student? (e.g., mechanical, speech, athletic, recreational) Minimal keypunch operation and such operational skills as are required to become "hands-on" users of all computer equipment used in the course. Each student is to be able to perform every operation from data preparation to control of the computer(s) during execution of programs.

5. other objectives or purpose? To develop experienced, highly motivated individuals through direct involvement in the development of significant computer applications, who may then volunteer to assist in the work of introducing such applications in appropriate ways throughout the college program.

B. How, in terms of teaching methods, instructional materials, assignments, etc., will the course objectives or purposes be realized? 1) Lecture/Demonstration, pre-assigned reading, reference lists, etc. 2) Guided group process, using the development project as vehicle. 3) Focus throughout the course - class to prepare a "position statement". 4) Explanation & Demonstration followed by assigned individual uses. 5) Organized voluntary program, coordinated by the instructors.

C. How will it be determined whether the course objectives or purposes have been met?
Measured by: 1) Objective testing
2) Completion of successful application project.
3) Beginning vs Ending attitudinal survey.
4) Individual performance of all operations.
5) Extent of successful subsequent use elsewhere in college program.

D. Please attach outline of major topics, with an indication of the approximate time to be spent on each. (next page)

Course Outline

Comp. Sci. 21 Computers ~~and~~ in Our FutureS Jan, 1974

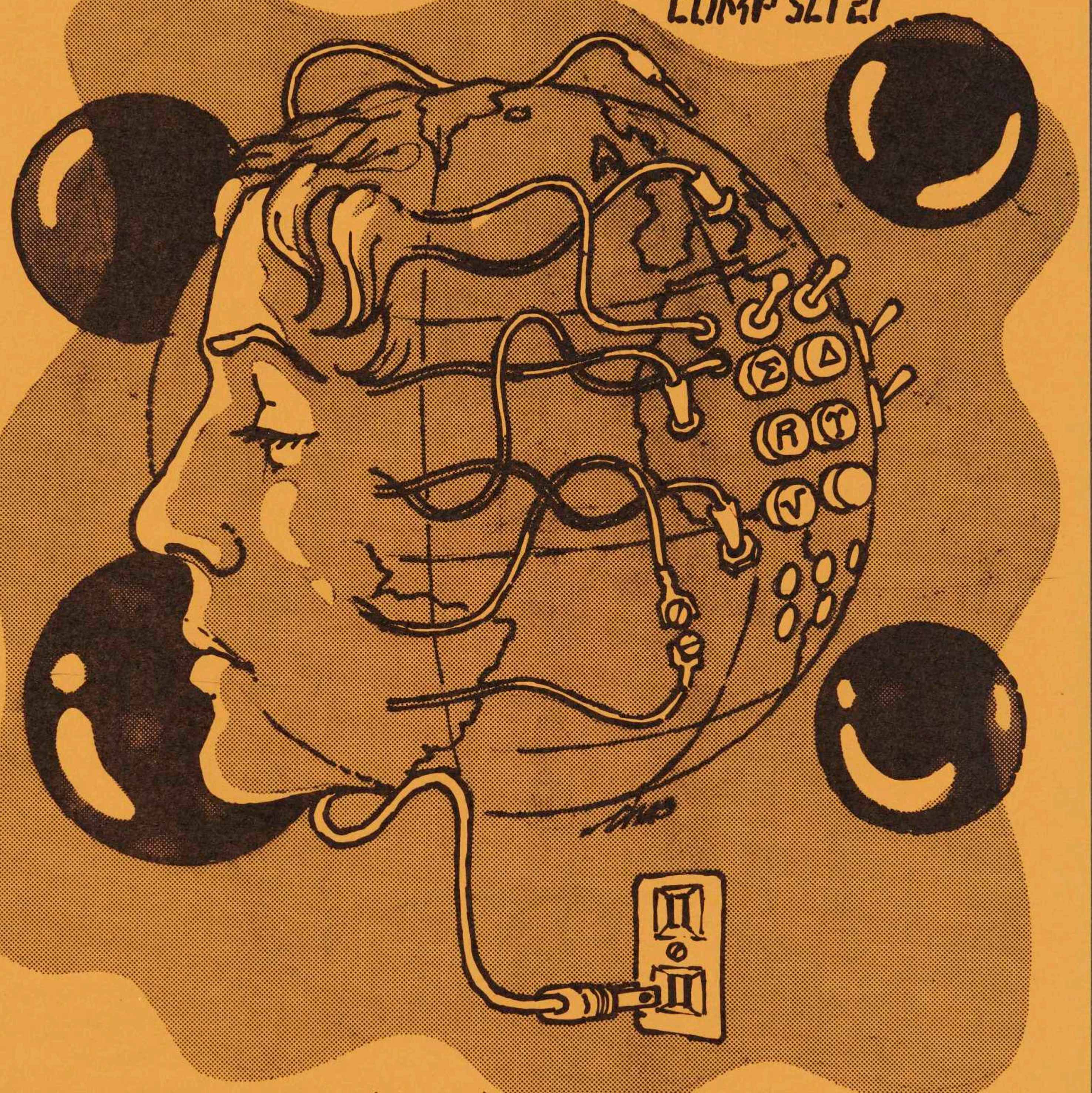
As the course is built around a particular project each time, the content and sequence will vary accordingly. Nonetheless, most of the formal instructional content will be required for any major project, so that it will always resemble the structure below, which is designed to facilitate the first project, operational World Systems Simulation Models on both analog and digital computers.

Week		1 hr.	2 hrs.	3 hrs.
1	Beginning attitudinal survey. Presentation of project and course goals. Familiarization with resources. Adoption of tentative program. Organization of information gathering.			
2				
3				
4–5	(General instruction, including testing)		(Analog Computer Fundamentals)	
6–9				(Group Project Development Process including topical instruction) + →
10–12		(Position Statement Development & Adoption)	(CSMP digital computer program)	
13–14		(Subsequent use planning and conferences)		
15				
16				
17	Final Exam			

ARE YOU INTERESTED IN THE NEXT FRONTIER OF HUMAN ENDEAVOR?
IS THE WORLD'S FUTURE WORTH ONE AFTERNOON A WEEK OF YOUR TIME?

"COMPUTERS IN OUR FUTURES"

COMP SCI 21



WEDNESDAYS, 2 pm until 5 pm (3 units)

Combine the greatest strengths of the human mind with the strengths of the computer ★ Construct a computer model of our dynamic social systems ★ Examine the unexpected consequences of our most popular social and political policies

Prerequisite: High School Algebra

Recommended: Futures Education Program Core Course (Inventihg the Future or Futures Perspectives)

For further information call: College of Marin, 454-3962, Extensions
Extensions 385, 394, 271


INTERDEPARTMENTAL
FUTURES
PERSPECTIVES
CLASS
OFFERINGS

COMMUNICATIONS 2A Dunstan

I see this course as primarily a Futures Consciousness Raising effort, that is, an exposure to ideas and notions which encompass alternative futures for people and not the same future for everyone. This involves people in new modes of thinking, new ways of looking at old problems, and a willingness to be open to at least entertain some rather outrageous proposals. My role is to stimulate, facilitate, and act as a resource person. After all, the future you invent will be your own!

COMMUNICATIONS 2B Dunstan
Prerequisite:Com,BeSc,SocSci,2A

This semester we will explore the future of work and any ramifications that exploration might have on our personal and collective lives.

BEHAVIORAL SCIENCE 2A Holmlund

Inventing the Future. An interdisciplinary look at the future and various concepts related to the future - time, change, values,prediction. Several paperbacks will be used dealing with various aspects of the future. The main focus of the course will be an individual project dealing with a particular topic and examining current trends and future

cont. above

BEHAVIORAL SCIENCE 2A cont.

predictions and then inventing creative alternatives to these current predictions. Many classes will consist of student progress reports on the projects; many films will be shown dealing with the future, and occasionally there will be guest speakers. Evaluation will be based on class participation and the individual projects.

I hope that in addition to gaining an understanding of various aspects of the future, everyone in the class will actively experiment with change and examine the consequences.

COMP. SCI. 21

Prerequisite: Com,BeSc,SocSc,2A

Three hours weekly, plus additional use of Science Computer Center facilities.

A fully operational World Systems Simulation Model (Jay Forrester's Dynamic World Model) will be set up in this course, and will subsequently be available for use throughout the college.

Three instructors will be involved, one from Computer Science and two Economists, one of whom has a social and psychological orientation, and the other a resource conservation and natural science background.

One of the course objectives will be to demonstrate the roles that the layman can and should

cont. above

COMP. SCI. 21 cont.

have in deciding the extent of future use of computers as "servants of mankind."

Students will learn to operate all equipment themselves, involving both analog and digital computer systems, and will become resource persons to assist in the subsequent use of the course results in any way that they may be of service to the college community.

BIOLOGY / COMMUNICATIONS 41
" A Wilderness Experience "

Interested in learning about the wilderness by being there?

Investigate "A wilderness Experience"-Bio/Comm.41, for the coming spring semester. We'll be camping out at Pt. Reyes, studying its history and geology, as well as exploring tidepools, freshwater ponds, sand dunes and forests.

This is an integrated biology - communication class in which the study of ecosystems is viewed from a futures perspective. Journals are required, in order to express the awareness one gains from experiences in the field.

Pick up an application from Science Center 137, Harlan Center 116, or any counselor.

cont. next page

BIOLOGY / COMMUNICATIONS 41
"A Wilderness Experience"

Applications must be completed and returned to the Science Secretary in SC 137 by December 1.

We're interested in a class of diverse ages and complementary interests. Join us!

Wanted: 2020 alternatives

By Drew Mendelson

The need for alternatives in education, often ascribed to a mere rebelliousness directed at the status quo, is getting meat on its bones. As the information explosion begins to foster interest in putting more and more of these data masses in some kind of order, new ways to approach learning appear increasingly imperative.

A new course at the College of Marin, for instance, is aimed at harnessing the digestive capacity of the computer to problems that education — and many other of our institutions — has paid not nearly enough attention to. Chief among those problems, perhaps, is a national attitude toward growth and its inevitability that is contradicted by nearly every social and economic indicator we can consult.

Professor Jay W. Forrester of the Massachusetts Institute of Technology might be called a 20th century computer oracle. Forrester has constructed a model of the earth's economic and social systems and, using the MIT computer, has taken his world model through the next century of human history.

Orthodox economists may not be pleased at the result, for it challenges that basic tenet of economics: growth. The concept in economics, as in biology, is that growth is synonymous with life. Any economic system which does not grow (its capitalization, its output, its consumption) is, it is felt, not accomplishing one of its basic objectives.

Forrester, however, armed with his computer-generated projections of the future, contends that growth is not integral to an economic system. Further, he says, the projections over the next century end in social and economic collapse as long as growth is a factor.

Population control will simply result in a higher standard of living and greater food supply. In the end the conditions which made population control necessary and acceptable will diminish and population will rise again.

Forrester's work is available to the public in a book titled *World Dynamics*, which explains both the structure of his world model and the results he obtained. *World Dynamics* does not just chart a landscape where all roads lead to hell; it also offers maps of a different landscape in which the roads, though they never quite climb to heaven, at least lead away from that final plunge. Forrester says that we have reached and perhaps left the peak of our quality of life. Nowhere, he says, will we achieve a level of existence offering us more; if anything, the law of diminishing returns has set in. Equilibrium, Forrester contends, is the state we must strive for, not growth.

We cannot increase industrial output but only maintain it, we cannot increase population but only maintain or preferably diminish it. Our resources are finite. Eventually, no matter how frugal we are, the earth will run out of those resources required to sustain life. Currently, Forrester says, we are using them up at an exceptional rate, faster each year than the year before. In the beginning the increase was hardly noticeable, but it has begun to rise fantastically until, according to the computer models, the end is in sight. It comes sometime in the next century, perhaps as early as 2020.

Perhaps the most valuable portion of Forrester's work is not the prediction of future catastrophy, nor even the world model he constructed. The greatest value might be the integration of diverse disciplines into one single method of future prediction. Other computer centers throughout the country can and are duplicating the Forrester World Model.

The computer science center at the College of Marin is one such facility. The structure for use of the computer-generated predictions already exists at the College, in the College's Interdepartmental Futures Education Program. The classes in the program use the techniques of different disciplines to investigate possible courses for the world in the next decades. Among the courses already in the program are Inventing the Future, Wilderness Experience, and Future Physics. Instructors from the departments of communications, social science, behavioral science, phenomena, mystical knowledge and spiritual development. Instructor will be Pascal Kaplan, a Ph.D. candidate at Harvard. Fee is $65. Information: 457-4440.

WEIGHT
The Marin County Heart Association is sponsoring a 12-week class in weight control beginning Wednesday, January 22 at Novato General Hospital. Classes will be from 7:30 to 8:30 p.m. Fee $5. Register in advance through the Heart Association, 456-9222.

KEEPING FIT
Bodies in Motion is the name of th class taught by Sylvia Boorstein at the Marin Jewish Community Center, starting Monday, January 20. Call 479-2000.

WEIGHT CONTROL
The Marin County Heart Association is sponsoring a 12 week class beginning January 22 at Novato General Hospital, Wednesdays from 7:30-8:30 p.m. Registration is $5 in advance. Call 456-9222.

BODY AWARENESS
Six Thurs. mornings in Mill Valley, Jan. 16-Feb. 20, 10-12 noon. Breath awareness, stretching & polarity yoga as a means of relaxing & integrating the body. Instructor, Gilda Meyers, M.A. $35. For info call 383-7567. Openings still available.

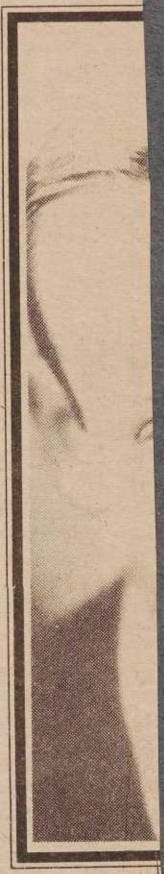
CHILDREN'S DRAMA
Classes forming now in the Magic Circle for children 6 to 15. Creative study in groups, culminating in performance with Marion Hayes Caine, 70 Monterey Ave., San Anselmo, 453-7882.

Work shops

FOOD, BODY, BALANCE
Food consciousness workshop with Billie Hobart, 1-5 p.m., Saturday, January 25 at the Marin Center of Parapsychology and Metaphysics, 1029 Fourth St., San Rafael (above Modern Eve). $10. For information, call 456-0955.

FOR OVEREATERS
Two free introductory sessions begin the 1975 sessions of Overeaters Workshops. 10 a.m. Friday, January 17 and 8 p.m. Monday, January 20; both at the San Rafael YMCA, 1618 Mission Ave. Featured is a non-diet, psychological approach. Information: 388-0560.

AUDIO-VISUAL
The Mill Valley Public Library is sponsoring an open house on the operation of audio-



Fred Astaire a

visual equipm
Saturday, Janu
cover casette ra
reel tape record
projectors, slid
copy machin
librarians and p

TRANSACTIC
Family Focu
YMCA progra
16 and continu
Call the Y at

PSYCHOSYNTHESIS GROUPS
An ongoing process of Self-discovery & creativity, Wednesdays 7:30 p.m. and Thursdays 9:30 a.m.; $26 per month. For info call 383-6489 or 383-3801.

"REALNESS"
A weekend workshop, Jan. 17-19, involving guided fantasy, writing, art & movement to help us get in touch with our real selves. $30, call 383-6489.

VIDEOGRAPHY
Marin Community Video has access to cable T.V. in Marin, only a few of us, however, use this powerful communications medium. More videographers means more community programming and more alternatives for T.V. viewing. For beginners, limited to 6 people, $25. For advanced, limited to 4, $60. For info call Burt Arnowitz, producer/-director Marin Video Magazine, 383-3515.

biology and physics participate.

The program has added a new class and a department which, once Forrester's work is understood, is logically part of the curriculum. The department is computer science. The new class is titled Computer Science 21: Computers in Our Futures. It is scheduled to be taught at the college starting with the spring semester next week. Three different instructors are involved, Mike Hansen of computer science, math and engineering, Laura Willson, an economist dealing with social and psychological areas, and Katherine King, an economist whose background is in natural science and resource conservation.

The College of Marin has two computer systems capable of handling a Forrester-type world model. The first is an analog computer in the Science Computer Center, which, being student operated, would more directly allow students to see the total operation of the model. The other is the large digital computer at the Data Processing Center in the New Library, which is used by the business department for data processing courses, and for the district administration, record-keeping purposes.

By using the larger digital system, students would not be able to follow the actual process, being able only to submit data to be processed and pick up the results. The analog computer is ideal, capable of handling a model as complex as Forrester's, yet without the demands of the larger system.

The strength of the analog computer, Hansen says, is that it handles continuous interactive situations simultaneously, the way they arise on the earth. The change of one factor in the computer not only alters that factor's relationship to other, it alters the nature of the other factors as well in what Forrester terms a feedback loop. The strength of the human mind is that it can perceive the problem. The mind's weakness is that it cannot handle at once more than two interacting factors.

"It puts the model into an examinable and unambiguous form," Hansen states. What this means is that a student can tell the computer to change — hypothetically — the rate at which earth's population is expanding and see what the earth will be like in fifty years because of such a change.

Computer Science 21 is perhaps a victim of its name. There is room in the class for 18 students and enrollment is far short of that to date. It is a rigorous course requiring at least a knowledge of high school algebra, and it will involve concepts from other disciplines — economics, social science, communications and behavioral science. But it is not just, or even primarily, a course in computer operation.

The concept of the course is to offer students some evidence of workable economic systems not based upon the present commitment to continuous growth. A course objective will be to show students the capabilities and limitations of computers, and demonstrate the roles the students may take in determining the future of computer use. Students will learn to operate the computers and help to pass on the information gained through their course work.

Katherine King suggests that one of the greatest benefits of the course will be placing the students in a "better position to survive probable future changes psychologically, and, possibly, physically."

The earth seems to be at the brink of a depression which is approaching in spite of the most determined efforts of the world's economists. The solutions which pulled the world out of depression in the thirties are inadequate to prevent the oncoming situation, as Alvin Toffler says in the current issue of *Esquire*. The fact that none of the current solutions seem to apply should add credibility to the Forrester model. Students will, through the computer, be examining solutions which the legion of economists employed by the Ford administration are unable to use because those economists are taking a piecemeal approach.

There are phone numbers which will provide more information to students who would like to take the course. The College number is 454-3962, with Hansen's extension 384; King's 325 and Willson's 347.

At any rate, the course was about a year in the planning, and there are no known colleges, certainly not two-year community colleges, offering anything comparable on the West Coast.

Man, his symbols and the media

By Sue Vaughn

Ever wonder why a Zulu warrior dances before the hunt? How a Yaqui sorcerer communicates with the spirits? How Madison Avenue gets its message to the people?

The answers to these and other questions about communications will be explored this spring semester at Indian Valley Colleges in a six-and-a-half unit coordinated studies course which will focus on the media.

Total media consumption per person in America averages some 50 hours per week (exceeding every other activity except sleeping). *The Media: Man and His Symbols* focuses on the media as it relates to the consumer and will stress the importance of its influence on daily life.

The purpose of the course, according to the instructors, is to analyze the media and to help students to become more aware, more discriminating, and more sensitive to the bombardment of their senses.

The course will be team taught by IVC instructors Jean Hartley and Leah Shelleda, and will combine Social Science 240, Speech 240, and English 100, a half-unit English skills course which offers students help with vocabulary, research techniques, and preparation of course materials.

According to the instructors, the new media course will use Marshall McLuhan's phrase, "the medium is the message," as a reference point. From that point, students will explore the form and content of television, film, radio, newspaper, magazines, books, comics and graffiti.

The class will visit radio and television stations as well as newspaper offices, and will be able to create its own video tapes and films. Guests from various media fields will be invited to participate in class discussions. Each student is expected to originate and develop a creative project through which he or she can explore a selected communication form.

Registration is now open at Indian Valley Colleges and spring semester classes start February 3. More information may be obtained by calling the Admissions Office at 883-5921. Entrance exams are not required.

Records

continued from page 5

wholesomeness, this might interest you. Riordan recently co-produced with Pat Gleeson a very classy *Christmas in San Francisco* LP for Embarcadero Center's Living Arts program.

•••

If you saw the movie *Death Wish* you know what a killer (no pun intended) it was, and listening to Herbie Hancock's soundtrack is an excellent insight into how the moods of the movie were created and into Hancock's wide-ranging capabilities as a composer and conductor. Hancock, of course, was one of last year's biggest local stories — the jazz artist who broke big commercially. Even this LP is up on the soul charts, just ten spots below Herbie's new (non-soundtrack) *Thrust*.

•••

Kicking Mule Records, an operation run jointly by Blue Bear Waltzer Ed Denson from his Oakland home and guitarist Stefan Grossman, who spends most of his time in Europe tracking down good acoustic guitarists, has just issued its twelfth release: *Fingerpicking Guitar Techniques*, subtitled Stefan Grossman's *Study into Blues and Ragtime Guitar*.

This record, like an earlier Grossman package, *How to Play the Blues* (and like some more KM records to be released soon) comes with a tablature book, so if you play guitar and want to learn some mellow picking techniques, the albums are a double deal. Even if you don't play, all the Mule records — which include work by Rev. Gary Davis, Mark Spoelstra, and some interesting Europeans in addition to Grossman — are things of beauty.

Price per disc is about $6; the more you order the cheaper it gets. Catalog and info available from Box 3233, Berkeley 94703.

WITH GRIM RESULTS

Computer Looks At Man's Future

By LEW CODDINGTON

How much longer can mankind carry on with its present population growth, industrialization, pollution and consumption of natural resources?

Some eloquent answers to these and other difficult questions are being supplied by a mute informant — a College of Marin computer hooked up to a graph machine, tracing inky curves to show man's fate 50, 100 or 200 years hence.

For the most part, the answers are grim, tending to confirm bleak predictions which started coming in the 1960s, from "zero population growth" advocates and ecologists. But it is better to know the worst while there is still time to do something, say Michael P. Hansen and Katherine King, two instructors involved in the project.

What the computer can do, they say, is be much more specific and accurate about what will happen than humans can. Feed a bewildering variety of data and assumptiions into the computer, and the answer will flash in lights or be traced across the graph.

The different factors interact in so many ways that the human mind cannot possibly keep track, but according to Mrs. King and Hansen the computer easily can do so.

Suppose, for example, the world's population increases by 4 per cent a year while the levels of pollution, industrialization and resource consumption remain the same.

Slowly, the red pen moved across the graph paper, began a sweeping curve as the population increased fourfold in 50 years, then leaped off the graph before the end of a century. Pollution also soared off the graph. Natural resources plummeted to one-third their current amount.

Had they wanted, the instructors could have poured in more data, and a more sophisticated, realistic graph would have resulted — with population dipping as pollution increased or with pollution decreasing as natural resources were used up, and so on.

Much of their work is based on research by Jay W. Forrester, a professor at the Massachusetts Institute of Technology. It is being used as a basis for a new course taught by Hansen, Mrs. King and Laura Willson. Called "Computers and Our Futures," the class combines economics and computer science.

Unlike the computer, human beings do not have the ability to remember and correlate the dozens of factors at once, and that is a source of their problems now, Hansen and Mrs. King said.

Instead, we have come up with simple-minded, "intuitive solutions" which may be good enough to solve short-term problems, but often produce long-term disaster, according to the teachers.

One example, Hansen said, is the creation of suburbs, really not a deliberate decision at all. Building on available, open land once seemed like a good way to solve housing problems, but it becomes more costly and less efficient to maintain suburbs as they sprawl across the countryside away from population centers.

Mrs. King said, another example, may be President Ford's proposed tax cut. By stimulating consumption, it could lead to scarcity of resources, and drive up prices of goods made from those resources.

Mankind has complicated the problem, Hansen and Mrs. King said, by failing to understand the full meaning of what mathematicians call "exponential growth." If a population doubles every generation, for example, it will take millions of years to become large, but only a century or two more to go from large to catastrophically overcrowded, he explained.

Like population, pollution and resource consumption also snowball, finally reaching limits imposed by nature, they said.

But even before that happens, the consequences are disastrous.

In light of this, Mrs. King said mankind must reexamine the very idea of unlimited growth, an idea which went challenged for so long.

"In the past, the human race always has solved its problems by expansion," she said. "Create jobs by expanding the economy. Or go to the New World. But that era is ending.

"We need to reach an equilibrium level, where we live within our resources. We should use no more trees than we can grow."

"For us to be encouraging underdeveloped nations to become industrialized may not be doing them any service," Hansen added. "They may be closer to a satisfactory equilibrium than we are."

Both agree the world has to be viewed as a whole and said part of our problems stem from only looking at the parts. For example, technology could solve the problem of too few trees by creating substitutes, but only by adding to the pollution problem and or depleting other resources.

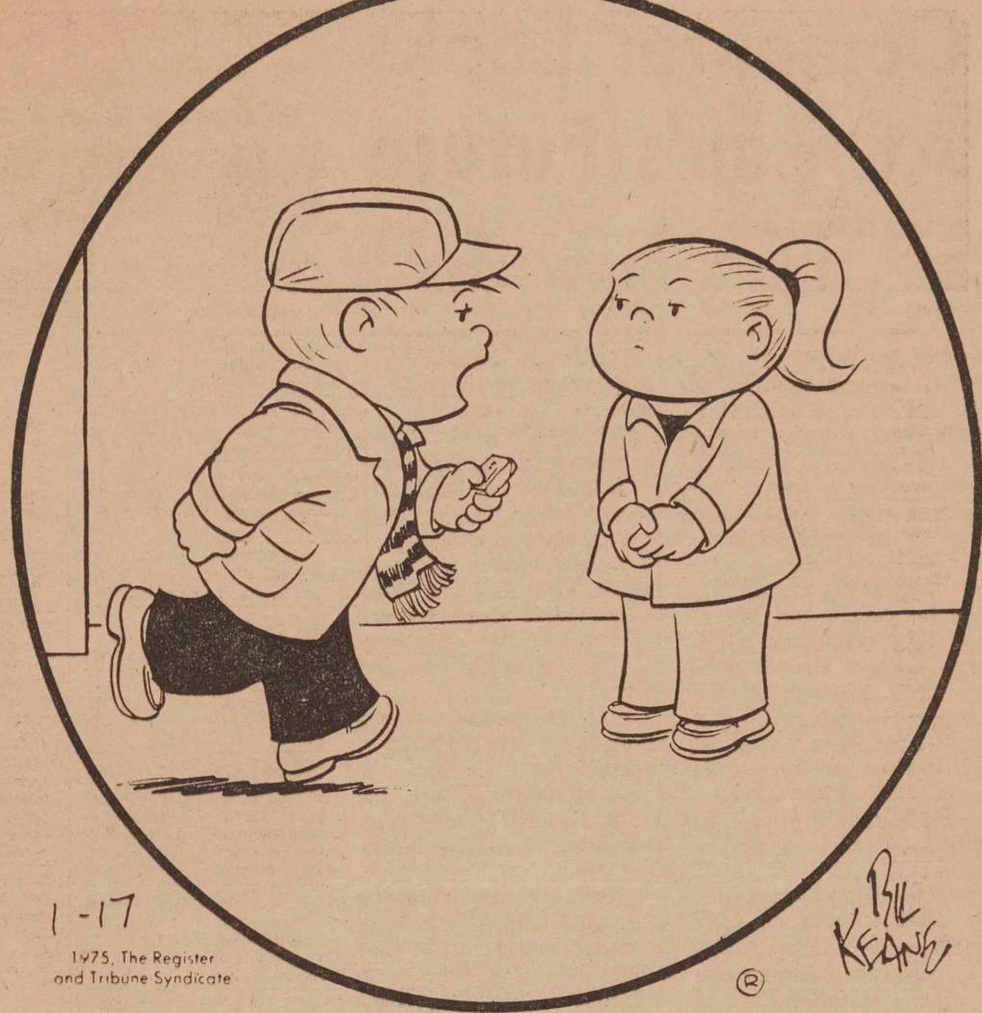
Going from a growth mentality to an equilibrum mentality presents all sorts of problems, and may involve giving up the current standard of living, Hansen said.

How bad will it be? Find enough accurate data to feed into that computer at College of Marin, and the answer may be read between the lines of the graph.

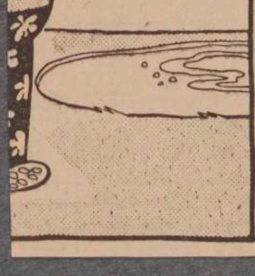
PLOTTING THE FUTURE — Katherine King (left) and Michael P. Hansen, professors at College of Marin, pore over graphs and charts generated by a computer while student John Pierce feeds in more data. Mrs. King and Hansen use the computer to predict what will happen in the future if various population, pollution and economic trends prevail.

(Photo by Bob Hax)

THE FAMILY CIRCUS



"Daddy's right! Inflation is really bad. Bubble gum's TWO cents now!"



HOW TO PLAY

WINNING BRIDGE

By ALFRED SHEINWOLD

If You Can't Trust Your Partner, Who Can You Trust?

Life is full of confusing advice. "A penny saved is a penny earned," you are told on one side. "Don't be stingy," you are told on another side. How do you know whom to believe?

The answer is very simple for

he assumes that there must be a reason for West's strange play at the fourth trick.

If East trusts his partner, he knows this is the time to act. He squanders that king of hearts on the fourth club.

MIKE HANSEN

COED

COMPUTERS IN EDUCATION DIVISION OF ASEE

Transactions

INTERACTIVE COMPUTER PROGRAMS FOR THE UNDERGRADUATE BIOLOGY STUDENT

BY

WARREN GUY, DEPARTMENT OF ELECTRICAL ENGINEERING
LAFAYETTE COLLEGE, EASTON, PENNSYLVANIA

AND

BERNARD FRIED, DEPARTMENT OF BIOLOGY
LAFAYETTE COLLEGE, EASTON, PENNSYLVANIA

A DYNAMIC WORLD MODEL

BY

DEREK H. BROWNLEE
GENERAL ELECTRIC CORPORATION

AND

WILLIAM S. ADAMS
PENNSYLVANIA STATE UNIVERSITY

ASEE

VOL. V NO. 10 OCTOBER 1973

A DYNAMIC WORLD MODEL

by

Derek H. Brownlee
General Electric Corporation

and

William S. Adams
Pennsylvania State University

Jay W. Forrester, in his recent book, "World Dynamics," provided a popular presentation of his work in digital computer simulation of world systems. He portrayed various possible futures for humanity in the form of computer printouts. Most of these futures were grim, conveying the message that none of the popular solutions to world problems were adequate.

Forrester made little claim to accuracy in his model. His equations were somewhat simplistic. He is trying to inspire people to make better models for decision-making than the intuitive ones they carry around in their heads.

What follows is one such model using an EAI 680 Analog Computer. It is limited by the equipment and time available, but it goes a little further than Forrester's. There is scope for much further development and analysis within the structure of this basic model and equipment.

The model was run and found to be stable, indicating a crowded, hungry, polluted future for mankind.

Performance indices were added to the model to evaluate incremental economic changes that could be applied in an attempt to improve matters. No major improvements resulted from such changes.

A major nuclear war was programmed and was found to promise a much more optimistic future for the survivors. It resulted in an alternative stable state in which economic control could be exercised. Without a nuclear war the only way to attain this alternative stable state is through a halving of the birth rate.

In the meantime, each additional child imposes costs of the order of $50,000 on the future.

LIST OF SYMBOLS AND SCALING INFORMATION

Symbol	Stands for	1 machine unit =
BR	Birth rate % of P per annum	10% per annum
C	Capital	3 units of NP
DR	Death rate	10 per annum
EP	Effective pollution	Same as POL
FC	Capital in food production	4 units of NP
FI	Investment in food production	Same as NP
FR	Food ratio	3000 kcal/person-day
GP	Gross product	Same as NP
GR	Growth rate	10% per annum
I	Investment	Same as NP
MSL	Material standard of living	2.5 times 1970 level
NC	Natural resources consumption	0.12 units of NR
NP	Net product	50 times 1970 level
NR	Natural resources	10/9 of 1970 level
P	Population	20 times 1970 level 5 volts = 72,000,000,000 people
PC	Capital in pollution control	Same as NP
PI	Investment in pollution control	Same as NP
POL	Pollution level	45.45 times 1970 level
PP	Pollution prevention	Same as POL
Q	Quality of life	2.5 times 1970 level

ASSUMPTIONS AND REALIZATION

Assumptions will be stated in the form of an analog circuit diagram, broken down into components or small blocks. These assumptions have been checked roughly against 1970 and 1900 data, where available, and examined for various times in the future for possible anomalies. They have been tailored somewhat to the capabilities of the analog machine.

Initial conditions are for 1970 = t_o. The time constant for all integrators is 1 second machine time, representing one year world time.

NATURAL RESOURCES LOOP

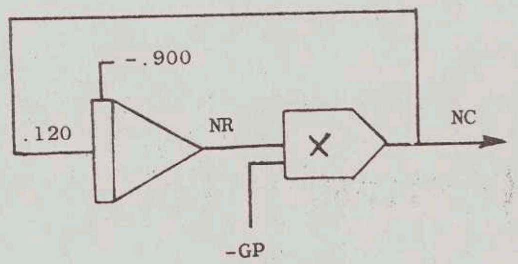


Figure 1. Natural Resources Loop

NR = .900 in 1970, corresponding to approximately 1.0 in the distant past. (Text follows equations in all cases, p. 6-18, 21,22.)

$$NR = 0.900 - \int_{t_0}^{t} (0.120*NC)dt$$

$$NC = NR*GP$$

CAPITAL GENERATION

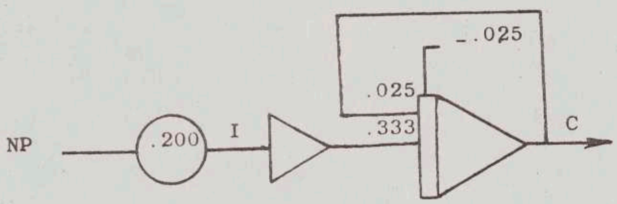


Figure 2. Capital Generation

$$I = 0.200*NP$$

$$C = 0.025 + \int_{t_0}^{t} (0.333*I - 0.025*C)dt$$

GROSS AND NET PRODUCT

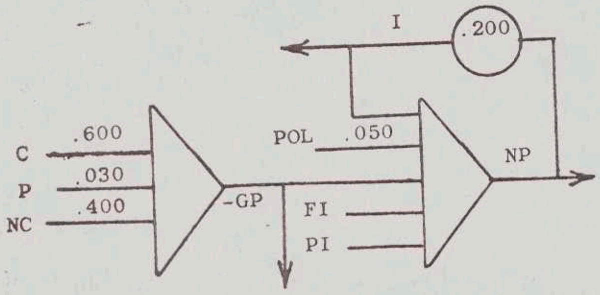


Figure 3. Gross and Net Product

The C input represents the productivity of capital and labor combined. The P input represents the residual labor product with zero capital, as in an undeveloped economy. The NC input completes a loop whose gain, 1/(1-0 .4NR) provides most of the stimulus for economic expansion as long as natural resources are plentiful. Subtracted from GP are all the investments, as well as a spoilage or wastage input associated with pollution, to yield net product NP.

$$GP = 0.600*C + 0.030*P + 0.400*NC$$

$$NP = GP - I - FI - PI - 0.050*POL$$

MATERIAL STANDARD OF LIVING

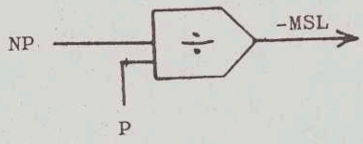


Figure 4. Material Standard of Living

$$MSL = NP/P$$

POLLUTION LOOP

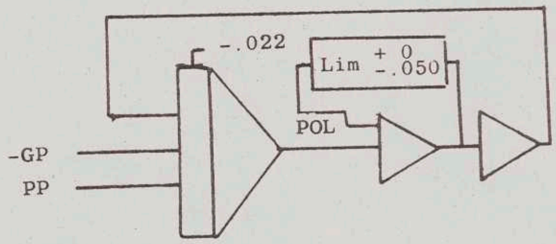


Figure 5. Pollution Loop

Pollution generation is assumed proportional to gross product; dissipation, which may take from a few hours to a few centuries depending on the pollution involved, is assumed to take one year on the average. A limit is placed on this dissipation, however, representing the maximum rate at which pollution products may be absorbed.

$$POL = 0.022 + \int_{t_0}^{t} (GP - PP - POL)dt \qquad POL \leqslant 0.050$$

$$= 0.022 + \int_{t_0}^{t} (GP - PP - 0.050)dt \qquad POL > 0.050$$

POLLUTION CONTROL EFFORT

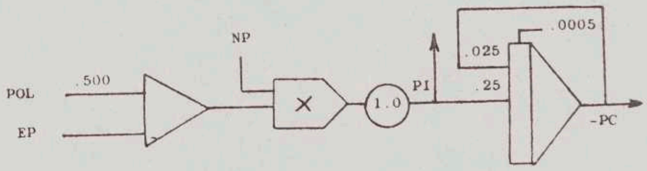


Figure 6. Pollution Control Effort

Pollution control effort is assumed to be in the nature of an investment rather than immediate action. This represents both actual investment in pollution control equipment and the inertia associated with any human endeavor.

$$PI = NP^* (0.500^*POL + EP)$$

$$PC = 0.0005 + \int_{t_0}^{t} (0.25^*PI - 0.025^*PC)dt$$

POLLUTION CONTROL EFFECTS

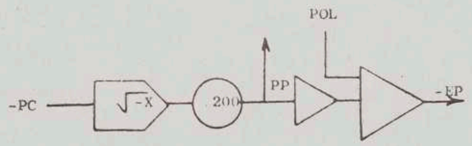


Figure 7. Pollution Control Effects

Pollution control is subject to diminishing returns. Some can be achieved cheaply and easily, but it gets harder both as the proportion removed increases, and as the gross product increases relative to fixed ultimate absorption facilities.

Note that the single term PP can represent both prevention and cleanup, thanks to the form of the assumptions. It can also be used to lessen the impact of pollution (artificial environments) on the individual, giving rise to a new variable EP.

$$PP = 0.200 \sqrt{PC}$$

$$EP = POL - PP$$

BASIC FOOD PRODUCTION

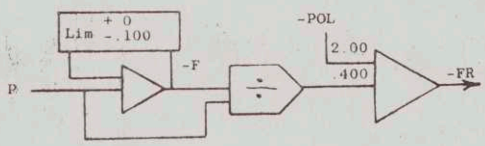


Figure 8. Basic Food Production

Basic food production is production by primitive methods, with labor and land inputs only. Neglecting pollution, this will provide only 1200 kcal per person-day, subject to a limit imposed by finite land area of feeding no more than twice the 1970 population at this level.

Pollution is assumed to reduce yield and/or food value by about 5% in 1970.

$$F = P \qquad p \leqslant 0.100$$

$$= 0.100 \qquad p > 0.100$$

$$FR = F/P - 2.00^*POL$$

INVESTMENT IN FOOD PRODUCTION

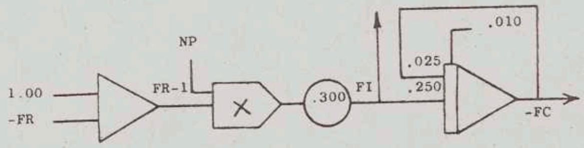


Figure 9. Investment in Food Production

Investment in food production (FI) is assumed proportional to food shortage (1 – FR). The accumulated capital is scaled above in such a way that FC will reach 1.000 when the whole world is producing its maximum possible output of conventional crops. The next stage, algae framing, which is even more capital-intensive, was not required in the range of possible futures examined.

$$FI = 0.300^*NP8(FR - 1)$$

$$FC = 0.010 + \int_{t_0}^{t}(0.250^*FI - 0.025^*FC)dt$$

AUGMENTED FOOD PRODUCTION

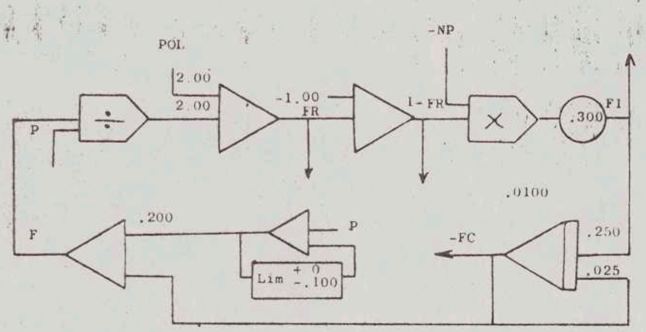


Figure 10. Augmented Food Production

The two preceding diagrams are here combined in fixed proportions. The 1970 parameters and initial conditions are such that basic food production is doubled by the addition of capital.

BIRTH RATE

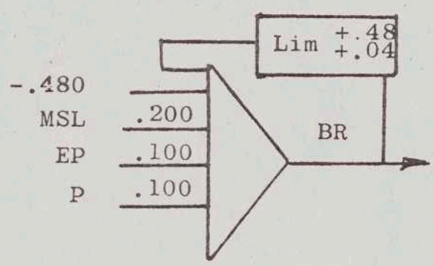


Figure 11. Birth Rate

BR = .480 (birth rate of 4.8% per annum) is the situation that obtains in undeveloped societies. It is reduced at present, principally by the standard-of-living effect, to about .400. Population and pollution effects, at present insignificant, represent government action to reduce fertility.

$BR = 0.48 - 0.200*MSL - 0.100*EP - 0.100*P$

$0.040 \leqslant BR \leqslant 0.48$

DEATH RATE

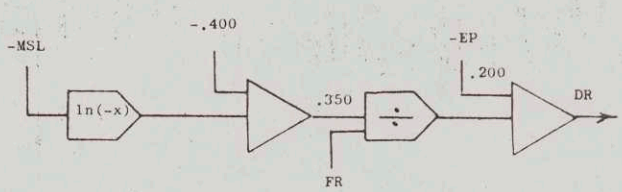
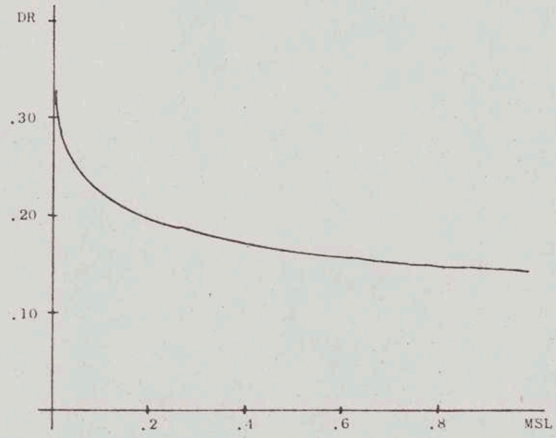


Figure 12. Death Rate

A basic death rate of 1.4% is assumed (DR = 0.14) which is increased if MSL or FR depart from one (in the negative direction). The MSL effect per diagram above is also displayed in the form of a graph below, for FR = 1. These relations fulfill the requirements for population growth 1900-1970, providing a current growth rate of 1.9% per annum.



$DR = (0.400 - \ln(MSL)) * 0.350/FR + 0.200*EP$

Figure 13. Dr vs. MSL Relationship

POPULATION LOOP

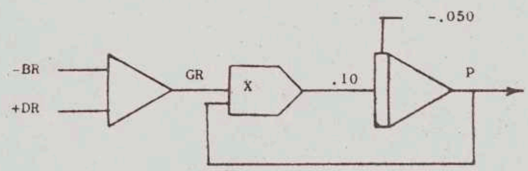


Figure 14. Population Loop

$$GR = BR - DR$$

$$P = 0.050 + \int_{t_0}^{t} (0.100*P*GR)dt$$

WORLD PERFORMANCE MEASUREMENT

A model can be used not only for predicting the probable future, but for evaluating changes that we may make in investment rates, fertility, etc. Evaluation requires a performance criterion so that we can decide whether or not the changes are worthwhile.

Selection of a performance criterion falls into two parts. First, selection of a measure of quality of life. This is surprisingly easy, as it is possible to come up with a fairly accurate consensus of what people want in the way of food, material standard of living, freedom from crowding and pollution, etc. Such an index is formulated in the section "Quality of Life."

The second part is determining how this index should be integrated.

If we consider the world from an Industrial Engineering point of view, the output of the "plant" is Q times P, quality times quantity, or population. In considering the future output of the plant, we would discount future years' "production" at an appropriate rate of interest.

In the case of real-world decision-makers in politics and industry this appropriate rate of interest can be very steep, of the order of 20% per annum. They are judged by their short-run performance and rarely look beyond the next election of the next promotion.

This performance index can thus be written:

$$\int_{t_0}^{\infty} QPe^{-.2(t-t_0)}\,dt$$

The above expression represents the most logical and reasonable form of performance index from the technical point of view, but it will not satisfy all political or religious viewpoints. It is, in fact, a mathematical expression of the dictum, "the greatest good for the greatest number," which appeals to humanitarian and socialist sentiments. It is satisfied by large P and small Q just as well as by small P and large Q. Most people would prefer to maximize Q, quality of life, and let population fall where it may. They would strike P out of the expression above:

$$\int_{t_0}^{\infty} Q\exp(-.02(t-t_0))dt$$

Most political decisions of the future are likely to favor this modified performance index.

A third view-point, corresponding to the official policy of the Catholic Church, holds that each individual sould has infinite worth, and any unnatural limitation of population is wrong. This would put Q equal to ∞ in the QP index. The question of whether P should now be maximized becomes moot, since ∞ multiplied by any positive integer is unchanged. No performance index can be specified for this viewpoint, but it is undeniable that it has a significant effect on fertility.

PERFORMANCE INDICES

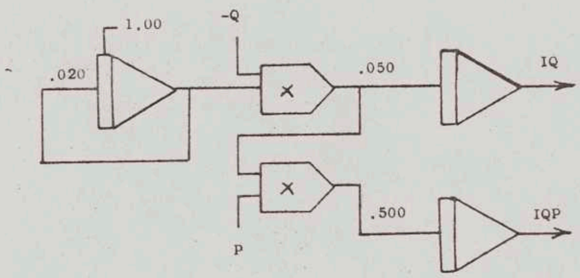


Figure 15. Performance Indices

The two principal performance indices discussed in the preceding section are generated as above. IQ is the integral of Q over time and IQP is the integral of QP overtime. The scale factors exist only to keep IQ and IQP below 1 mu.

$$IQ = \int_{t_0}^{t} (0.050*Q*(\exp(-.02(t-t_0)))dt$$

$$IQP = \int_{t_0}^{t} (0.500*Q*P*\exp(-.02(t-t_0)))dt$$

QUALITY OF LIFE

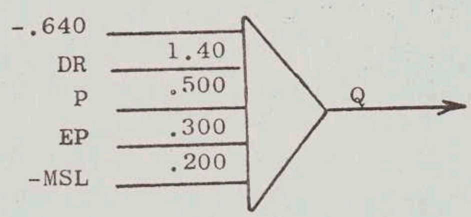


Figure 16. Quality of Life

Death rate is the principal determinant of quality of life, since if reflects lack of food and material goods such as housing and medical care. Additional inputs shown have a minor effect. Q is scaled to be approximately zero in undeveloped societies where BR and DR are at a maximum and equal to each other, and the other terms are near zero. It is also scaled, like MSL, to yield .400 in 1970.

Whereas the relative weight given to the inputs is a matter of personal preference, the effect on Q is minor, since the factors are closely inter-related. An improvement in one is generally associated with improvements in the others.

$$Q = 0.640 - 1.40*DR - 0.500*P - 0.300*EP + 0.200*MSL$$

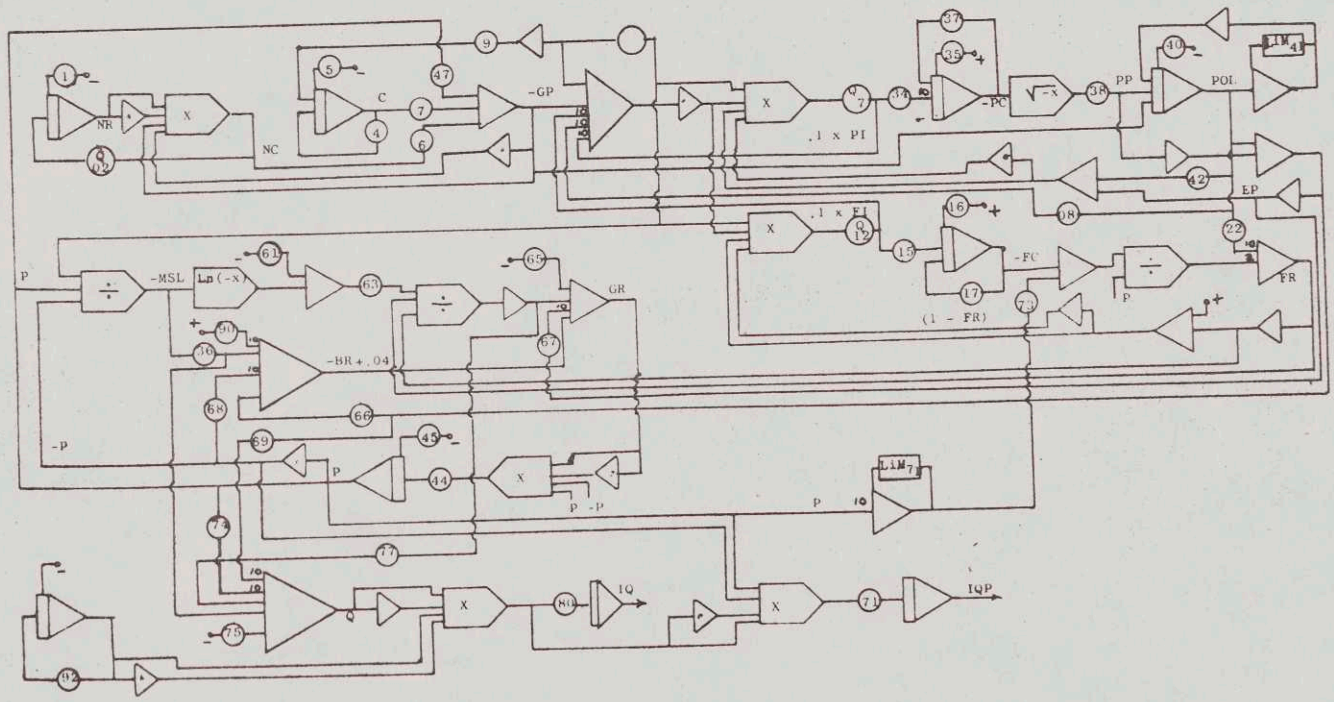


Figure 17. World Model Patching Diagram For the EAI 680 Analog Computer

Pots Integr. Summer Mult (incl. Invert.) Funct Mult Funct. Div. Funct. Gen. Limiter

Potentiometers were set per table below.

Tens \ Units	0	1	2	3	4	5	6	7	8	9
0		9000			0250	0250	4000	6600	0050	3333
1						0250	0100	0250		
2			2000							
3					0250	0005	2000	0250	2000	
4	0220		5000		1000	0500		0300		
5										
6		4000		3500	0100	0400	1000	0200	0100	5000
7		5000	0100	0200	0500	6400		1400		
8	0500									
9	0440		0200							

Q02: 1200; Q07: 1000; Q09 2000; Q12: 3000.

Limiters: L41: +0 - .05
L71: +0 - 1.00

THE NEXT THREE HUNDRED YEARS

Population (P), pollution (POL), material standard of living (MSL), natural resources (NR), food ratio (FR), and quality of life (Q) over the next three hundred years as displayed by the model are graphed below. Since the solution was stable, the steady state is also shown.

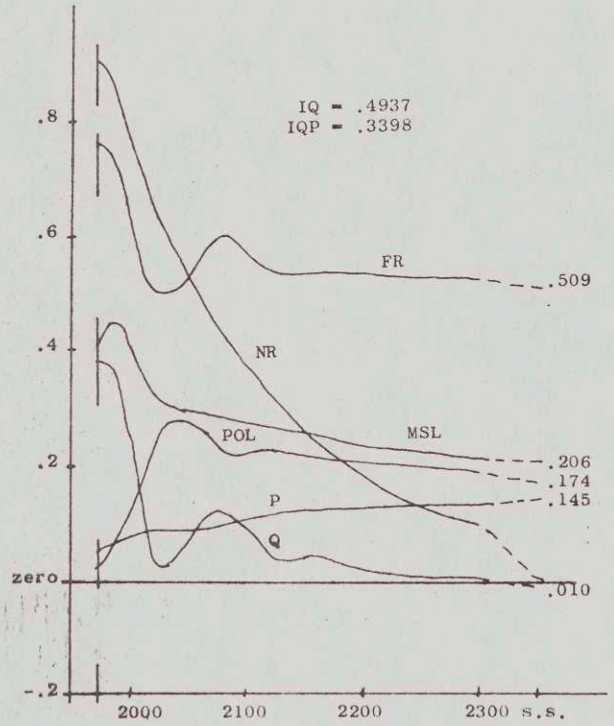


Figure 18. The Next Three Hundred Years

PARAMETER OPTIMIZATION

Some of the parameters of the world model come under our control, notably the amount of investment and its distribution between food, pollution control and material production.

The ratio I/NP was scanned and found to maximize both indices near the value .13. This solution is graphed below.

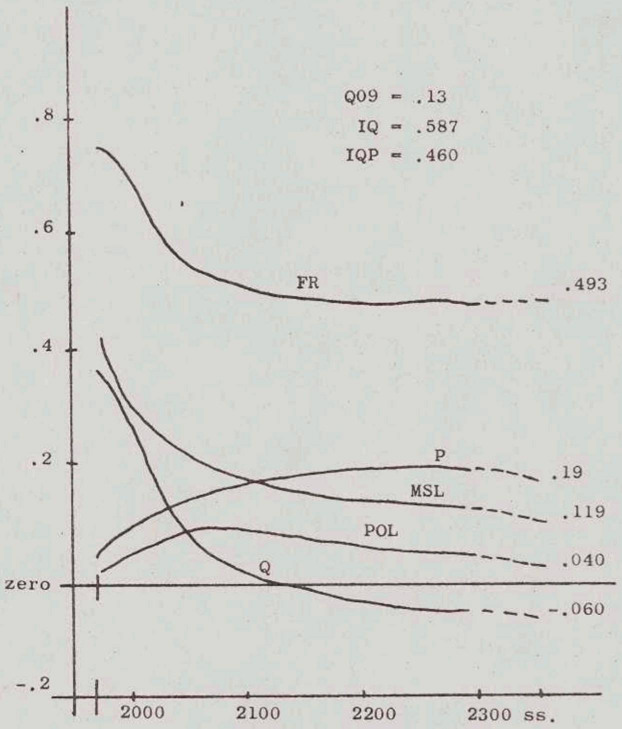


Figure 19. Parameter Optimization

The above solution is an improvement mainly because it removes the pollution crisis of 2040. The long-term situation is disimproved, however. This is an example of how even medium-term soulution can produce long-term ill effects.

It might be more accurate to say that parameter optimization involves finding a function rather than a new constant value. This is referred to in the section, "Areas for Further Work."

Within the scope of this brief approach to optimization, several other parameters were altered as follows:

Investment in pollution control (PI) and in food production (FI) were separately changed and found to have little effect on either performance index if increased. Decrease in either investment had a negative effect.

A 20% reduction in the initial value of C was found to have negligible effect on either index.

A shift of the same amount of capital from C to FC produced a 2% improvement in both indices.

A shift of the same amount of capital from C to PC produced a 5% improvement in both indices.

A 20% increase in the initial value of P changed IQ to .3954 and IQP to .3030. The purpose of this change was to evaluate the impact of each additional child born today. A rough dollar value can be put on this as follows. Estimate MSL at $400 per person per annum. The MSL effect on Q, or dQ/dMSL, is .2. Units of MSL are thus $1000 and of Q, $5000. IQ is scaled down by a factor of 20 from Q, therefore its units are $100,000. The change in IQ, –.0983, represents a decline of $9830 per person. Now multiply by P/ΔP to obtain the global impact of a single additional child as measured by the IQ criterion: $49,150! It might be a good idea to introduce this staggering figure into the present abortion controversy. This is what a birth costs, if not to us, then to our successors.

A very similar effect results from prolonging life, towards which efforts are continually being made. So far, even with perfect diet and medical care, the death rate has refused to budge below 1.4% (71.4 years life expectancy). But a break-through in the form of some treatment to retard aging could occur at any time.

An increase of maximum life expectancy to 91 years was programmed by changing P65 to .07. The effect on both indices was predictably negative. IQ became .4213 and IQP .2861. These effects are nevertheless small, since death rates will reach high levels in the future and few people will be able to take advantage of such treatment. Those who do will increase their personal IQ at the expense of their contemporaries and successors.

STABILITY

The basic world model as described above is stable with a steady state condition of high birth and death rate, low food ratio, high pollution level, low standard of living and three times as many people as at present.

Modifying investment parameters will adjust pollution and material standards up or down somewhat. The only other steady state condition of interest is the case where capital investment is allowed to decline until the world returns to a largely non-industrialized state, supporting a population about 50% larger than at present.

Stable states in this range all display miserable world performance, with Q index in the neighborhood of zero, or no better than in the distant past.

Another stable state, or range of states, characterized by high standard of living and low population, seems to be at least theoretically possible, even if it cannot be reached by modifying the parameters of the world model, given initial conditions as of now. In this stable state the MSL effect on fertility would hold births down to replacement level, with stability maintained by mild economic controls and incentives.

This state was observed when different initial conditions were programmed. (See "After an Atomic War")

AFTER AN ATOMIC WAR

The only means presently at hand for substantially altering mankind's future consist of nuclear weapons. These are in plentiful supply and come complete with fast delivery systems for dissemination throughout the globe. The probability of employment, whether accidentally or on purpose, has been estimated as high as 10% per annum. This is significant enough to warrant special programming and a graph to complement to standard solution presented in "The Next Three-hundred Years."

A fatality rate of 90% is assumed, and initial conditions are set up as listed below to represent the aftermath of the war, when death rate and pollution levels have returned within the range that can be handled by the model.

POST-WAR INITIAL CONDITIONS

Population P (P45)	.005
Pollution POL (P35)	.300
Capital C (P05)	.002
Food Capital FC (P16)	.001

Other conditions unchanged.

This small list of changes still leaves the initial time as 1970. The solution is graphed below.

NOTE

The POL input to NP had to be unpatched and some feedback had to be applied to the MPC function to obtain this solution

The postwar situation features rapid recovery (MSL and Q return to prewar levels in 10 years) followed by rapid growth. High pollution stops the growth, and a 600-year period of stability ensues, with high MSL, high pollution and population about at the 1950 level. No doubt this

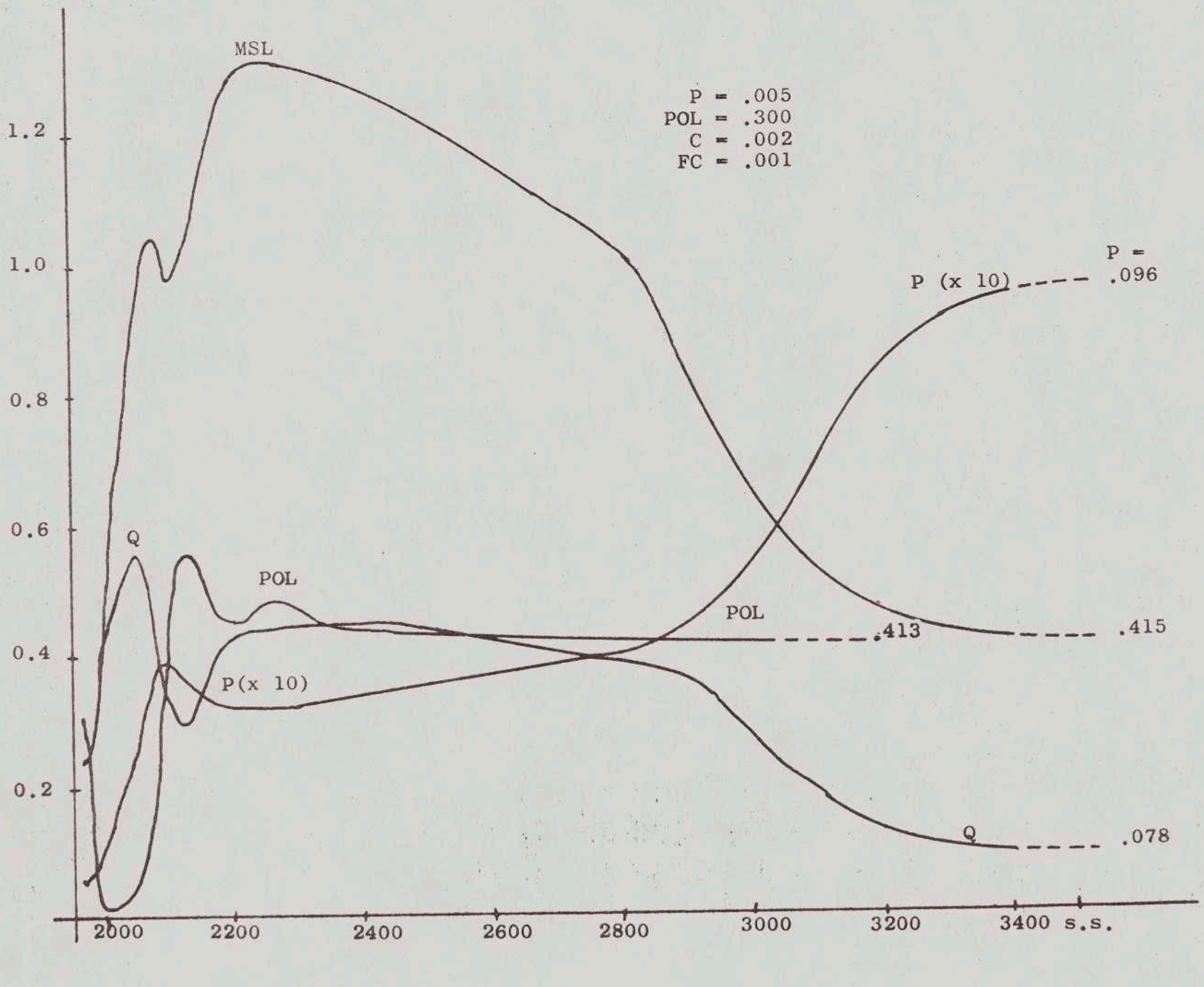


Figure 20. After an Atomic War

period could be used to establish a true stability through suitable economic controls, but falling MSL brought the model back to the lower stable state in the 3000's.

Thus the world model offers some support to the view, surprisingly common in this country, that an atomic war offers the only solution to our problems. The IQ index for the postwar period is certainly improved. But if the war years are also included IQ falls to .486, or about the same as without a war. And the IQ index is based on an altruistic view. If we regress to the personal or political viewpoint a 10% chance of surviving to see this alternative future does not have much to recomment it. However, the button-pushers in their deep shelters will be spared both the trauma and the death and may see things in terms of the post-war graph alone. 10,000 to

AREAS FOR FURTHER WORK

The one major goal that emerges from all world modeling attempts is the achievement of the alternative stable state without the trauma and uncertainties of going through an atomic war.

The key to this is a reduction of birth rate by half or more, to return to the 1950 population level, which was seen in the atomic war solution to be marginally unstable.

Since birth rate modification is so crucial, research into the effects and mechanisms of public policies in sterilization, contraception, and abortion must precede further optimization attempts. These mechanisms must be programmed into the model with parameters representing rates of expenditure, effort or commitment to birth control. If, at some feasible level of control, birth rate comes even close to the required value, then optimization can proceed. A strategy to maximize the IQ index with control effort costs factored in is called for.

Hybrid operation would be required for the optimization process, both to handle the more complex function that would replace the constant parameters and to scan the very large number of solutions necessary. Not only is an optimum strategy needed, but a continuum of suboptimal strategies to apply in the case of failure to implement the optimal strategy.

REFERENCE

1. J. W. Forrester, World Dynamics, Wright-Allen Press, Cambridge, Mass., 1969.

A FRESHMAN ENGINEERING MODULE USING THE LIMITS TO GROWTH AND THE WORLD3 COMPUTER MODEL

by

William G. Vogt, Marlin H. Mickle* and Hrair Aldermeshian

Department of Electrical Engineering
348 Benedum Engineering Hall
University of Pittsburgh
Pittsburgh, PA 15261

ABSTRACT

The Limits to Growth, by D. L. Meadows, et al, is a book which describes a possible future for the world and the people on it through a digital computer WORLD3 model. Using this book as a text and a University of Pittsburgh interactive version of the WORLD3 model, a 7 1/2 week course module was offered to second term freshman engineers who had a module in their first term on computer programming. The educational objectives of the module included the reinforcement and extension of knowledge of computer programming and the use of computers for modeling and simulating social as well as physical processes. Student evaluation at the end of the course indicated not only that these objectives were met, but that students became personally involved in the study.

+This paper was delivered during the CoED/ASEE Middle Atlantic Section Meeting at the University of Maryland, Baltimore, on May 4, 1974.

**Currently on leave of absence at the National Science Foundation, Washington, D.C.*

INTRODUCTION

The Freshman Engineering Program of the School of Engineering of the University of Pittsburgh has a group of 7 1/2 week courses called *Modules* some of which are required and some of which are elective. The required modules provide basic information and tools such as computer programming. The elective modules provide, among other things, breadth of knowledge of engineering areas and reinforcement of basic skills learned in the required modules and elsewhere.

Global Modeling was an elective module specifically prepared to introduce the students to the concepts of modeling and simulation with particular demonstrations being in the general area of socio-economic systems. The educational objectives of the module were:

1. to reinforce and extend knowledge of computer programming and utilization of the digital computer;
2. to reinforce and extend the communication skills involved in the presentation of graphical information;
3. to serve as an introduction to the modeling of complex systems;
4. to serve as an introduction to and utilization of the digital computer as a tool for modeling and simulating social as well as physical processes;
5. to introduce certain new concepts in interesting ways, including positive and negative feedback and the effects that these have on both physical and nonphysical systems;
6. to introduce the concept of the use of modeling and simulation as a tool to disclose alternative futures and to evaluate policies which lead to these alternative futures.

The format for the module was to be three one hour lectures per week with one three hour laboratory-recitation period. The remainder of this paper deals with the implementation and results of the course module, *Global Modeling*.

THE SUBJECT MATTER

One of the past difficulties encountered in teaching and reinforcing engineering skills and methodologies in the freshman year has been the lack of familiarity with any particular engineering discipline. Thus, many of the traditional vehicles of teaching were either oversimplified or else they required an inordinate amount of time for definition and introduction. The lack of experience and familiarity with the subject matter frequently resulted in little appreciation of the importance of, as well as the subtleties of, what was being presented.

The book, *The Limits to Growth,*(1) is a topical presentation of subject materials which are of concern to all people as well as being representative of an emerging area of applications frequently termed socio-economics, societal engineering, etc. The subjects of population, resources, capital, etc. are familiar at least in the conceptual sense and, in most cases, in a substantive sense to college freshman.

The WORLD3 Model provides a basis for national discussion of the complex interactions of a number of important variables of our world system. This position does not imply acceptance of any particular conclusions regarding the predicament of mankind or those drawn in the book. However, the model does provide an understandable and relatively easy to follow model which is at least plausible although it may not be entirely accurate.

On the basis of the model and the corresponding coverage, the book, *The Limits to Growth* was chosen as the text for the module.

The computer program, written in DYNAMO, which was the basis for the examples and the experiments of the Limits Book is to be included as a part of the final report under preparation for the Club of Rome.(3) A preliminary copy of the final technical report was obtained from Professor Meadows early in 1973. It was felt that the computer simulation program would provide the opportunity for students to vary constants, tables and initial conditions as well as to perform certain structural modifications. Because of the computer configuration and method of operation of the computing system at the University of Pittsburgh, it was decided that it would be expedient to have the

WORLD3 computer program converted to FORTRAN. The program was converted from DYNAMO to FORTRAN and made available in two modes – time sharing and batch.*

The resulting FORTRAN Program representing the PITT Interactive Version of the WORLD3 model is entitled LIMITS. The FORTRAN Program LIMITS requires 12 K or core as opposed to 48 K for the original DYNAMO version. The PITT Interactive WORLD3 Model can be accessed in both the time sharing and batch modes.

THE TIME SHARING MODE

The time sharing mode, conducted at a remote terminal, has interactive, operationally descriptive features printed at the terminal which allow complete familiarization with the details of data input, program execution, and, in addition, allows experimental determination of desired parameter values to take palce before extensive data is produced. When the user gains confidence in his ability to supply the proper data input required, it is possible to suppress the detailed explanations and examples given on the teletype by pressing an appropriate control key at the start of the explanatory paragraphs. The user then supplies the necessary input data in the required format.

THE BATCH MODE

Access in the batch mode is provided through a set of control cards. This access becomes especially convenient when full familiarization with the program has been obtained. Except for the interactive and descriptive features, and the availability of remote plotting, all program options can be specified in either mode.

OPTIONS

As an example of what can be specified by the user, the list of the eight basic options available to the user of the PITT Interactive WORLD3 Model is provided. The options are: 1) Change in built in data, 2) Output of initial conditions, 3) Output of final conditions, 4) Creation of a modified data file, 5) Creation of a data file at the end of a run, 6) Use of a data file previously created, 7) Plotting of simulation output, and 8) Printing of simulation output.

AN EXAMPLE

As an example of the interactive nature of the model and the options available, the following exerpt illustrates the changes possible for constants, initial conditions and certain parameters through the above Option No. 1.

Constants and initial conditions as well as certain other parameters can be changed by inputting this data through Option No. 1. The following material taken from the terminal input-output of the interactive mode, is self-explanatory. User inputs are underlined.

```
OPTION    (1)        CHANGE OF BUILT IN INITIAL CONDITIONS AND TABLES
          (A)        TO CHANGE INITIAL CONDITIONS AND CONSTANTS/
                     ENTER "$$INIT" FOLLOWED BY ANY CONSTANT, SEPARATED
                     BY COMMAS, END THE FINAL LINE BY "$"
          FOR EXAMPLE: $$INIT   IET = 3500
                                NRI = .5E12 $
          IF NO CHANGE IS DESIRED ENTER "$$INIT$"
          (B)        TO CHANGE TABLES/
                     ENTER "$$TABLE" FOLLOWED BY ANY TABLE VARIABLE "="
                     THE NEW VALUES DESIRED, SEPARATED BY COMMAS,
                     END THE FINAL LINE BY "$"
          FOR EXAMPLE: $$TABLE      M2T = .04, .06,
                                    LMFT = 0.1, 0.95 $
          IF NO CHANGE IS DESIRED ENTER "$$TABLE$"
$$INIT    ZPGT = 1975,
          IET = 1990,
          IOPCD = 350
          NRUF2 = .25,
          PPGF2 = .25,
          ALIC2 = 21,
          ALSC2 = 30   $

$$TABLE   ISPC2T = 60, 450, 960, 1500, 1830, 2175, 2475, 2700, 3000,

          IFPC2T = 345, 720, 1035, 1275, 1455. 1605, 1725, 1815, 1875  $
```

If no changes are made, the standard run is conducted.

THE METHOD OF APPROACH

The module is based on *The Limits to Growth* as a text used for the lecture and on the LIMITS Program (PITT Interactive WORLD3 Model) which was used to provide an experimental tool as a supplement to the lecture material and as an introduction to the more general topics of modeling, simulation, large scale systems and simulation languages. The built in plotting routines provided the students with graphical output while allowing them to select scales, variables to be plotted, length of simulation time, etc. Thus, the students could use the graphical output both for the technical aspects of experimentation, in data presentation, and also to substantiate any theories or conclusions regarding the WORLD3 Model.

**The FORTRAN Program of the WORLD3 Model may be purchased at cost from William G. Vogt, Electrical Engineering Department, 348 BEH, University of Pittsburgh, Pittsburgh, PA 15261*

The lecture followed the text providing an understanding of the components of the WORLD3 Model while at the same time putting into perspective the field of socio-economics as one field of application of engineering tools and methodologies. Visual aids were used to facilitate the presentation of the material in a sufficiently short amount of time to allow for experimentation, with the WORLD3 Model after all basic components had been covered in lecture within the overall 7 1/2 week time period.

The empahsis was to be on experimentation rather than theory, and as such, only one quiz was given while the students were given two projects and a series of homework problems in the laboratory session.

The lecture met three times a week. The following is a list of the topics covered with each topic representing roughly one lecture hour: Introduction; Levels, Rates, Auxiliary Variables, etc.; The Nature of Exponential Growth, World Population; World Economic Growth; The Limits to Exponential Growth, Food; Nonrenewable Resources; Pollution; Growth in the World System; The WORLD3 Model; The Usefulness of the World Model; The PITT Interactive WORLD3 Model; Technology and the LIMITS to Growth; Technology in the Real World; The State of Global Equilibrium, and The Equilibrium State. Finally, at the end of the course, rebuttal and additional references were included. Some of these are listed in the references.

The following paragraphs are exerpts from the first lecture.

". . . There are many possible forms which the definition of an engineer could take. One form would be the denotative or dictionary definition, i.e.,

> "1. A designer or constructor of engines. 2. *Mil Naval.* One of a corps of men who perform engineering work, as in building forts, bridges, etc. 3. One versed in, or who follows as a calling, any branch of engineering. 4. One who operates an engine. 5. *Colloq.* One who skillfully carries through some enterprise."*

In order to explain what an engineer does within the above definition, one possibility would be to list the job description for each type of engineer. Each person could then try to relate the information into some type of a mental picture or model of what an engineer does. Obviously, such a mental picture will vary from individual to individual based on personal experiences, values, motivation, etc.

Actually, the activities in which engineers engage are extremely broad in scope. Engineers have practical, professionally oriented backgrounds which allow them to interact with others and with institutions at any level commensurate with their individual abilities. Thus, we have engineers acting as salesmen, researchers, teachers, foremen, presidents of industrial concerns, leaders of consumer groups, politicians, consultants, civil servants, armed forces, etc. This, notwithstanding, there are certain traditional areas in which most engineers are active. For purposes of illustration, this could be graphically shown in Figure 1. Two groups of occupations are indicated in this simplistic figure. The first is normally termed the *technologies* and includes such occupations as mechanics, electricians, draftsmen, technicians, carpenters, bricklayers, etc. The second is the physical and life sciences including persons such as mathematicians, physicists, chemists, biochemists, biologists, etc.

Separating the two groups, the technologies and the physical sciences, is an area with two boundaries (which will be discussed later in more detail) which indicate the relationship of engineering to the technologies and the physical sciences as well as a nonexclusive spectrum of activities engineers are involved in.

It is important at this time to expand somewhat on the two related areas, the technologies and the physical sciences, in order to more lucidly define and illustrate engineering and the engineer. The physical scientist is normally concerned with the systemization of knowledge derived from study, observation, experimentation, etc. which, in their final forms, may or may not bear any resemblence to physical or social problems or concerns. This is not meant as a criticism of the physical sciences. This role is an absolute necessity to science and society.

**Webster's New Collegiate Dictionary*

Figure 1. Traditional View of Engineering

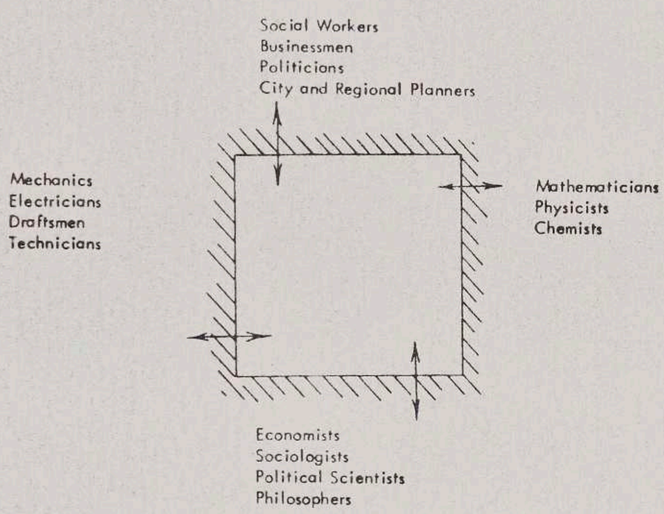


Figure 2. Current View of Engineering

The technologist is concerned with the everyday manufacture, operation and maintenance of the various tools, devices, etc. which are a part of industry, home, transportation, health, etc. The theoretical concerns must of necessity be secondary to the technologist and to the practical operational problems which are encountered in real-world situations. The language and mathematics of the technologies is, of necessity, normally neither abstract nor theoretical as might be found in the physical sciences, but rather definitive and practical in an everyday sense. For example, a metallurgist may be concerned with the molecular structure and electron arrangement of an alloy which could eventually be used to resist the high temperatures in an automotive muffler clamp while the technologist might be concerned with the setting up of a lathe to cut SAE or nonstandard threads on the bolt for the muffler clamp. . .

. . . The title of Figure 1 indicates a traditional view which has been taken of engineering. As with any other occupation, engineering is constantly undergoing change. Today a broadened concept, although it actually represents only a new problem set, has been applied to engineering. This broadened concept will now be discussed with reference to Figure 2.

In Figure 2, the broadened concept of engineering is described in relation to two new areas which have been added in the figure. The first is what might properly be termed the *social technologies* including social workers, businessmen, politicians, city and regional planners, etc. These are persons concerned with the practical and everyday working and implementing of political, social and ecomomic developments

The second area introduced is the traditional *social sciences.* The persons in this area are concerned with the more abstract and theoretical developments in economics, sociology, political science, etc.

The concern of the engineer is also one of bridging the two new boundaries which have been introduced in the model of Figure 2.

While at first this current model may appear to be a departure from traditional engineering, it is in fact only a broadening of the areas to which engineers direct their efforts. For many years, engineers have been concerned with the social impacts and economic factors of their work in bridging the physical sciences and technologies. The concern for the factors involving the social sciences and social technologies has now been expanded to include an active role in the bridging of the two indicated areas.

The discussion to this point has been descriptive and makes particular use of the models of Figures 1 and 2. Thus far we see the engineer as a builder who is able to *bridge* the theoretical-practical gap. . .

. . . Traditionally, the engineer has been able to take a theoretical development in the physical sciences and apply it to practical situations through engineering developments and technology. Now, engineering has come of age, and it is up to us to begin to engineer the social changes which must be accomplished if our society, national or international, is to be a viable one. We will begin by considering an international, in fact, a world problem regarding the "Predicament of Mankind."

THE LABORATORY – RECITATION

The Laboratory – Recitation sections met once a week for three hours. Thus, within the time period of the course, each section met seven times.

The first meeting was primarily an introduction with emphasis on the use of the computing facilities at the University of Pittsburgh. While the students had already taken a required module on computer programming and had some familiarity with using a computer, the present module required more use of computer peripherals and consequently, some additional introduction was required. FORTRAN Programming was reviewed as it relates to the PITT Interactive WORLD3 Model.

The second meeting was a follow-up of the initial introduction with the first assignment on a modeling and simulation problem involving bank account interest and dollar value depreciation. The program was written in FORTRAN showing some of the basics of simulation programming languages to provide the basis for a transition into the DYNAMO language.

The third meeting was an introduction to DYNAMO with particular applications to: Aspects of Population and Exponential Growth; Birth Rate, Death Rate; Simple Feedback Model of Population Growth; Similarity to the Homework of the Previous Session; and the Dependency of Birth Rate and Death Rate on both Exogenous and Endogenous Variables. A homework problem involving graphical data on birth rate and death rate with the goal of predicting future population was assigned. The students were required to write a simulation program both in FORTRAN and in DYNAMO to predict future population trends.

The fourth meeting was a follow-up on the use of DYNAMO and the introduction to the PITT Interactive WORLD3 Model. A homework problem on Modeling and Simulation of resources to be written in FORTRAN was assigned. The students were also assigned the task of exercising the PITT model so as to introduce them to the mechanics of how to run the program and to participate in the interactive mode.

The remaining three sessions were devoted to the use of the PITT model with homework assignments involving various scenarios in the WORLD3 Model.

STUDENT PERFORMANCE

As a whole the performance was as expected. The students enjoyed working with the computer and their interest was heightened considerably by the relevancy of the subject matter of the module. From a technical standpoint, the topic into which they probably gained the most insight was that of the appreciation of the operation of a complex or large scale system. A significant result was the student's understanding of the operation of a digital computer system and in particular the organization and use of computer peripherals such as the disk, printer, card reader, etc.

STUDENT REACTIONS

As is normally done with any new course, the student reaction is obtained from a number of different sources. In particular, two sources in the case of the module were the oral comments of the students and the responses to a questionnaire which was distributed. The questionnaire results will be discussed first.

A summary statement with reference to other modules the students had taken in the Freshman Engineering Program is that the Global Modeling Module was more difficult with more work and contributed more to their knowledge and was felt to be more important than the other modules the students had taken.

The question of including more theory or more computer programming resulted in somewhat mixed reactions with perhaps an inclination of the students toward suggesting more computer programming. Thus, it is felt that a relatively good balance had been achieved in the module development.

The students felt that DYNAMO was an easier language with which to write simulation programs and they felt they would be able to model small systems. The ability to use another computer language was felt to be one of the successful accomplishments of the module.

The students felt they had a fair understanding of the LIMITS Model. Questions regarding how they felt the model should be modified as a part of the course, i.e. constants and tables vs. structural modifications showed no clear response.

The general comments cited too much work required as the major fault of the module.

The oral comments were quite complimentry with the students indicating they felt they had learned a considerable amount of relevant material which would be useful in their careers.

STUDENT PROJECTS

As mentioned earlier, the students were assigned projects which allowed a considerable amount of flexibility. The term project was essentially to determine a set of variations of the WORLD3 Model which were of interest to the student and to exercise the model to determine how these variations affected the outcome and to write a detailed report. The quality of these reports were average to superior. Excerpts from one of the superior reports[31] is presented below.

In addition, the students decided they would like to exercise another model rather than have a final exam. Therefore, the Natural Resources Model by William Behrens III[2] was made available. The students exercised this Model for various natural resources with the result being that either, new major finds must be made which will delay depletion for only a relatively short time, rate of use must be decreased or, the most effective way was to drastically increase prices. This last showed up most often in an examination of oil resources, which was brought about by the recent crises.

The overall results of these projects were much better than we had expected. We were amazed on the one hand by some of the sophisticated thinking and experimenting which went into the reports and on occasion perplexed about obviously, wrong ideas which crept into some of the reports.

Excerpt from (31)

". . . Despite all the scientific, agricultural, industrial, and technological advances and improvements made in the most optimistic view of the future, none of the adjustments tend to stabilize the complex problem: particularly the ominous exponential growth and then collapse of population. How then should we approach the future? What is man's next move in this daring game of equilibrium where the stakes are no less than his life? Shall we introduce widespread sterilization to reduce the population by abrupt, drastic measures? In addition we could cut the reproductive lifetime – RLT – in half; replace RLT = 30 with RLT = 15. Set the population equilibrium time – PET – equal to 1990 instead of PET = 4000. These drastic measures in order to be effective must be immediately enforced. Cut the maximum total fertility normal in half; replace MTFN = 12, with MTFN = 6. If life expectancy increases then we must also reduce the fecundity multiplier – FM, in effect reversing the old table given: FMT = 0/ .2/ .4/ .6/ .8/ .9/1/1.05/1.1. Replace the old table given with FMT = 0/1.1/1.05/1/.9/.8/.6/.4/.2. Make ZPGT-(the time when the desired family size equals two children) equal to 1990 instead of it being as far off in the future as 4000. Family response to the social norm – FRSN, must approach 100% cooperation. Change FRSN = .82 to FRSN = .99 and FRSNT = .5/.6/.7/.85/1 to FRSNT = .89/.91/.95/.98. Social family size norm – SFSN, must be on the rapid decline. Therefore, change SFSNT = 1.25/1/.9/.8/.75 to SFSNT = 2/1.5/1/.5/0. All this must take place in a phenomenally short time so that SAD-social adjustment delay is cut from SAD = 20 to SAD = 10. People are coerced into accepting and adapting to such radical, bizarre, freedom robbing demands. If this rash program is adopted then the population will be leveled off after an inevitable rise. (Refer to Figure 13) Is this a price which we're all willing to pay for stable equilibrium? I claim adamantly NO! We must arrive at an equilibrium position without simultaneously stripping man of his fundamental humanistic privileges. I do not have the ultimate solution on hand; it is not one to be easily found. Possible some time in the near future, hopefully, man in his wisdom will come to grips with the intricate problem and save us all from the frightening "Future Shock" of destruction!"

CONCLUSIONS

The authors feel that the module was a success. The goals and educational objectives which were set were achieved. In fact, there were a number of additional benefits such as student appreciation of the workings of complex or large scale systems, and almost total involvement on the part of some students in the project. The student comments concerning what they felt was a considerable amount of work were to be expected in light of the expected benefits of the module.

The use of a socio-economic vehicle such as the WORLD3 Model is an excellent method to teach engineering tools and methodologies to freshman while providing additional benefits in relevant problems and current engineering applications, as well as assuring personal and emotional involvement in the course.

ACKNOWLEDGEMENTS

The University of Pittsburgh School of Engineering provided graduate student assistants to convert the DYNAMO WORLD3 Model to the FORTRAN LIMITS Model. The Melissa S. McKee Carnahan Trust of the Pittsburgh Foundation provided for the development, preparation and duplication of material for the Global Modeling Module. We are grateful for both sources of support.

REFERENCES

1. The Limits to Growth, Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, Universe Books, New York, 1972.
2. *Toward Global Equilibrium:* Collected Papers, edited by Dennis L Meadows, Wright-Allen Press, Inc., Cambridge, Mass., 1972.
3. *The Dynamics of Growth in a Finite World,* Edited by Dennis L Meadows, et al., Preliminary copy of the book to be published in 1974.
4. *World Dynamics,* Jay W. Forrester, Wright-Allen Press, Cambridge, Mass., 1971.
5. *Models of Doom, A Critique of the Limits to Growth,* Edited by H.S.D. Cole, Cristopher Freeman, Marie Jahoda and K.L.R. Pavitt, Universe Books, 1973.
6. *DYNAMO USERS MANUAL*, Fourth Edition, Alexander Pugh III, MIT Press, 1973.
7. "The Implications for Government Action of *The Limits to Growth,*" Walton J. Francis, HEW Office of Planning and Evaluation.
8. "Unlimited Growth: Growing, Growing, Gone?" F. H. Bormann, *Bioscience*, Vol. 22, No. 12, December, 1972.
9. "World Dynamics: A Note," Robert Boyd, *Science*, Vol. 177, August 11, 1972, pp. 516-519.
10. "Modeling the World", LETTERS regarding 9 above by Parl E. Damon, R. Joel Rahn, Robert Boyd, *Science,* Vol. 180 June 22, 1973, pp 1236-1239.
11. "Nuclear Energy," LETTERS by John T. Edsall and Alvin M Weinberg, *Science,* Vol. 178, December 1, 1972, pp. 933-934
12. "Nuclear Energy and Growth," LETTERS regarding 10. above by Dennis L. Meadows and Alvin M. Weinberg, *Science,* Vol. 179, March 2, 1973, pp. 855-856.
13. "Modeling on a Grand Scale," by Martin Shubik, BOOK REVIEW of *World Dynamics* by Jay W. Forrester, *Science,* Vol. 174, December 3.
14. "World Modeling," LETTERS regarding 13 above by Dennis Gabor, Harold H. Hemond, Richard H. Goodwin, William A Niering, Jay W. Forrester and Martin Shubik, *Science,* Vol 176, April 14, 1972, pp. 109-113.
15. "The Limits to Growth: Hard Sell for a Computer View of Doomsday," NEWS AND COMMENT by Robert Gillette, *Science,* Vol. 175, March 10, 1972, pp. 1088-1092.
16. "Limits to Growth," EDITORIAL by Philip H. Abelson, *Science,* Vol. 175, March 17, 1972, pp. 1197
17. "The Economics of Overexploitation," Colin W. Clark, *Science,* Vol 181, August 7, 1973, pp. 630-634.
18. "The Institute for Global Dynamics," LETTERS by Charles M. Cargille, et al., *Biosciences,* Vol. 22, No. 10, October, 1972, p. 569.
19. "Environmental Impact: Controlling the Overall Level," Walter E. Westman, Roger M. Gifford, *Science,* Vol. 181, August 31, 1973, pp. 819-825.

20. *Principles of Systems,* Jay W. Forrester, Wright-Allen Press, 1968.

21. "Parameters of Technological Growth," Chauncy Starr and Richard Rudman, *Science,* Vol. 182, October 26, 1973, pp. 358-364.

22. "To Grow or Not to Grow: That's Not the Relevant Question," Ronald G. Ridker, *Science,* Vol. 182, December 28, 1973, pp. 1315-1318.

23. "Sensitivity in the World Dynamics Model", Joseph Salemo, *Nature,* Vol. 244, August 24, 1973, pp. 488-492.

24. "Hope for the Technological Solution", Thomas J. Boyle, *Nature,* Vol. 245, September 21, 1973, pp. 127-128.

25. "Model of Destruction", J. H. Fremlin, (Correspondence), *Nature,* Vol. 245, September 28, 1973, p. 226.

26. "Problems of Predicting Future World Trends", Sir Alan Cottrell, *Nature,* Vol 245, October 12, 1973, pp. 280-281.

27. "Simulating the Obvious", (Book Review of No. 2 above), Eric Ashby, *Nature,* Vol. 245, October 26, 1973, p. 421.

28. "Predicting Technology", (Book Review of *Technological Planning and Social Futures* by Eric Jantsch), *Nature,* Vol. 246, November 2, 1973, p. 48.

29. "Typographical Errors and Technological Solutions", Donella H. Meadows and Dennis L. Meadows, (Response to 24 above), *Nature,* Vol. 247, January 11, 1974, pp. 97-98.

30. "Sussex Replies to Rome", (Book review of 5 above), J. W. Bray, *Nature,* Vol. 248, March 22, 1972, p. 291.

31. "WORLD3 Model: Limits to Growth," Carol Ann Parente, Project Report, School of Engineering, University of Pittsburgh, April 1974.

3/30/77

afcet

AUTOMATIQUE
INFORMATIQUE
MATHÉMATIQUES APPLIQUÉES
RECHERCHE OPÉRATIONNELLE

Paris, March 16, 1977

Ryan
Davidson
7RD
~~for your info~~
Return

JDL/hs/AT

Professor J. W. FORRESTER
Massachusetts Institute of Technology
CAMBRIDGE, Mass. 02139

U. S. A.

Dear Jay,

Mr. KARSKY who is my successor as leader of the working group on System Dynamics of A. F. C. E. T. (french correspondant of I. F. A. C.) and I wish to inform you of a two days seminar on System Dynamics.

That seminar will be held June 20 and 21 at the oil refinery of ELF in Solaize near Lyon in France. (People from Belgium, Italy and Spain are expected).

That seminar, like the one held in Grenoble last year, will be limited to participants actively engaged in System Dynamics. That is why we would welcome someone from your group. For him it would provide a first hand acquaintance with European workers in System Dynamics. However to fully participate he should understand french, although he might ask questions and/or deliver a presentation in english.

You will find hereto enclosed a list of the topics which we intend to cover .

Yours sincerely,

Karsky J. D. Lebel

M. Karsky Jean D. Lebel

Association Française pour la Cybernétique Économique et Technique. 156 boulevard Pereire, 75017 Paris - BP 571 - 75826 Paris Cedex 17 - Tél. 766.24.19. 766.24.23. 766.24.27
Télex 290163 code 235 - CCP Paris 25.281-75 - INSEE 94575117 0029 B - SIRET 784671380 00029 - Association déclarée conformément à la Loi du 1er Juillet 1901

afcet
AUTOMATIQUE
INFORMATIQUE
MATHÉMATIQUES APPLIQUÉES
RECHERCHE OPÉRATIONNELLE

Paris, le 24 Mars 1977

DYNAMIQUE DES SYSTEMES

Prochaine Réunion du Groupe

date: Vendredi 22 Avril 1977 à 14 heures

lieu : A. F. C. E. T. , 156 Bd. Péreire, 75017 Paris

1 - EXPOSE de Monsieur WILMES, Président de l' I A G, Université Catholique de Louvain:

Application de la Dynamique des Systèmes à l'étude des systèmes d'information.

2 - Préparation du séminaire de Solaize.

Rappelons que ce séminaire aura lieu au Centre de Recherche de ELF à Solaize (Banlieue de Lyon) les 20 et 21 Juin 1977.

La participation est gratuite, les déjeuners seront pris sur place (cantine) et coûteront environ 13 Fr. par repas.

Les thèmes retenus sont:

- Applications Industrielles

  Responsable : M. BOURGEOIS, 4 Rue Gilbert de Guingand,
  78000 Versailles - tél. 950 45 75

- Etudes Economiques et Socio-économiques

  Responsables: M. BRETON, U. E. R. MIAGE, Université de Rennes I
  35000 Rennes
  et M. KARSKY, ELF - ERAP, 4 Rue Léon Jost,
  75017 Paris - tél. 755 97 80 poste 121

- Méthodologie

  Responsable: M. ADAMO, Université Claude Bernard, MIAGE
  43, Bd. du 11 Novembre 1918, 69621 Villeurbanne
  tél. (78) - 52 07 04 - poste 3050

- Etudes Agro-Alimentaires

Responsable: M. KARSKY, ELF - ERAP

- Enseignement

Responsable: M. LEBEL, Haute Bruyère, 78690 Les Essarts
tél. 487 81 08 ou 878 93 50

De même qu'à Grenoble l'an passé, ce séminaire est destiné à permettre d'une part un échange d'idées (exposés succints suivis de questions, sans limite de temps), d'autre part de faire - ou refaire - connaissance entre personnes intéressées par la Dynamique des Systèmes.

D'ores et déjà, un certain nombre d'exposés sont prévus dans les domaines suivants:

- Gestion financière : M. BLASCO (Grenoble)
- Contrôle de Production : M. BOURGEOIS (Paris)
- Théorie de la firme (croissance) : M. DEBAR (Namur)
- Agro-Alimentaire :
  - Prix : M. GUILLON (Paris)
  - Production : M. KARSKY (Paris)
- Modèles d'Entreprise : M. WILMES (Louvain)
- Méthodologie : Dynamique des Systèmes et Ensembles Flous : une application
  - M. ADAMO (Lyon)
  - M. KARSKY (Paris)

  Ensembles Flous et analyse multicritère
  - M. ADAMO (Lyon)

  Dynamique des Systèmes et Econométrie :
  - (à confirmer) M. FASSINE (Frankfort)
- Enseignement : M. LEBEL et al

Nous espérons avoir d'autres propositions d'exposés, en particulier dans les domaines des Etudes Economiques, de la méthodologie et de l'enseignement, et venant de plusieurs pays (Allemagne, Belgique, Espagne, Italie).

Il n'y aura pas de possibilité de traduction simultanée, mais compte tenu de l'expérience des participants, les exposés pourront être faits en Français ou en Anglais.

Pour que nous puissions connaître assez tôt le nombre de participants au séminaire, il est demandé à chacun de faire parvenir dès que possible à

M. KARSKY , ELF
4, Rue Léon Jost
75017 PARIS

une déclaration d'intention de participation.

Les feuilles ci-jointes (lettre de H. Weinblatt et réponse de Forrester) sont tirées de la revue du M. I. T. : Technology Review (Juillet-Août 1976). Celle-ci étant assez peu connue, nous avons pensé que la réponse de Forrester intéresserait certains d'entre vous, en particulier les spécialistes de Dynamique Urbaine.

Klabbers
✓ SD Centers

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

February 18, 1976

Jay W. Forrester
Germeshausen Professor

Dr. Jan Klabbers
Social Systems Research Group
Psychologisch Laboratorium
der Katholieke Universiteit
Erasmuslaan 16
Nijmegen, THE NETHERLANDS

Dear Jan:

Thank you for your letter of February 29. Unfortunately, I have plans for this summer that will make it impossible to attend your summer course.

Regarding the matter of values, I tried to construct a model that reflects the decision-making processes and values represented by the persons, groups, or societies that are being modeled. In other words, the model should represent the policies that are governing the system under its actual operating circumstances. One can then use a model to examine alternative policies. Alternative policies imply alternative outcomes, and the choice of alternative futures does constitute a value judgment. However, such value judgment is probably best made explicit by showing the alternative computer runs in which a different policy must be adopted to lead to some different and desired future. Others are then brought into the discussion of whether or not the alternative policy can be implemented and whether or not the resulting direction of system change is desirable.

Sincerely yours,

JWF*eac

PSYCHOLOGISCH LABORATORIUM DER KATHOLIEKE UNIVERSITEIT

NIJMEGEN, February 9, 1976.
Erasmuslaan 16
Tel. ~~xxxxx~~ 80-512562
our ref.no. WSS.76.682.

Professor Jay W. Forrester
Alfred P. Sloan School of Management
50 Memorial Drive
CAMBRIDGE, Mass. 02139
U.S.A.

Dear Jay,

One of the many activities of the Netherlands Society For Systems Research is to organize a summer course each year.
Last years topic was "Simulation and Systems". This year we are planning to have a summer course focussing on future oriented research and modelbuilding.
As you are one of the pioneers in this field, I, with great pleasure, would like to invite you to give a lecture during the course, which will be held either from August 18 to 20, or from August 25 to 27.
Travelexpenses and costs of your stay in the Netherlands will be taken care of by the organizing committee.
If it is convenient to you, we prefer to have your lecture on friday morning August 20; will otherwise friday August 27 be convenient ?
We very mich look forward to discuss with you your current research and hopefully you are willing to make it the subject of your talk.
Hopefully your answer will be positive.

I also like to ask you a personal question. While teaching a course on principles of systems every year for graduate students in the social sciences and discussing your book "World dynamics", many times students ask me from what vision related to society and the individual in society you have developed your model, what values are concerned and in which direction you hope society and the individual human being has to or

-/-

will change. From reading your publications I am hoping to be able to make a fairly good interpretation but I lack an explicite and precise answer to this very difficult question.
Do you have any paper concerning this issue, which might be of help discussing the philosophy of systems dynamics from society point of view ?

Looking forward to hearing soon from you,

sincerely yours,

Dr. Jan Klabbers,
Social Systems Research Group.

Reprint Permissions
Spain
SD Centers

February 3, 1976

Professor Javier Aracil
Escuela Tecnica Superior de Ingenieros
Industriales de Sevilla
Avda. Reina Mercedes s/n
Sevilla, SPAIN

Dear Professor Aracil:

In reply to your letter of January 22, you have my agreement to publication of "Common Foundations Underlying Engineering and Management" and "System Analysis as a Tool for Urban Planning."

Sincerely yours,

JWF/ndb

1/27/76

AVDA. REINA MERCEDES, S/N.
TELS. 61 11 50 - 61 11 54 - 61 11 58

ESCUELA TECNICA SUPERIOR
DE
INGENIEROS INDUSTRIALES
DE SEVILLA

Profesores

Prof. J. Aracil
Esc.Téc.Sup.Ing.Industriales
Avda. Reina Mercedes, s/n
Sevilla - 12 (SPAIN)

SEVILLA, January 22, 1976

Destinatario:

Prof. Jay W. Forrester
M.I.T.
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Mass. 02139
U.S.A.

Dear Prof. Forrester,

The Instituto de Estudios de Planificación (Institute of Planification Studies) is a consultating organization for the realization of socioeconomic studies for the spanish Goverment. This Institute has a publications section which publishes books of methodological interest within its scope.

The Instituto de Estudios de Planificación is interested in the publication of a book which would include a series of papers on System Dynamics. This Institute has given me the work of editing such a book.

I am interested in the inclusion in the mentioned book of your papers, " COMMON FOUNDATIONS UNDERLYING ENGINEERING AND MANAGEMENT " which apeared in the review IEEE Spectrum, September 1964, and " SYSTEM ANALYSIS AS A TOOL FOR URBAN PLANNING", which apeared in the review IEEE Spectrum, January 1971.

In order to obtain the licence of publication, I wrote to the editors of the journal that agree in the inclusion in our book through they sugest, as a matter of courtesy, for me to contact you to confirm that permission.

Thanking you very much for all your help.

Yours sincerely,

J. Aracil

✓ Spain
✓ SD Centers

January 7, 1976

Professor Javier Aracil
Escuela Tecnica Superior de
Ingenieros Industriales de Sevilla
Avda. Reina Mercedes s/n
Sevilla, SPAIN

Dear Professor Aracil:

In response to your request of December 9, Professor Forrester has asked me to send you the papers you mentioned.

Sincerely,

(Miss) Emaline Cornett
Secretary to Professor Forrester

eac
Encls: (4)
"Confidence in Models of Social Behavior--with Emphasis on System Dynamics Models" by Jay W. Forrester (D-1967)
"The National Socio-Economic Model--An Overview of Structure" by Gilbert W. Low (D-2123)
"Issues Underlying the Representation of Social Variables in System Dynamics Models" by Dale Runge (D-2167)
"Testing Estimation Techniques for Social Models" by Peter M. Senge (D-2199-4)

12/17/75

ESCUELA TECNICA SUPERIOR
DE
INGENIEROS INDUSTRIALES
DE SEVILLA

AVDA. REINA MERCEDES, S/N.
TELS. 61 11 50 - 61 11 54 - 61 11 58

Profesores

Prof. J. Aracil
Esc.Téc.Sup.Ing.Industriales
Avda. Reina Mercedes, s/n
Sevilla - 12 (SPAIN)

SEVILLA, 9th December 1975

Destinatario:

Professor Jay W. FORRESTER
M.I.T.
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Mass. 02139

U.S.A.

all such people should go on the mail list ✓

Put him on S.S. mail list.

Dear Prof. Forrester,

Thank you very much for your letter dated on October 27th.

In the number of August of the Simulation review I have seen a short resume of a summer course on System Dynamics that was organized in June by your group. In this short paper a list of references that we think are of great interested apears, these are :

- Forrester J.W.
  "Confidence in Models of Social Behavior -with Emphasis on System Dynamics Models"

- Low, G.W.
  "The National Economics Model - an Overview of Structure"

- Runge, D.
  "Issues Underlying the Representation of Social Variables in System Dynamic Model" D-2167

- Senge, P.M.
  "An Experimental Evaluation of Generalized Least Squares Estimation" D-2199-

Send the one he wants used.

Send these by surface mail.

../..

I would be very gratefull if you could send us an example of each of the mentioned memoranda.

If it was possible to photocopy them could you please indi cate me where.

To get bibliografic material as the mentioned above is of great interested for isolated groups as ours.

Sincerely,

J. Aracil

System Dynamics Centers, Active 2 of 4

SLOAN SCHOOL OF MANAGEMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTER-OFFICE CORRESPONDENCE

SD Centers

TO Jay W. Forrester DATE 9/23/73

FROM Nathaniel J. Mass

SUBJECT Francois Rechenmann

FOLLOW-UP

FILE

I spoke last week for approximately one hour with Francois Rechenmann. He is part of a research group of seven individuals in Grenoble, interested in sytem dynamics modeling as well as in Mesarovic's work on hierarchical systems. The group is currently trying to define an appropriate research area but seems particularly interested in national economic modeling and in the application of the Urban Dynamics model to French cities. They are currently assembling a team of economists and computer scientists to begin construction of a national economic model of France. I expect that we will hear more from them in the near future.

SLOAN SCHOOL OF MANAGEMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTER-OFFICE CORRESPONDENCE

TO Jay W. Forrester DATE 9/23/73

FROM Nathaniel J. Mass

SUBJECT Francois Rechenmann

FOLLOW-UP
FILE

I spoke last week for approximately one hour with Francois Rechenmann. He is part of a research group of seven individuals in Grenoble, interested in sytem dynamics modeling as well as in Mesarovic's work on hierarchical systems. The group is currently trying to define an appropriate research area but seem particularly interested in national economic modeling and in the application of the Urban Dynamics model to French cities. They are currently assembling a team of economists and computer scientists to begin construction of a national economic model of France. I expect that we will hear more from them in the near future.

TO CORRESPONDENT WHO RETURNS THE ORIGINAL WITH COMMENT AND RETAINS THE PINK TRIPLICATE COPY.

9/12/73
France

institut national polytechnique de grenoble

école nationale supérieure
d'informatique et de mathématiques appliquées
domaine universitaire / cedex 53 / 38 grenoble-gare / tél. (76) 87.45.61-87.93.71

[illegible]

François RECHENMANN
Ingénieur de l'Ecole Nationale
Supérieure d'Informatique et de
Mathématiques Appliquées de Grenoble
Bureau C 206
Boîte Postale 53
38041 - GRENOBLE (FRANCE)

le 3 Septembre 1973

x 3-1493
Mary Smith
MIT Housing Office
120 Mass. Ave.
right

to Professor Jay W. FORRESTER
Room E52-454
Alfred P. Sloan School of Management
Cambridge, Massachusetts, 02139

Dear Sir,

Thank you very much for your rapid answer. I give you confirmation that I shall be in Boston on Monday, the seventeenth of September. I beleive I shall stay there still Wednesday, 26, because, according to the clauses of the scholarship I have, I must go to the University of Cleveland during my stay in the United States.

Sincerely yours,

F. Rechenmann

France
Visitors

EAC
FYI

August 13, 1973

Mr. Francois Rechenmann
Ingenieur de l'Ecole
Nationale Superieure d Informatique
et de Mathematiques Appliquees
de Grenoble
Bureau C 206
Boite Postale 53
38041 GRENOBLE, FRANCE

Dear Mr. Rechenmann:

Thank you for your letter of August 6 telling us of your plans to be in Boston September 15 through October 15 to work on economics. When you arrive, please telephone to Miss Cornett at 253-1571 or to Miss Evans at 253-2653. If Professor Forrester happens to be away on a trip, we will make arrangements for you to meet with a member of his System Dynamics Group.

Since you are going to Boston University to study, we believe you should write as soon as possible to your sponsor, or the Housing Office at Boston University, to let them know you will need lodging and board for thirty days.

We shall expect to hear from you after September 15.

Sincerely yours,

(Miss) Isabella S. Evans
Secretary to Professor Jay W. Forrester

/E

73

mathématiques appliquées - informatique
UNIVERSITÉ SCIENTIFIQUE et MÉDICALE de GRENOBLE
BOITE POSTALE 53 / 38041 GRENOBLE Cédex

TÉLÉPHONE (76) 87.45.61 / 87.93.71

RECHENMANN François
Ingénieur de l'Ecole
Nationale Supérieure
d'Informatique et de
Mathematiques Appliquées de
Grenoble
Bureau C 206

le 6 Aout 1973

to Professor Jay. W. FORRESTER

If he is going to Boston Uni, suggest that he then contact his sponsor there, or their housing office about where to live.

Sir,

Last Easter, you received Mademoiselle Parente, a member of our team at Grenoble, working on models and techniques of modelisation. We have worked on the studies achieved by your team and we have written a report.

As for me, I have received a grant to work on economics for one month in the United States.

This grant will enable me to get acquainted with the progress of research in social-economical models at the University of Boston and Cleveland.

I shall stay from September 15 th. till October 15 th. I beg to ask you when it is most convenient for me to get in contact with you and your ~~t~~ time. I shall then ask you where I can find board and lodging.

Inclosed a letter of introduction from the Recteur de l'Université de Grenoble.

Faithfully yours.

F. Rechner.

15

LETTRE DE RECOMMANDATION

UNIVERSITE DE GRENOBLE

BOURSE DE MISSIONS ECONOMIQUES

Monsieur . . François RECHENMANN . . . .

Né le . . 29 mai 1951 . . . . . . à . . METZ (Moselle) . . . .

Etudiant à . . l'Ecole Nationale Supérieure d'Informatique . . et de Mathématiques Appliquées de Grenoble (3e Année) . . a obtenu une bourse de Missions Ecomomiques "Université-Industrie" de Grenoble.

L'objet de cette bourse est de permettre à cet étudiant, qui a fait la preuve qu'il possédait les connaissances économiqu et les qualités humaines nécessaires, de contribuer à l'intensification des échanges entre les peuples, afin de créer ou de développer entre eux une bonne compréhension et des relations confiantes.

La présente lettre lui est délivrée pour servir d'introducti et de recommandation.

Le Recteur de l'Académie de Grenobl

Fait à Grenoble, le 8 avril 1973

1/11

Spain
SD Centers

January 7, 1976

Professor Javier Aracil
Escuela Tecnica Superior de
Ingenieros Industriales de Sevilla
Avda. Reina Mercedes s/n
Sevilla, SPAIN

Dear Professor Aracil:

In response to your request of December 9, Professor Forrester has asked me to send you the papers you mentioned.

Sincerely,

(Miss) Emaline Cornett
Secretary to Professor Forrester

eac
Encls: (4)
"Confidence in Models of Social Behavior--with Emphasis on System Dynamics Models" by Jay W. Forrester (D-1967)
"The National Socio-Economic Model--An Overview of Structure" by Gilbert W. Low (D-2123)
"Issues Underlying the Representation of Social Variables in System Dynamics Models" by Dale Runge (D-2167)
"Testing Estimation Techniques for Social Models" by Peter M. Senge (D-2199-4)

12/17/75

ESCUELA TECNICA SUPERIOR
DE
INGENIEROS INDUSTRIALES
DE SEVILLA

AVDA. REINA MERCEDES, S/N.
TELS. 61 11 50 - 61 11 54 - 61 11 58

Profesores

Prof. J. Aracil
Esc.Téc.Sup.Ing.Industriales
Avda. Reina Mercedes, s/n
Sevilla - 12 (SPAIN)

SEVILLA, 9th December 1975

Destinatario:

Professor Jay W. FORRESTER
M.I.T.
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Mass. 02139

U.S.A.

all such people should go on the mail list ✓

Put him on S.S. mail list.

Dear Prof. Forrester,

Thank you very much for your letter dated on October 27th.

In the number of August of the Simulation review I have seen a short resume of a summer course on System Dynamics that was organized in June by your group. In this short paper a list of references that we think are of great interested apears, these are :

- Forrester J.W.
  "Confidence in Models of Social Behavior -with Emphasis on System Dynamics Models"

- Low, G.W.
  "The National Economics Model - an Overview of Structure"

- Runge, D.
  "Issues Underlying the Representation of Social Variables in System Dynamic Model" D-2167

- Senge, P.M.
  "An Experimental Evaluation of Generalized Least Squares Estimation" D-2199-4

Send the one he wants used.

Send these by surface mail.

..//..

I would be very gratefull if you could send us an example of each of the mentioned memoranda.

If it was possible to photocopy them could you please indi- cate me where.

To get bibliografic material as the mentioned above is of great interested for isolated groups as ours.

Sincerely,

J. Aracil

MODELLING THE DEMOGRAPHIC IMPACT OF A NEW FACTORY

by

Javier ARACIL and José Mª BUENO

Dept. of Automatic Control
Esc.Téc.Sup.Ing.Industriales
University of Sevilla
Sevilla (Spain)

The paper developes a Dynamic Model of the Demographic evolution of a non industrialized area where a big and important factory - is built to industrialize the zone. The time horizon is the year 2000. The dynamic model has sixty four variables wich represents a very desagregated model of its kind. The model studies different classes of population (ages, sex, jobs,...) and projects them, and their interelations, for the period. The modelling methodollogy used has been the Forrester systems dynamics. The model has been actualy applied to forecast the demographic evolution os a small town in the Spanish mediterranean coast where a big siderurgy is now going to be built.

Submitted to the " Third International Congress of Cybernetics and Systems " . - Bucharest (Romania), August 1975

1. INTRODUCTION

This paper is intended to present a dynamic model which will enable us to simulate the impact produced by the setting up of a new factory on the demography of a certain area. The work is motivated by the need of availing ourselves of a device that will permit us to foretell the demographic evolution of a certain area when it undergoes an important change as a result of the establishment of a new factory which will sensibly alter the work positions in that area. This will determine, for example, a strong inmigration for which a suitable social infrastructure (schools, housings, services, etc.) is to be scheduled. The model presented here intends to carry out a projection of this nature.

The methodology used in the development of the model is Forrester' s System Dynamics [1,2,3,4], as it is believed that this methodology is specially suitable for a job of this nature. One of the reasons for having selected this methodology has been its suitability for the integration of opinions from experts of varied training. Along the same lines we can point out the accessbility of the model to manager (decision making) and planners who have used it as an aid to their decision-taking duties.

The work has been arranged in a progressive manner from the first working hypothesis and first causal diagram to the strongly disaggregated final model, which comprises 64 levels. The work will be accomplished in four steps, by establishing four models of increasing complexity designated as S 1, S 2, S 3 and S4.

2. BASIC HYPOTHESIS.

In the demographic area there are three fundamental variables : births, deaths and migration. Regarding migration it is assumed that the establisment of the new factory will give rise to the - creation of a great number of work positions that will require - outside labor migrating from other areas to settle in the area - involved. It is estimated that there is a nation-wide migrating potential towards the area involved and that, therefore, a de - mand for jobs (work positions) exceeding the supply (active popu lation) will always be satisfied.

Regarding the employment area in the initial models industrial - jobs have been separated from jobs involved in serving the popu- lation. The more elaborate models define a third area which is that of employment in construction, especially housing, due to - the relative importance of this area.

As stated above, four models have been worked out that can be con sidered to differ from each other even though each comprises the previous one and develops greater accuracy in dealing with cer - tain areas. The first three models deal with an aggregate form - whilst the last one deals with a disaggregate form.

2.1. Two-level model S 1

The object aimed at in setting up this elementary model is - the establishment of a first model that will define the beha vior of the system with a view to preparing the later phases of the study. Thus, the causal diagram shown in figure 1 wass obtained and is self-explanatory.

Of the variables appearing on this diagram only the population and employment are cumulative and, in consequence, are shown - as levels. The variables births, deaths and emigration, which act on the population level, are flows. Likewise, the net - annual growth of work positions will also be a flow. The re - mainder of variables are shown as auxiliary variables. On the basis of these considerations we obtain the applicable DYNAMO diagram shown in figure 2.

Model S 1 represents the system, although in an excessively sim plified manner. One of the first insufficiencies that was noti ced in connection with model S 1 was the treatment of the em - ployment strain when the labor force (supply of employment) was greater than the demand for employment. In accordance with the model, emigration would take place in an automatic manner. It is believed, on the contrary, that the worker is reluctant to go away even when he is out of a job and at any rate a certain pe- riod of time. elapses between the moment he becomes unemployed and the moment he emigrates to other areas. Thus, it becomes - necessary for the causal diagram to include a new loop which - will act when the employment is negative, i.e. when the labor - force is greater than the employment. Figure 3 shows the new causal diagram resulting from this modification. It includes a new exogenous variable wich is the rate of absorption of unem - ployment and therefore represents the maximum percentage of - unemployed that the system is capable of absorbing. Figure 4 shows the DYNAMO diagram corresponding to this modification.

Two conclusions are drawn from an analysis of this first model. On the one side, in view of the high increase of the system during the first years it becomes necessary to specifically deal with the employment in the construction of housing, which was not dealt with under model S 1, as temporary employment was considered to be implied in industrial construction only. On the other hand, there arises the problem of accurately defining the absorption rate of unemployment in an exogenous manner. It is considered more necessary to define this variable in an endogenous manner, precisely as a function of a new area : the infrastructure area.

Model S 2, with five levels, was developed having regard of these remarks.

2.2. Five-level model S 2

In accordance with the consideration stated above, we are faced with the need of dealing with the infrastructure area.

It is of primary importance within this area to consider the need for the construction of housing. The construction of services (hospitals, cinemas, markets, schools, etc.) was disregarded at first but the demand for them was included in further elaborations.

The consideration of the infrastructure level permits us to elaborate a function defining the rate of absorption of unemployment in an endogenous manner. It can be estimated that the motivation for leaving the municipality due to shortage of of work is checked by the existence of a suitable infrastructure therein. A table (figure 5) is defined which gives the rate of absorption of unemployment in accordance with the new variable measuring the degree of utilization of the existing infrastructure.

In accordance with these consideration and starting from model S 1 we obtain model S 2 whose causal and DYNAMO diagrams are shown in figures 6 and 7 respectively.

A close relation between positive and negative loops is still observed in the causal diagram. With this, the type of growth of the system will continue to be essentially alike even though it differs punctually on the basis of the new considerations made in connection with this model. This is demonstrated in the various simulations to which the model was subjected.

2.3. Eight-level model S 3

Two consideration led to the need for elaborating a model more sophisticated than model S 2. First, the need for dealing separately with housing and services in order that the final level of housing built included housing only and precluded the introduction of errors in the employment absorption table. Secondly, there becomes evident the existence of two different types of employment, permanent and temporary, which involve different sociological characteristics. It is necessary to deal separately with these two different types of employment.

These considerations modify model S 2 and thus we obtain model S 3 whose causal and DYNAMO diagrams are shown in figures 8, 9.1 and 9.2 respectively.

2.4. Disaggregated model S 4

Model S 3 is considered satisfactory enough as far as its level is aggregation is concerned. However, applications expected from this model lead to the need of availing ourselves of a disaggregated form of same which ill permit us to study, for example, the structure of the age of the population with a - view to defining in a more precise manner the needs that will arise at the various levels. It can be readily seen, for example, that initially the system has a pyramidal structure whilst emigration tends to strengthen the intermediate age groups. - Thus, the resulting system will have a lower death-rate and - perhaps a higher birth-rate. On the other hand, the active population area will increase. These considerations give rise - to the requirement for separating the population in groups of different ages so that all rate applicable to each class can - be defined in this way and that the adjustment can continue to be acceptable. This differentiation in categories of age affects both types of population, permanent and temporary.

On the other hand, although in principle differentiation by sexes seems unnecessary within each category, this differentiation - does become necessary due to considerations similar to - those stated above. It is relevant to know the potential acti vity of females and especially the way in which the employment saturation effects will be produced and the different manner in which they will act on males and females. In principle, if a woman becomes unemployed she will not tend to emigrate, althought a man will. In addition, the man will carry his family with him in either direction of emigration. Therefore, each of the age groups defined above is divided into two parts, males and females, and the parameters refer to each of these categories.

In order to evaluate the employment strains in both channels, masculine and feminine, the demand for employment is separated into two levels, one regarding the demand for male employment (for men only) and one relating to indistinct employment (for men or women), according to the situation of the labor - market at the time.

In accordance with the above considerations, model S 3 was disaggregated and model S 4 was thus obtained. For disaggregating the population levels use was made of the diagram shown in figure 10. The age groups established are included in - table I .. Thus, model S 4 was obtained and includes 64 levels .

Acknowledgment

Discussions with Mr. Eugenio Galdon, Mr. Juan R. de la Rua and Miss Carmela Martin of PREYSER, are gratefully acknowledged.

R E F E R E N C E S

1.- J.W. Forrester

Industrial Dynamics , M.I.T. Press (1961)

2.- J.W. Forrester

Principles of Systems , Wright-Allen Press (1968)

3.- H.R. Hamilton et alters.

Systems Simulation for Regional Analysis: An application to River - Planning. , M.I.T. Press (1969).

4.- J.J. Hellman

Migration in a Developing Contry : a Systems Study : The Stimulation and retention of agricultural migrants.

Ph D. Thesis, M.I.T. (1972)

APPENDIX A : TWO-LEVEL MODEL. S.1 - VARIABLE DEFINITION

NAME	T	DEFINITION
AEEN	A	AUXILIARY ECUATION FOR EFECTIVE NEED (PERSONS/YEAR)
E	L	EMPLOYMENT (PERSONS)
EI	C	EMPLOYMENT INITIAL (PERSONS)
ENFB	A	EMPLOYMENT IN THE NEW FACTORY BUILDING (PERSON/ YEAR)
ENFBT	T	EMPLOYMENT IN THE NEW FACTORY BUILDING TABLE (PERSON/ YEAR)
ENLF	A	EFECTIVE NEED FOR LABOR FORCE (PERSONS / YEAR)
EPS	A	EMPLOYMENT IN POPULATION SERVICES (PERSONS / YEAR)
ESRN	N	EMPLOYMENT IN SERVICES RATE NORMAL (PERSONS/PERSONS-YEAR)
FMD	N	FAMILLY DIMENSION PER MIGRANT (DIMENSIONLESS)
FENF	A	FIXED EMPLOYMENT IN THE NEW FACTORY (PERSONS / YEAR)
FENFT	T	FIXED EMPLOYMENT IN THE NEW FACTORY TABLE (PERS / YEAR)
IPLY	A	INCREASING POPULATION FROM LAST YEAR (PERSONS)
LF	A	LABOR FORCE (PERSONS)
LFPF	N	LABOR FORCE PARTICIPATION FRACTION (DIMENSIONLESS)
LYP	A	LAST YEAR POPULATION (PERSONS)
NBR	N	NET BIRTH RATE (BIRTHS / PERSONS - YEAR)
NBY	R	NET BIRTHS PER YEAR (PERSONS / YEAR)
NDR	N	NET DEATH RATE (DEATHS/PERSON-YEAR)
NDY	R	NET DEATHS PER YEAR (PERSON / YEAR)
NEY	R	NET EMPLOYMENTS PER YEAR (PERSONS/ YEAR)
NLF	A	NEED FOR LABOR FORCE (PERSONS / YEAR)
NMY	R	NET MIGRANTS PER YEAR (PERSONS / YEAR)
P	L	POPULATION (PERSONS)
TAPD	N	TIME AVERAGE POPULATION DELAY (YEARS)
ULF	A	UNEMPLOYED LABOR FORCE (PERSONS / YEAR)
UPR	N	UNEMPLOYED POPULATION RATE (DIMENSIONLESS)

APPENDIX B : FIVE - LEVEL MODEL S.2 - VARIABLE DEFINITION

NAME	T	DEFINITION
AEEN	A	AUXILIARY ECUACION FOR EFECTIVE NEED (PERSONS/YEARS)
E	L	EMPLOYMENT (PERSONS)
EI	C	EMPLOYMENT INITIAL (PERSONS)
ENFB	A	EMPLOYMENT IN THE NEW FACTORY BUILDING (PERSONS/YEAR)
ENFBT	T	EMPLOYMENT IN THE NEW FACTORY BUILDING TABLE (PER/YEAR)
ENLF	A	EFECTIVE NEED FOR LABOR FORCE (PERSONS/YEAR)
EPS	A	EMPLOYMENT IN POPULATION SERVICES (PERSONS/YEAR)
ESRN	N	EMPLOYMENT IN SERVICES RATE NORMAL (PERSONS/PERSONS-YEAR)
FDM	N	FAMILY DIMENSION PER MIGRANT (DIMENSIONLESS)
FENF	A	FIXED EMPLOYMENT IN THE NEW FACTORY (PERSONS/YEAR)
FENFT	T	FIXED EMPLOYMENT IN THE NEW FACTORY TABLE (PERS./YEARS)
H	L	HOUSEHOLDS (HOUSEHOLDS)
HUC	L	HOUSEHOLDS UNDER CONSTRUCTION (HOUSEHOLDS)
IHCLY	A	INCREASING FOR HOUSEHOLDS UNDER CONSTRUCTION FROM LAST YEAR(HOUSEHOL
IPLY	A	INCREASING POPULATION FROM LAST YEAR (PERSONS)
LF	A	LABOR FORCE (PERSONS)
LFPF	A	LABOR FORCE PARTICIPATION FRACTION (DIMENSIONLESS)
LTH	C	LIFE TIME FOR HOUSEHOLDS (YEARS)
LYHUC	A	LAST YEAR HOUSEHOLDS UNDER CONSTRUCTION (HOUSEHOLDS)
LYP	A	LAST YEAR POPULATION (PERSONS)
NBEY	R	NET BUILDING EMPLOYMENT PER YEAR (PERSONS/YEAR)
NBER	N	NET BUILDING EMPLOYMENT RATE (PERSONS/HOUSEHOLDS-YEAR)
NBR	N	NET BIRTH RATE (BIRTHS/PERSONS-YEAR)
NBY	R	NET BIRTHS PER YEAR (PERSONS/YEAR)
NC	L	NEED FOR CONSTRUCTION (HOUSEHOLDS)
NCY	R	NEED FOR CONSTRUCTION PER YEAR (HOUSEHOLDS/YEAR)
NDR	N	NET DEATH RATE (DEATHS/PERSONS-YEAR)
NDY	R	NET DEATHS PER YEAR (PERSONS/YEAR)

NAME	T	DEFINITION
NEY	R	NET EMPLOYMENTS PER YEAR (PERSONS/YEAR)
NHCR	N	NEED FOR HOUSEHOLD CONSTRUCTION RATE (HOUSEHOLD/PERSONS YEAR)
NHPY	R	NET HOUSEHOLDS PER YEAR (HOUSEHOLDS/YEAR)
NHRR	N	NEED FOR HOUSEHOLD RENOVATION RATE (HOUSEHOLD/PERSONS-YEAR)
NLF	A	NEED FOR LABOR FORCE (PERSONS/YEAR)
NMY	R	NET MIGRANTS PER YEAR (PERSONS/YEAR)
NPHR	N	NORMAL PERSONS PER HOUSEHOLD RATE (PERSONS/HOUSEHOLD)
NRY	R	NEED FOR RENOVATION PER YEAR (HOUSEHOLDS/YEAR)
P	L	POPULATION (PERSONS)
TACD	N	TIME AVERAGE FOR CONSTRUCTION DELAY (YEARS)
TALYC	N	TIME AVERAGE FOR LAST YEAR CONSTRUCTION (YEARS)
TAPD	N	TIME AVERAGE POPULATION DELAY (YEARS)
TC	N	TIME UNDER CONSTRUCTION
UHHY	R	UN-HABITABLE HOUSEHOLDS PER YEAR (HOUSEHOLDS/YEAR)
ULF	A	UNEMPLOYED LABOR FORCE (PERSONS/YEAR)
UPR	N	UNEMPLOYED POPULATION RATE (DIMENSIONLESS)

APPENDIX C : EIGHT - LEVEL MODEL S.3 - VARIABLE DEFINITION

BER	N	BUILDING EMPLOYMENT RATE (PERSONS/HOUSEHOLD-YEAR)
BEY	R	BUILDING EMPLOYMENT PER YEAR (PERSONS/YEAR)
BNRFP	N	BIRTH NORMAL RATE OF FIXED POPULATION(PERSONS/PERSONS-YEAR)
BRM	A	BIRTH RATE MULTIPLIER (DIMENSIONLESS)
BRMT	T	BIRTH RATE MULTIPLIER TABLE (DIMENSIONLESS)
BRNP	N	BIRTH RATE NON-PERMANENT POPULATION (PERSONS/ PERSONS-YEAR)
BYFP	R	BIRTHS PER YEAR OF FIXED POPULATION (PERSONS/YEAR)
BYNP	R	BIRTHS PER YEAR NON-PERMANENT POPULATION (PERSONS/YEAR)
CFR	N	CONSTRUCTION TO FIXED POPULATION RATE (HOUSEHOLDS/PERSON-YEAR)
CNR	N	CONSTRUCTION TO NO-PERMANENT POPULATION RATE (HOUSEHOLDS/PERSON-Y)
DNRFP	N	DEATH NORMAL RATE OF FIXED POPULATION (PERSONS/PERSONS-YEAR)
DRM	A	DEATH RATE MULTIPLIER (DIMENSIONLESS)
DRMT	T	DEATH RATE MULTIPLIER TABLE (DIMENSIONLESS)
DRNP	N	DEATH RATE NON-PERMANENT POPULATION (PERSONS/PERSONS-YEAR)
DYFP	R	DEATHS PER YEAR FIXED POPULATION (PERSONS/YEAR)
DYNP	R	DEATHS PER YEAR NON-PERMANENT POPULATION (PERSONS/YEAR)
EFPS	A	EMPLOYMENT IN FIXED POPULATION SERVICES(PERSONS/YEAR)
EFSNR	N	EMPLOYMENT IN FIXED POPULATION SERVICES NORMAL RATE (DIMENSIONLESS)
ENLF	A	EFECTIVE NEED FOR LABOR FORCE (PERSONS/YEAR)
ENPSR	N	EMPLOYMENT IN NON-PERMANENT POPULATION SERVICES RATE(DIMENSIONLESS)
ENPS	A	EMPLOYMENT IN NON-PERMANENT POPULATION SERVICES (PERSONS/YEAR)
ESRM	A	EMPLOYMENT SERVICES RATE MULTIPLIER(DIMENSIONLESS)
ESRMT	T	EMPLOYMENT SERVICES RATE MULTIPLIER TABLE (DIMENSIONLESS)
FDFP	N	FAMILY DIMENSION AT FIXED POPULATION (DIMENSIONLESS)
FDNP	N	FAMILY DIMENSION NON-PERMANENT POPULATION (DIMENSIONLESS)
FE	L	FIXED EMPLOYMENT (PERSONS)
FEI	C	FIXED EMPLOYMENT INITIAL (PERSONS)
FENF	A	FIXED EMPLOYMENT IN THE NEW FACTORY (PERSONS/ YEAR)
FENFT	T.	FIXED EMPLOYMENT IN THE NEW FACTORY TABLE (PERSONS/YEAR)

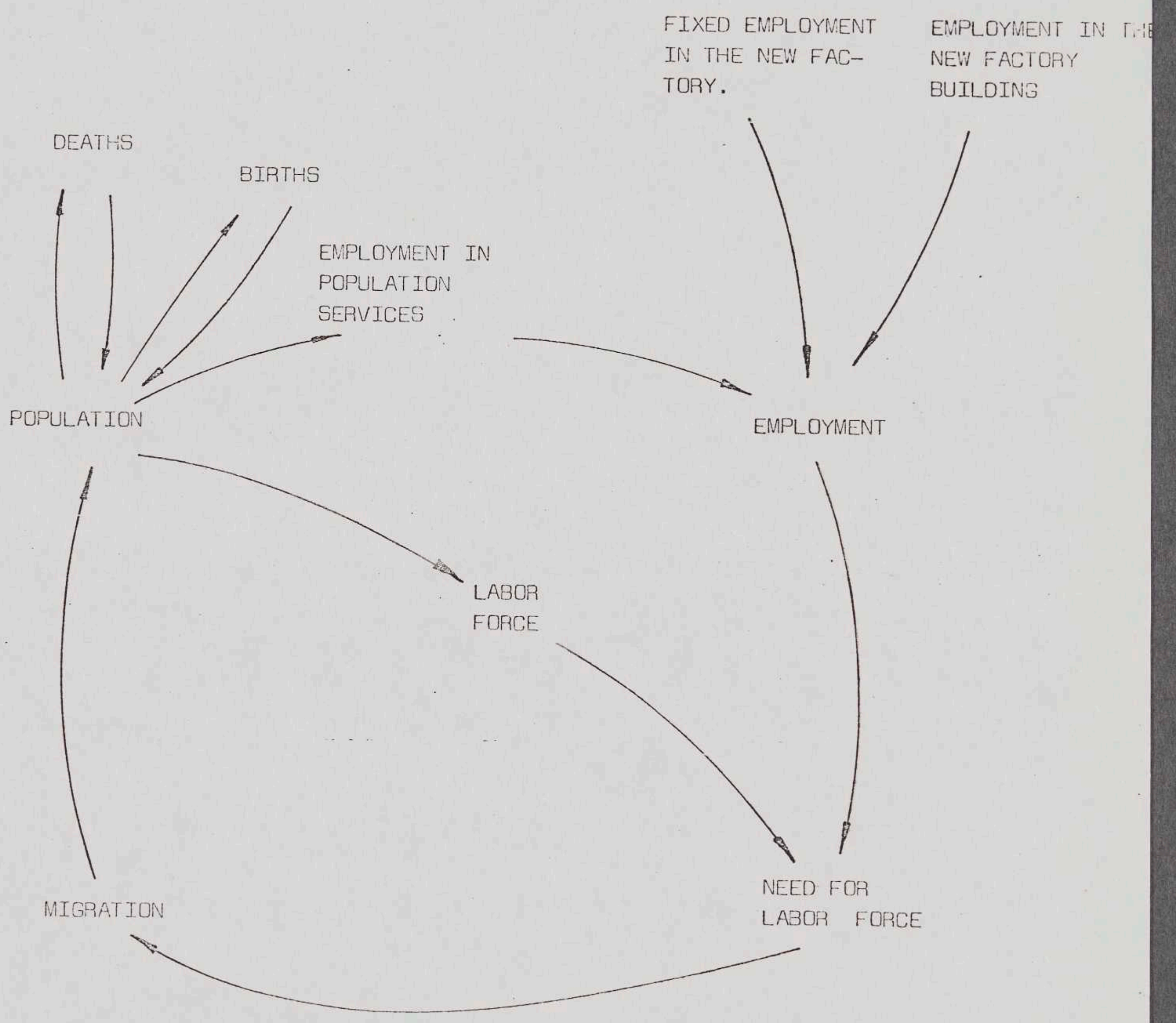
FEY	R	FIXED EMPLOYMENTS PER YEAR (PERSONS/YEAR)
FP	L	FIXED POPULATION (PERSONS)
FPI	C	FIXED POPULATION INITIAL (PERSONS)
H	L	HOUSEHOLDS (HOUSEHOLDS)
HI	C	HOUSEHOLDS INITIAL (HOUSEHOLDS)
HP	A	HOUSEHOLD POLICY (HOUSEHOLDS/YEAR)
HPD	A	HOUSEHOLD POLICY DELAY (HOUSEHOLDS/YEAR)
HPT	T	HOUSEHOLD POLICY TABLE (HOUSEHOLDS/YEAR)
HPY	R	HOUSEHOLD POLICY PER YEAR (HOUSEHOLDS/YEAR)
HSR	N	HOUSEHOLDS VS SERVICES RATE (DIMENSIONLESS)
HSUC	L	HOUSEHOLDS AND SERVICES UNDER CONSTRUCTION (HOUSEHOLDS)
HSUCI	C	HOUSEHOLDS AND SERVICES UNDER CONSTRUCTION INITIAL (HOUSEHOLDS)
ICLY	A	INCREASING FOR CONSTRUCTION FROM LAST YEAR (HOUSEHOLDS)
IFP	A	INCREASING FIXED POPULATION (PERSONS)
INP	A	INCREASING NON-PERMANENT POPULATION (PERSONS)
LF	A	LABOR FORCE (PERSONS)
LFPNR	N	LABOR FORCE PARTICIPATION NORMAL RATE (DIMENSIONLESS)
LRM	A	LABOR RATE MULTIPLIER (DIMENSIONLESS)
LRMT	T	LABOR RATE MULTIPLIER TABLE (DIMENSIONLESS)
LTH	C	LIFE-TIME FOR HOUSEHOLDS (YEARS)
LTS	C	LIFE-TIME FOR SERVICES (YEARS)
LYFP	A	LAST YEAR FIXED POPULATION (PERSONS)
LYHSC	A	LAST YEAR HOUSEHOLDS AND SERVICES UNDER CONSTRUCTION (HOUSEHOLDS)
LYNP	A	LAST YEAR NON-PERMANENT POPULATION (PERSONS)
MYFP	R	MIGRATION PER YEAR TO FIXED POPULATION (PERSONS/YEAR)
MYNP	R	MIGRATIONS PER YEAR TO NON-PERMANENT POPULATION (PERSONS/YEAR)
NC	L	NEED FOR CONSTRUCTION (HOUSEHOLDS)
NCI	C	NEED FOR CONSTRUCTION INITIAL (HOUSEHOLDS)
NCFP	R	NEED FOR CONSTRUCTION TO FIXED POPULATION (HOUSEHOLDS/YEAR)
NCNP	R	NEED FOR CONSTRUCTION TO NON-PERMANENT POPULATION(HOUSEHOLDS/YEAR)
NE	L	NON-DURABLE EMPLOYMENT (PERSONS)

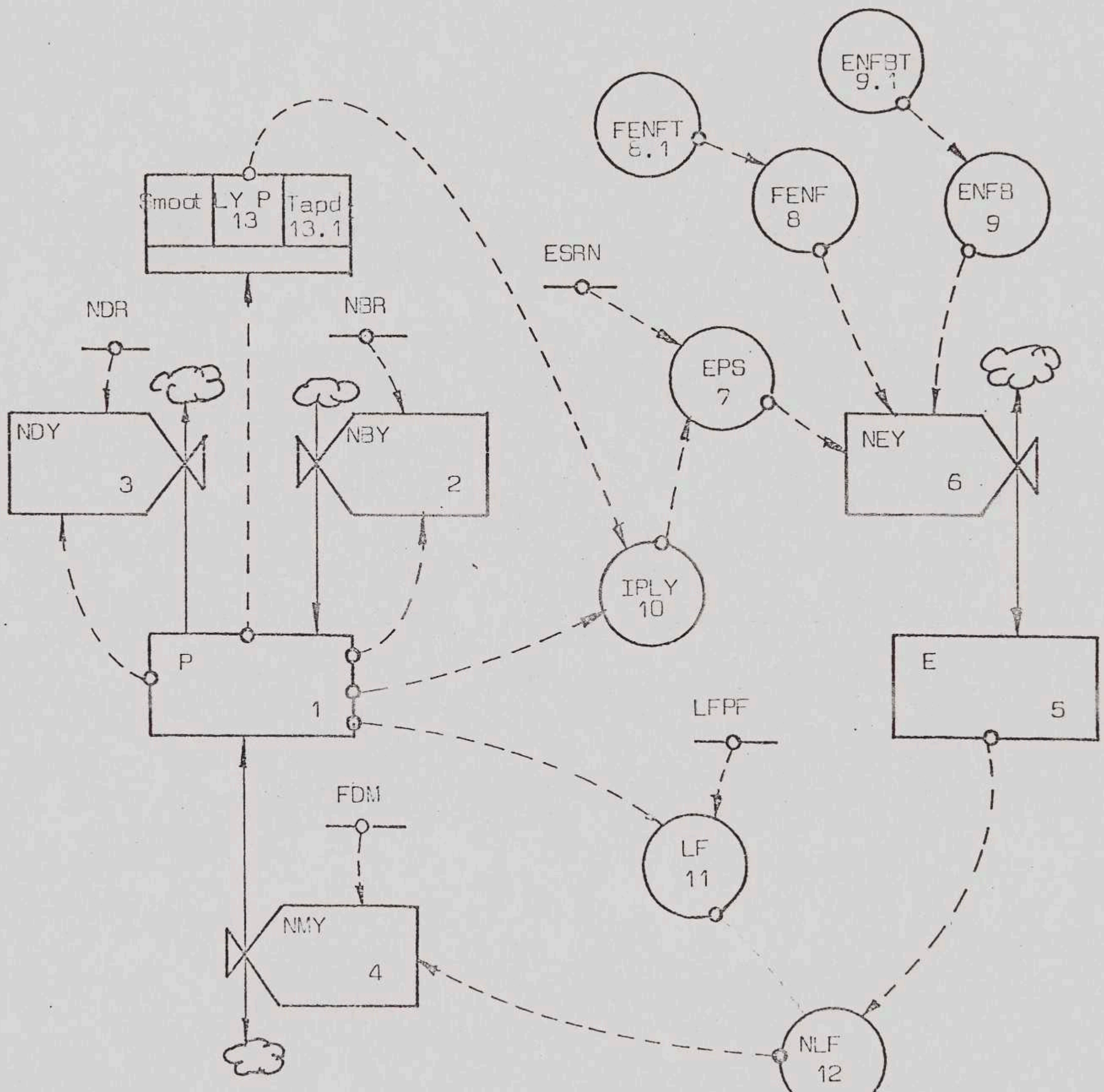
NENF	A	NON-DURABLE EMPLOYMENT IN THE NEW FACTORY (PERSONS/YEAR)
NENFT	T	NON-DURABLE EMPLOYMENT IN THE NEW FACTORY TABLE (PERSONS/YEAR)
NEY	R	NON-DURABLE EMPLOYMENT PER YEAR (PERSONS/YEAR)
NHY	R	NET HOUSEHOLDS PER YEAR (HOUSEHOLDS/YEAR)
NLF	A	NEED FOR LABOR FORCE (PERSONS/YEAR)
NNLF	A	NEED FOR NON-PERMANENT LABOR FORCE (PERSONS/YEAR)
NP	L	NON-PERMANENT POPULATION (PERSONS)
NRY	R	NEED FOR RENOVATION PER YEAR (HOUSEHOLDS/PERSONS-YEAR)
NSHP	R	NEED SATISFACTION FOR HOUSEHOLD POLICY (HOUSEHOLDS/YEAR)
NSM	R	NEED SATISFACTION FOR MODEL (HOUSEHOLDS/YEARS)
NSY	R	NET SERVICES PER YEAR (HOUSEHOLDS/YEAR)
PHNR	N	PERSONS PER HOUSEHOLDS NORMAL RATE (DIMENSIONLESS)
RRH	N	RENOVATION RATE FOR HOUSEHOLDS (YEARS)
RRS	N	RENOVATION RATE FOR SERVICES (YEARS)
S	L	SERVICES (HOUSEHOLDS)
SHR	N	SERVICES VS HOUSEHOLDS RATE (DIMENSIONLESS)
SI	C	SERVICES INITIAL
TACD	N	TIME AVERAGE FOR CONSTRUCTION DELAY (YEARS)
TAFP	N	TIME AVERAGE FIXED POPULATION (YEARS)
TAHPD	N	TIME AVERAGE HOUSEHOLD POLICY DELAY (HOUSEHOLD/YEAR)
TAHSC	C	TIME AVERAGE HOUSEHOLDS AND SERVICES UNDER CONSTRUCTION (YEARS)
TANP	N	TIME AVERAGE NON-PERMANENT POPULATION (PERSONS)
TCH	N	TIME UNDER CONSTRUCTION FOR HOUSEHOLDS (YEARS)
TCS	N	TIME UNDER CONSTRUCTION FOR SERVICES (YEARS)
UHHY	R	UN-HABITABLE HOUSEHOLDS PER YEAR (HOUSEHOLDS/YEAR)
UHSY	R	UN-HABITABLE SERVICES PER YEAR (HOUSEHOLDS/YEAR)
ULF	A	UN-EMPLOYMENT LABOR FORCE (PERSONS)
UPR	A	UN-EMPLOYMENT POPULATION RATE (DIMENSIONLESS)
UPRT	T	UN-EMPLOYMENT POPULATION RATE TABLE (DIMENSIONLESS)

TABLE I

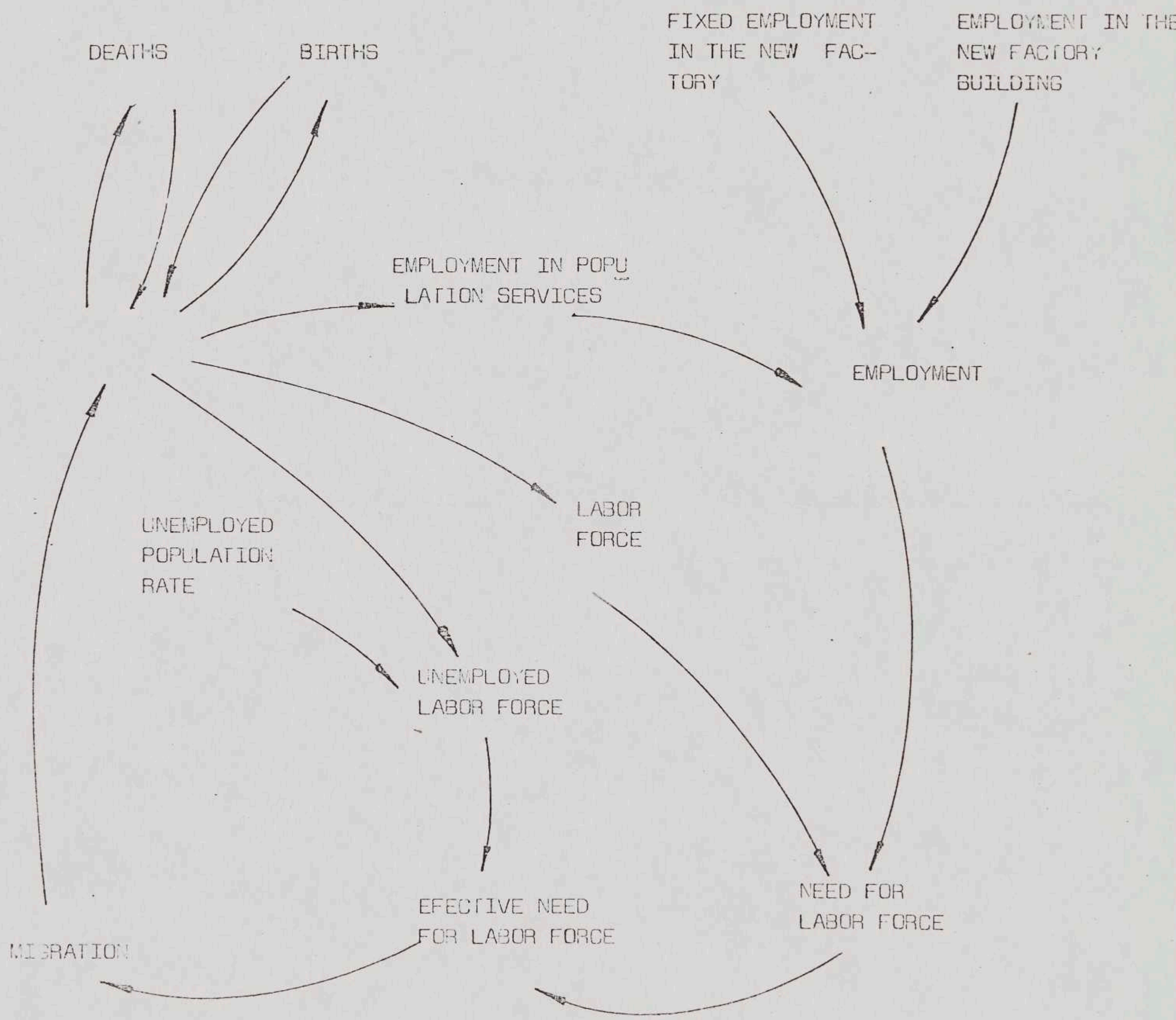
POPULATION

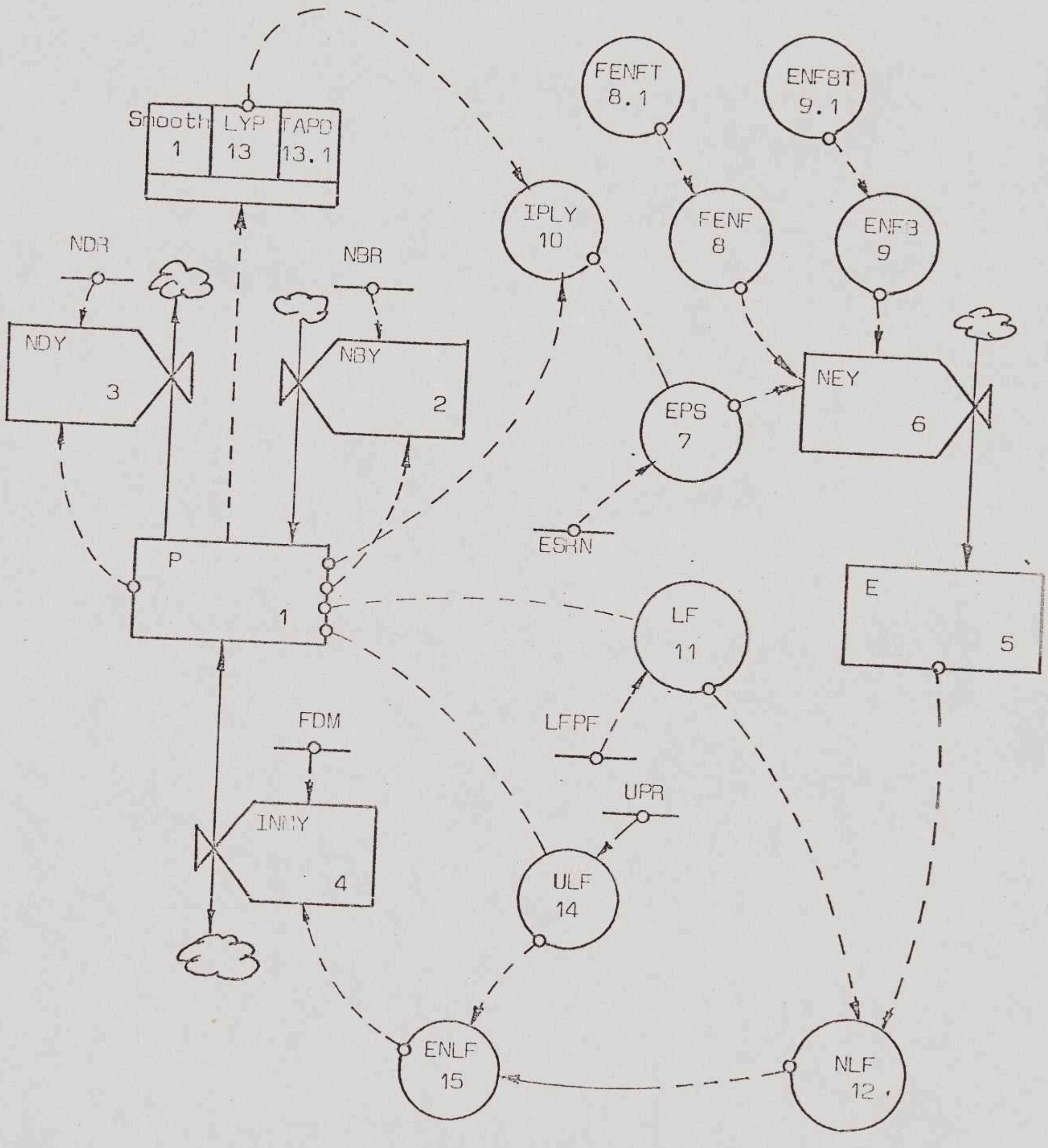
AGED LIMITS	FIXED		NON PERMANET	
	MALE	FEMALE	MALE	FEMALE
0 - 4	FPMA	FPFA	NPMA	NPFA
5 - 9	FPMB	FPFB	NPMB	NPFB
10 - 14	FPMC	FPFC	NPMC	NPFC
15 - 19	FPMD	FPFD	NPMD	NPFD
20 - 24	FPME	FPFE	NPME	NPFE
25 - 29	FPMF	FPFF	NPMF	NPFF
30 - 34	FPMG	FPFG	NPMG	NPFG
35 - 39	FPMH	FPFH	NPMH	NPFH
40 - 44	FPMI	FPFI	NPMI	NPFI
45 - 49	FPMJ	FPFJ	NPMJ	NPFJ
50 - 54	FPMK	FPFK	NPMK	NPFK
55 - 59	FPML	FPFL	NPML	NPFL
60 - 64	FPMM	FPFM	NPMM	NPFM
65	FPMN	FPFN	NPMN	NPFN

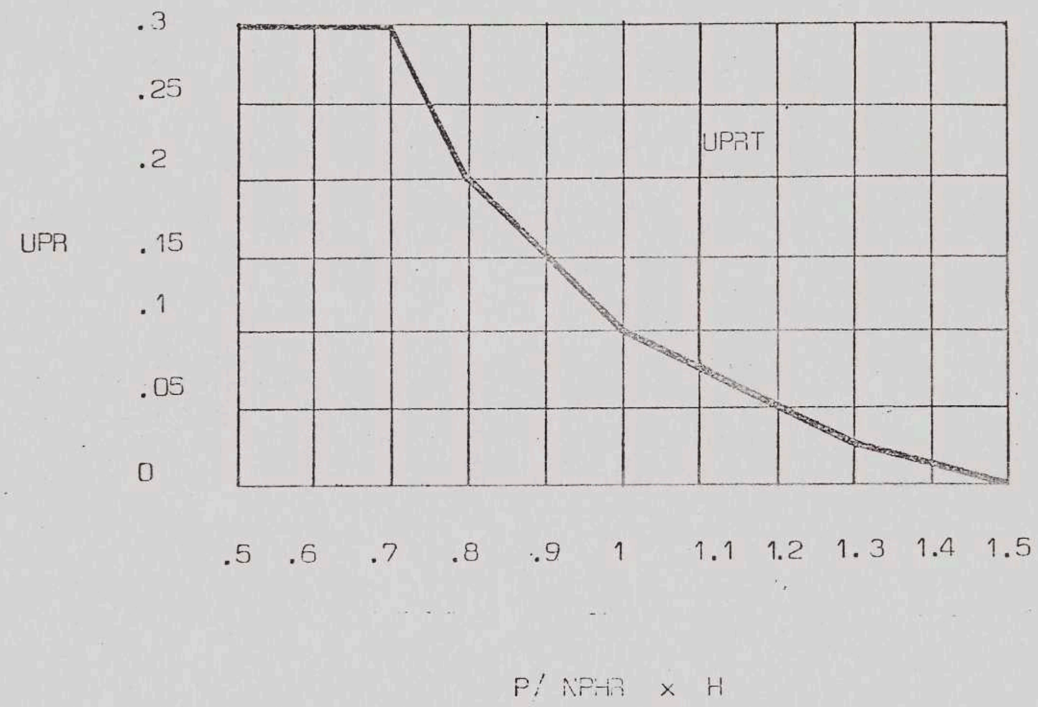

FIXED EMPLOYMENT IN THE NEW FACTORY.
EMPLOYMENT IN THE NEW FACTORY BUILDING
DEATHS
BIRTHS
EMPLOYMENT IN POPULATION SERVICES
POPULATION
EMPLOYMENT
LABOR FORCE
NEED FOR LABOR FORCE
MIGRATION

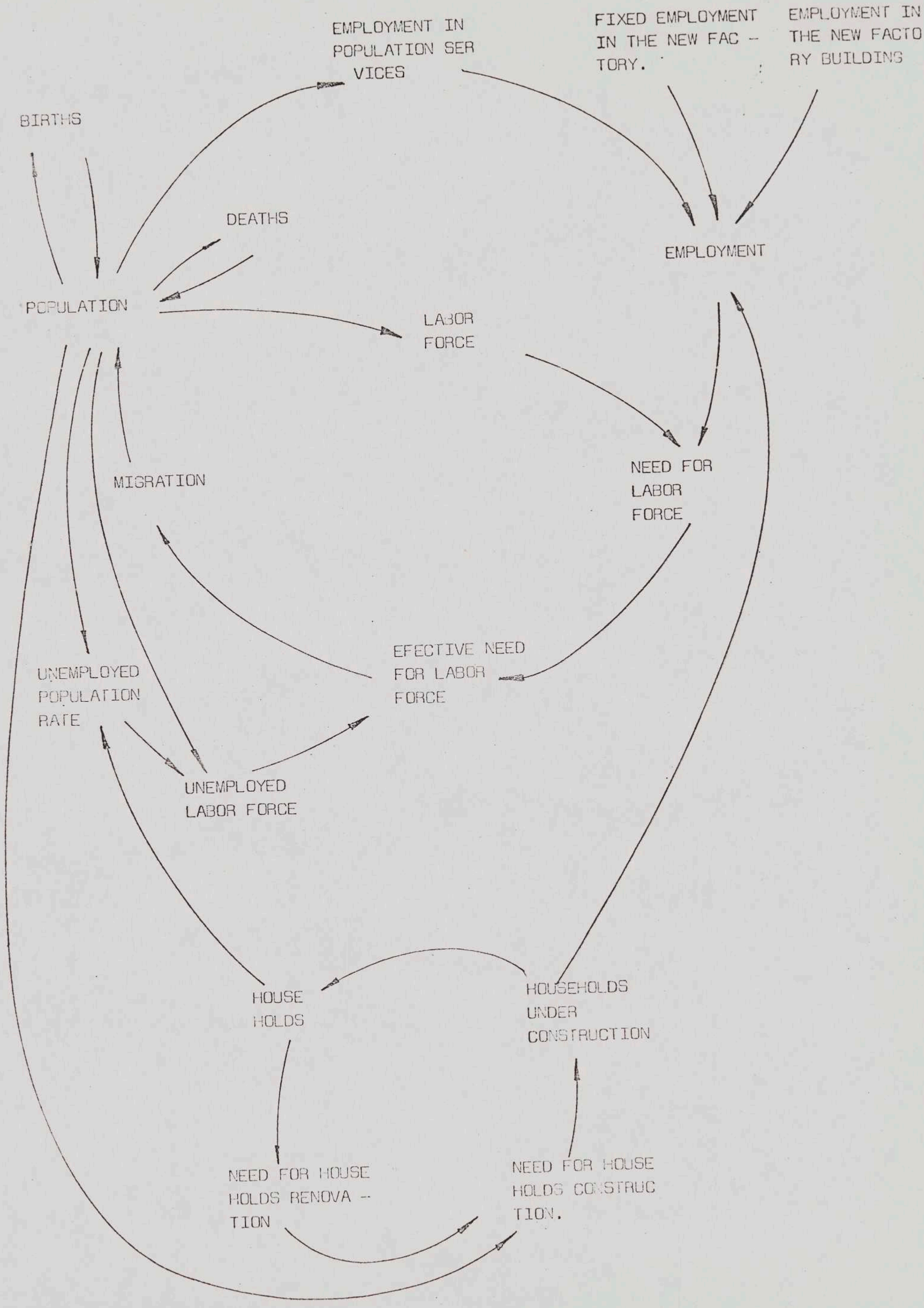


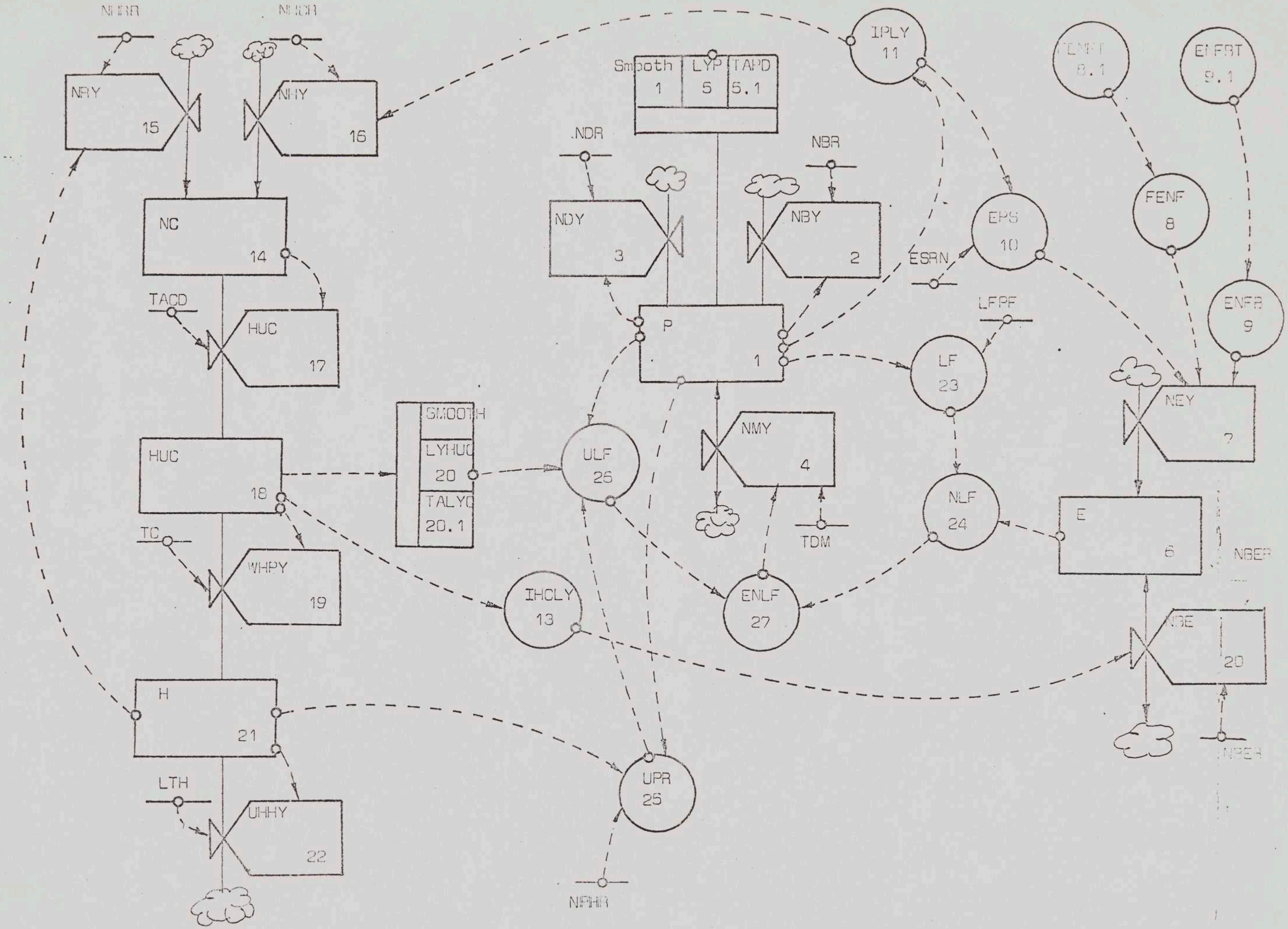
ENFBT
9.1
FENFT
8.1
FENF
8
ENFB
9
Smoot
LY P
13
Tapd
13.1
ESRN
NDR
NBR
EPS
7
NDY
3
NBY
2
NEY
6
IPLY
10
P
1
E
5
LFPF
FDM
LF
11
NMY
4
NLF
12


DEATHS
BIRTHS
FIXED EMPLOYMENT IN THE NEW FAC- TORY
EMPLOYMENT IN THE NEW FACTORY BUILDING
EMPLOYMENT IN POPU LATION SERVICES
EMPLOYMENT
LABOR FORCE
UNEMPLOYED POPULATION RATE
UNEMPLOYED LABOR FORCE
EFECTIVE NEED FOR LABOR FORCE
NEED FOR LABOR FORCE
MIGRATION

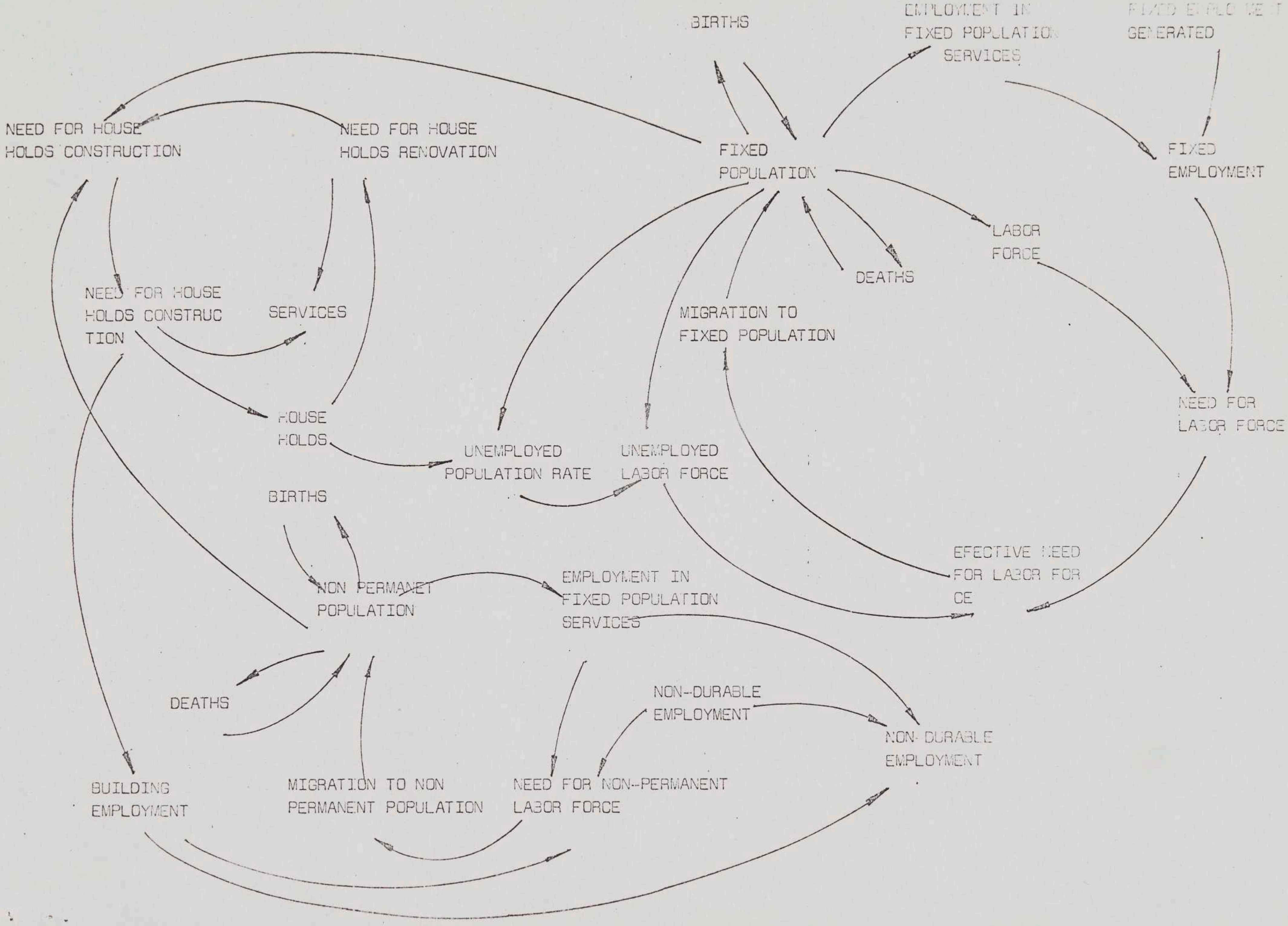

Smooth
1
LYP
13
TAPD
13.1
FENFT
8.1
ENFBT
9.1
IPLY
10
FENF
8
ENFB
9
NDR
NBR
NDY
3
NBY
2
EPS
7
NEY
6
ESRN
P
1
LF
11
E
5
FDM
LFPF
UPR
INMY
4
ULF
14
ENLF
15
NLF
12

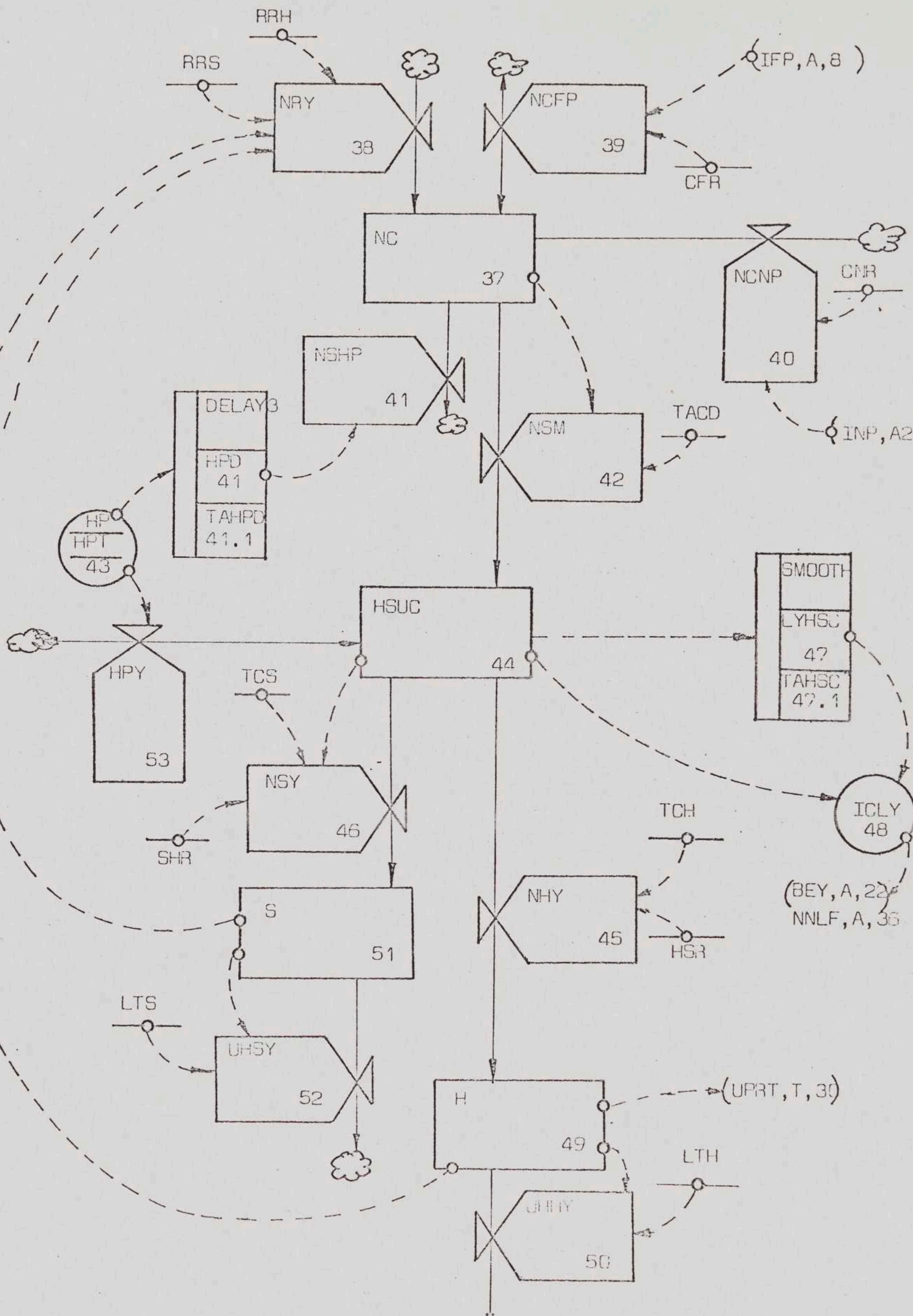

.3
.25
.2
UPR
.15
.1
.05
0
UPRT
.5
.6
.7
.8
.9
1
1.1
1.2
1.3
1.4
1.5
P/ NPHR x H


EMPLOYMENT IN POPULATION SER VICES
FIXED EMPLOYMENT IN THE NEW FAC - TORY.
EMPLOYMENT IN THE NEW FACTO RY BUILDING
BIRTHS
DEATHS
EMPLOYMENT
POPULATION
LABOR FORCE
MIGRATION
NEED FOR LABOR FORCE
EFECTIVE NEED FOR LABOR FORCE
UNEMPLOYED POPULATION RATE
UNEMPLOYED LABOR FORCE
HOUSE HOLDS
HOUSEHOLDS UNDER CONSTRUCTION
NEED FOR HOUSE HOLDS RENOVA - TION
NEED FOR HOUSE HOLDS CONSTRUC TION.



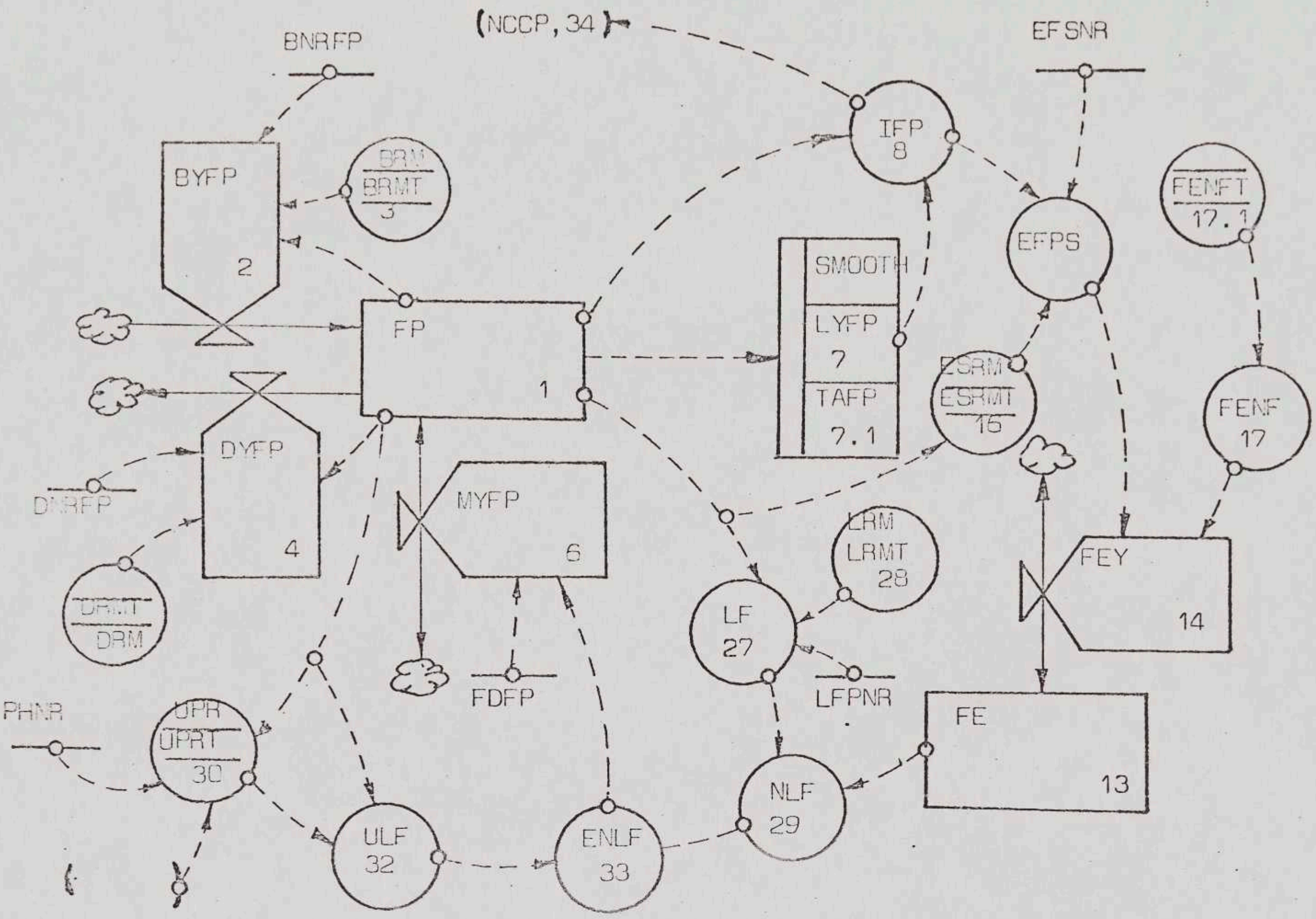
NRY
15
NHY
16
Smooth
1
LYP
5
TAPD
5.1
IPLY
11
ENFRT
9.1
NC
14
.NDR
NDY
3
NBR
NBY
2
EPS
10
ESRN
FENF
8
TACD
HUC
17
P
1
LFPF
LF
23
ENFR
9
NEY
7
SMOOTH
LYHUC
20
TALYC
20.1
HUC
18
ULF
26
NMY
4
TDM
NLF
24
E
6
NBER
TC
WHPY
19
IHCLY
13
ENLF
27
NBE
20
H
21
UPR
25
NPER
LTH
UHHY
22
NPHR

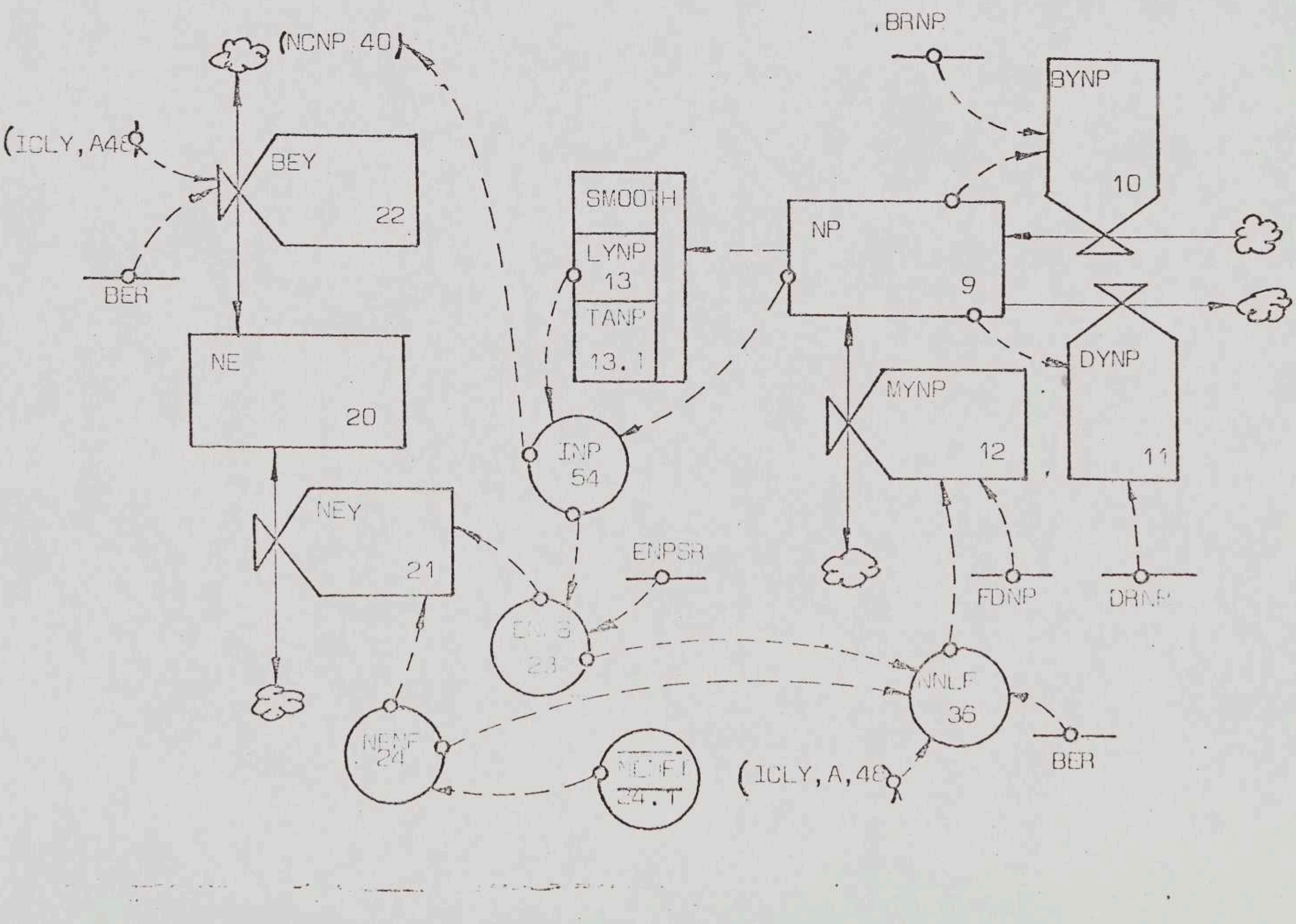

BIRTHS
EMPLOYMENT IN FIXED POPULATION SERVICES
FIXED EMPLOYMENT GENERATED
NEED FOR HOUSE HOLDS CONSTRUCTION
NEED FOR HOUSE HOLDS RENOVATION
FIXED POPULATION
FIXED EMPLOYMENT
LABOR FORCE
DEATHS
NEED FOR HOUSE HOLDS CONSTRUC TION
SERVICES
MIGRATION TO FIXED POPULATION
NEED FOR LABOR FORCE
HOUSE HOLDS
UNEMPLOYED POPULATION RATE
UNEMPLOYED LABOR FORCE
BIRTHS
EFECTIVE NEED FOR LABOR FOR CE
NON PERMANET POPULATION
EMPLOYMENT IN FIXED POPULATION SERVICES
DEATHS
NON-DURABLE EMPLOYMENT
NON-DURABLE EMPLOYMENT
BUILDING EMPLOYMENT
MIGRATION TO NON PERMANENT POPULATION
NEED FOR NON-PERMANENT LABOR FORCE

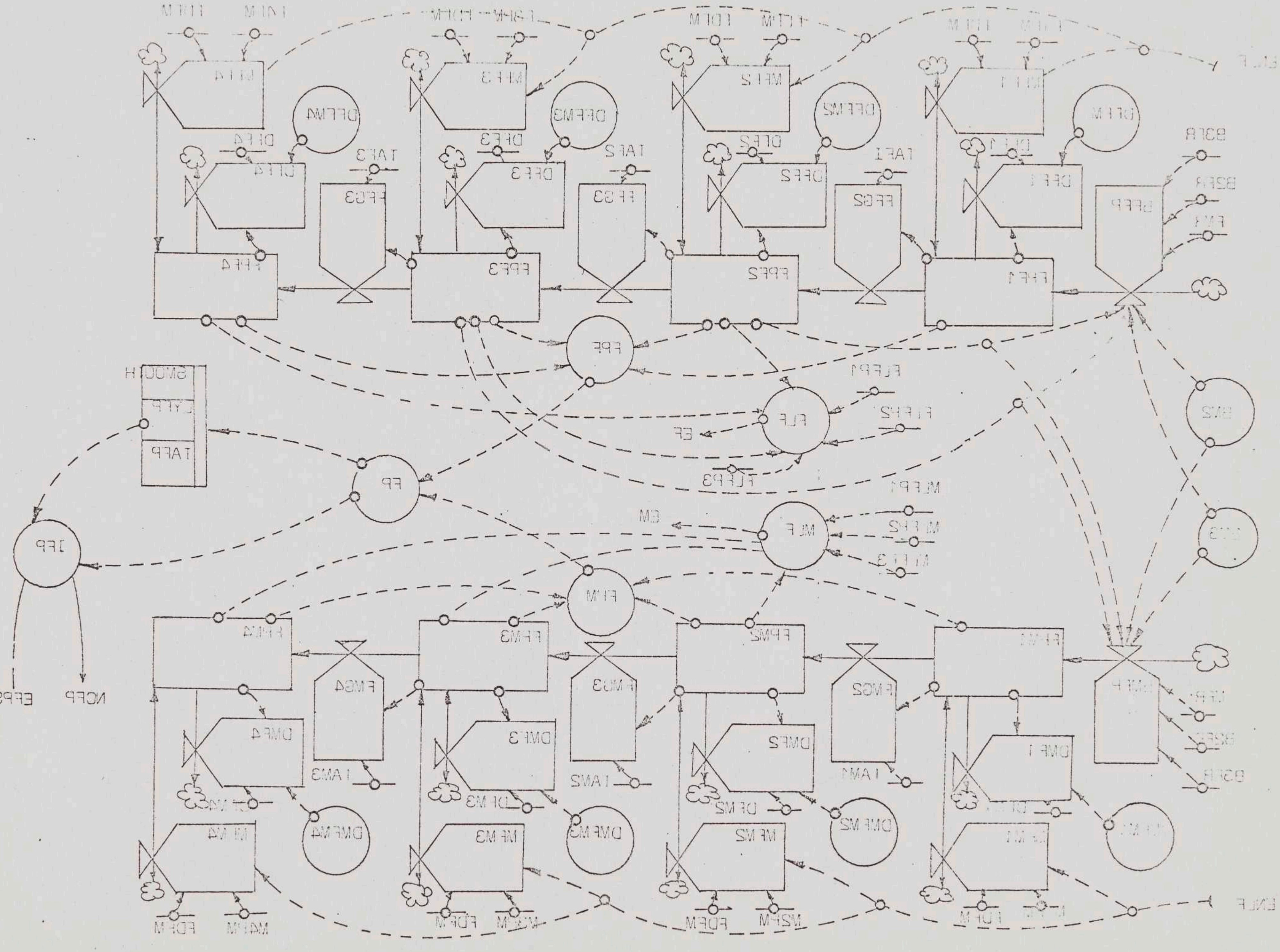


RRH
RRS
NRY
38
NCFP
39
(IFP, A, 8)
CFR
NC
37
NCNP
40
CNR
(INP, A23)
NSHP
41
DELAY3
HPD
41
TAHPD
41.1
NSM
42
TACD
HP
HPT
43
HSUC
44
SMOOTH
LYHSC
42
TAHSC
42.1
HPY
53
TCS
NSY
46
SHR
ICLY
48
TCH
(BEY, A, 22)
NNLF, A, 36
S
51
NHY
45
HSR
LTS
UHSY
52
H
49
(UPRT, T, 30)
LTH
UHHY
50

FIG. 9.4


(NCCP, 34)
BNRFP
EFSNR
IFP
8
BYFP
2
BRM
BRMT
3
FENFT
17.1
EFPS
SMOOTH
LYFP
7
TAFP
7.1
FP
1
ESRM
ESRMT
15
FENF
17
DYFP
4
DNRFP
MYFP
6
LRM
LRMT
28
FEY
14
DRMT
DRM
LF
27
FDFP
LFPNR
PHNR
UPR
UPRT
30
FE
13
NLF
29
ULF
32
ENLF
33


(NCNP, 40)
BRNP
(ICLY, A48)
BEY
22
BYNP
10
SMOOTH
LYNP
13
TANP
13.1
NP
9
BER
NE
20
DYNP
11
MYNP
12
INP
54
NEY
21
ENPSR
FDNP
DRNP
23
NNLF
36
24
24.1
BER
(ICLY, A, 48)



MFF4
MFF3
MFF2
MFF1
DFFM4
DFFM3
DFFM2
DFFM
DFF4
DFF3
DFF2
DFF1
TAF3
TAF2
TAF1
FFG3
FFG3
FFG2
BFFP
B3FR
B2FR
FM1
FFF4
FFF3
FFF2
FFF1
FFF
FLF
FLFP1
FLFP2
FLFP3
EF
MLF
MLFP1
MLFP2
MLFP3
EM
SMOOTH
CYFP
TAFP
FP
IFP
FPM
EFPS
NCFP
FFM4
FFM3
FFM2
FFM1
FMG4
FMG3
FMG2
BMFP
B2FR
B3FR
DMF4
DMF3
DMF2
DMF1
IAM3
IAM2
IAM1
DFMM4
DFMM3
DMFM4
DMFM3
DMFM2
MFM4
MFM3
MFM2
FDFM
M4FM
M3FM
M2FM
ELF
ENLF
BM2
BM3

Fig 10

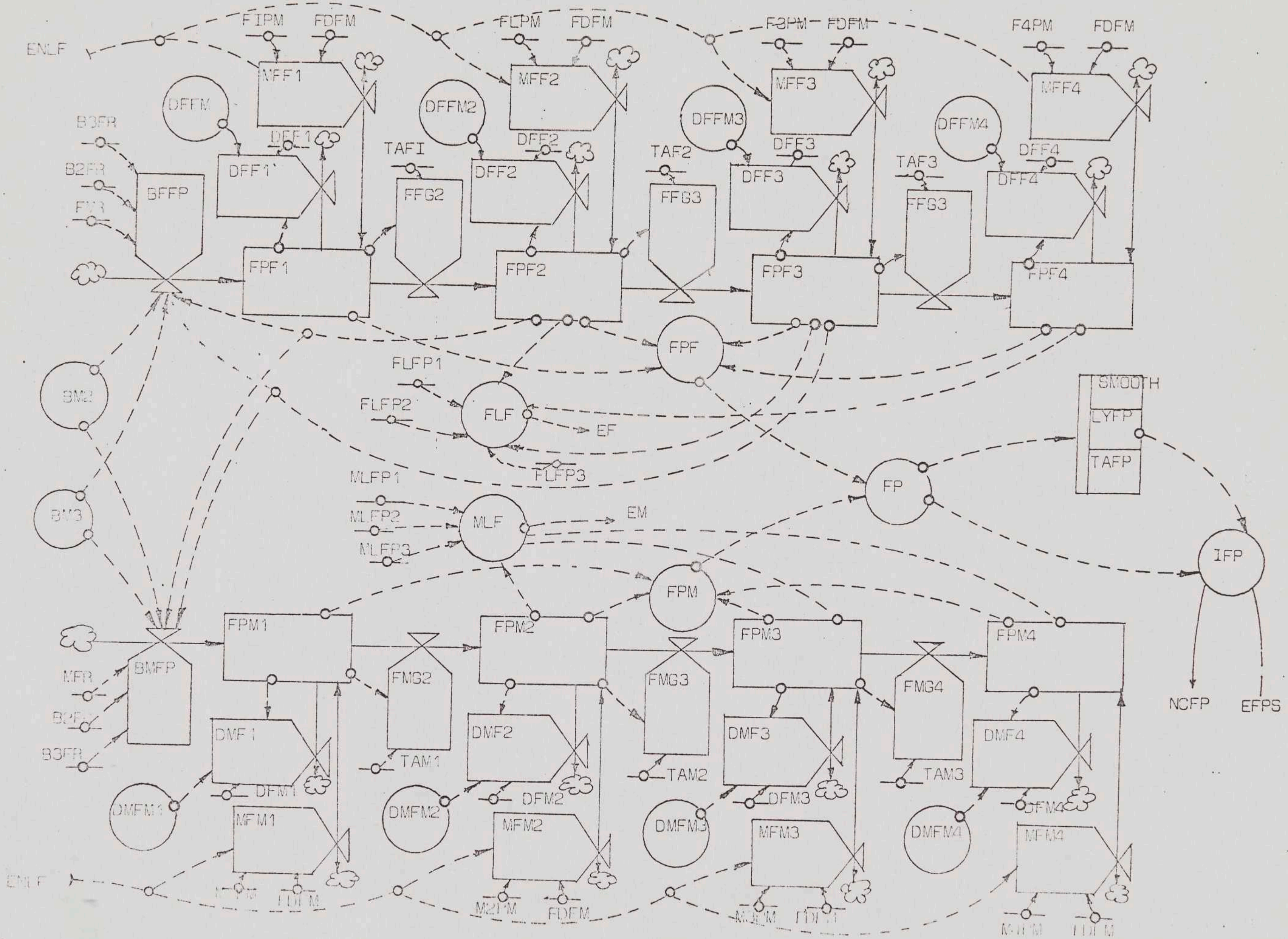

ENLF
FIPM
FDFM
FLPM
F3PM
F4PM
MFF1
MFF2
MFF3
MFF4
DFFM
DFFM2
DFFM3
DFFM4
B3FR
B2FR
BFFP
DFF1
DFF2
DFF3
DFF4
TAFI
TAF2
TAF3
FFG2
FFG3
FPF1
FPF2
FPF3
FPF4
FPF
FLFP1
FLFP2
FLFP3
FLF
EF
SMOOTH
LYFP
TAFP
FP
IFP
MLFP1
MLFP2
MLFP3
MLF
EM
FPM
FPM1
FPM2
FPM3
FPM4
BMFP
MFR
B3FR
FMG2
FMG3
FMG4
DMF1
DMF2
DMF3
DMF4
TAM1
TAM2
TAM3
DFM1
DFM2
DFM3
DFM4
DMFM1
DMFM2
DMFM3
DMFM4
MFM1
MFM2
MFM3
MFM4
M2PM
FDFM
NCFP
EFPS

FIG. 10

USD Centers
Spain

October 27, 1975

Professor J. Aracil
Escuela Tecnica Superior De
Ingenieros Industriales De Sevilla
Avda. Reina Mercedes S/N
Sevilla (Spaiå)

Dear Professor Aracil:

Thank you very much for your letter of Aggust 16 and the enclosed paper. I am sorry to be so late in acknowledging it but I have been away from the office much of the time.

I have looked at it with interest and will pass it along to those in the group here more actively interested in regional development.

Sincerely yours,

JWF/ndb

MODELLING THE DEMOGRAPHIC IMPACT OF A NEW FACTORY

by

Javier ARACIL and José Mª BUENO

Dept. of Automatic Control
Esc.Téc.Sup.Ing.Industriales
University of Sevilla
Sevilla (Spain)

The paper developes a Dynamic Model of the Demographic evolution of a non industrialized area where a big and important factory - is built to industrialize the zone. The time horizon is the year 2000. The dynamic model has sixty four variables wich represents a very desagregated model of its kind. The model studies different classes of population (ages, sex, jobs,...) and projects them, and their interelations, for the period. The modelling methodollogy used has been the Forrester systems dynamics. The model has been actualy applied to forecast the demographic evolution os a small town in the Spanish mediterranean coast where a big siderurgy is now going to be built.

Submitted to the " Third International Congress of Cybernetics and Systems " . - Bucharest (Romania), August 1975

1. INTRODUCTION

This paper is intended to present a dynamic model which will enable us to simulate the impact produced by the setting up of a new factory on the demography of a certain area. The work is motivated by the need of availing ourselves of a device that will permit us to foretell the demographic evolution of a certain area when it undergoes an important change as a result of the establishment of a new factory which will sensibly alter the work positions in that area. This will determine, for example, a strong inmigration for which a suitable social infrastructure (schools, housings, services, etc.) is to be scheduled. The model presented here intends to carry out a projection of this nature.

The methodology used in the development of the model is Forrester' s System Dynamics [1,2,3,4], as it is believed that this methodology is specially suitable for a job of this nature. One of the reasons for having selected this methodology has been its suitability for the integration of opinions from experts of varied training. Along the same lines we can point out the accessbility of the model to manager (decision making) and planners who have used it as an aid to their decision-taking duties.

The work has been arranged in a progressive manner from the first working hypothesis and first causal diagram to the strongly disaggregated final model, which comprises 64 levels. The work will be accomplished in four steps, by establishing four models of increasing complexity designated as S 1, S 2, S 3 and S4.

2. BASIC HYPOTHESIS.

In the demographic area there are three fundamental variables : births, deaths and migration. Regarding migration it is assumed that the establisment of the new factory will give rise to the creation of a great number of work positions that will require outside labor migrating from other areas to settle in the area involved. It is estimated that there is a nation-wide migrating potential towards the area involved and that, therefore, a demand for jobs (work positions) exceeding the supply (active population) will always be satisfied.

Regarding the employment area in the initial models industrial jobs have been separated from jobs involved in serving the population. The more elaborate models define a third area which is that of employment in construction, especially housing, due to the relative importance of this area.

As stated above, four models have been worked out that can be considered to differ from each other even though each comprises the previous one and develops greater accuracy in dealing with certain areas. The first three models deal with an aggregate form whilst the last one deals with a disaggregate form.

2.1. Two-level model S 1

The object aimed at in setting up this elementary model is the establishment of a first model that will define the behavior of the system with a view to preparing the later phases of the study. Thus, the causal diagram shown in figure 1 wass obtained and is self-explanatory.

Of the variables appearing on this diagram only the population and employment are cumulative a·d, in consequence, are shown - as levels. The variables births, deaths and emigration, which act on the population level, are flows. Likewise, the net - annual growth of work positions will also be a flow. The re - mainder of variables are shown as auxiliary variables. On the basis of these considerations we obtain the applicable DYNAMO diagram shown in figure 2.

Model S 1 represents the system, although in an excessively sim plified manner. One of the first insufficiencies that was noti ced in connection with model S 1 was the treatment of the em - ployment strain when the labor force (supply of employment) was greater than the demand for employment. In accordance with the model, emigration would take place in an automatic manner.It is believed, on the contrary, that the worker is reluctant to go away even when he is out of a job and at any rate a certain pe- riod of time. elapses between the moment he becomes unemployed and the moment he emigrates to other areas. Thus, it becomes - necessary for the causal diagram to include a new loop which - will act when the employment is negative, i.e. when the labor - force is greater than the employment. Figure 3 shows the new causal diagram resulting from this modification. It includes a new exogenous variable wich is the rate of absorption of unem - ployment and therefore represents the maximum percentage of - unemployed that the system is capable of absorbing. Figure 4 shows the DYNAMO diagram corresponding to this modification.

Two conclusions are drawn from an analysis of this first model. On the one side, in view of the high increase of the system during the first years it becomes necessary to specifically deal with the employment in the construction of housing, which was not dealt with under model S 1, as temporary employment was considered to be implied in industrial construction only. On the other hand, there arises the problem of accurately defining the absorption rate of unemployment in an exogenous manner. It is considered more necessary to define this variable in an endogenous manner, precisely as a function of a new area : the infrastructure area.

Model S 2, with five levels, was developed having regard of these remarks.

2.2. Five-level model S 2

In accordance with the consideration stated above, we are faced with the need of dealing with the infrastructure area.

It is of primary importance within this area to consider the need for the construction of housing. The construction of services (hospitals, cinemas, markets, schools, etc.) was disregarded at first but the demand for them was included in further elaborations.

The consideration of the infrastructure level permits us to elaborate a function defining the rate of absorption of unemployment in an endogenous manner. It can be estimated that the motivation for leaving the municipality due to shortage of of work is checked by the existence of a suitable infrastructure therein. A table (figure 5) is defined which gives the rate of absorption of unemployment in accordance with the new variable measuring the degree of utilization of the existing infrastructure.

In accordance with these consideration and starting from model S 1 we obtain model S 2 whose causal and DYNAMO diagrams are shown in figures 6 and 7 respectively.

A close relation between positive and negative loops is still observed in the causal diagram. With this, the type of growth of the system will continue to be essentially alike even though it differs punctually on the basis of the new considerations made in connection with this model. This is demonstrated in the various simulations to which the model was subjected.

2.3. Eight-level model S 3

Two consideration led to the need for elaborating a model more sophisticated than model S 2. First, the need for dealing separately with housing and services in order that the final level of housing built included housing only and precluded the introduction of errors in the employment absorption table. Secondly, there becomes evident the existence of two different types of employment, permanent and temporary, which involve different sociological characteristics. It is necessary to deal separately with these two different types of employment.

These considerations modify model S 2 and thus we obtain model S 3 whose causal and DYNAMO diagrams are shown in figures 8, 9.1 and 9.2 respectively.

2.4. Disaggregated model S 4

Model S 3 is considered satisfactory enough as far as its level is aggregation is concerned. However, applications expected from this model lead to the need of availing ourselves of a disaggregated form of same which ill permit us to study, for example, the structure of the age of the population with a view to defining in a more precise manner the needs that will arise at the various levels. It can be readily seen, for example, that initially the system has a pyramidal structure whilst emigration tends to strengthen the intermediate age groups. Thus, the resulting system will have a lower death-rate and perhaps a higher birth-rate. On the other hand, the active population area will increase. These considerations give rise to the requirement for separating the population in groups of different ages so that all rate applicable to each class can be defined in this way and that the adjustment can continue to be acceptable. This differentiation in categories of age affects both types of population, permanent and temporary.

On the other hand, although in principle differentiation by sexes seems unnecessary within each category, this differentiation does become necessary due to considerations similar to those stated above. It is relevant to know the potential acti vity of females and especially the way in which the employment saturation effects will be produced and the different manner in which they will act on males and females. In principle, if a woman becomes unemployed she will not tend to emigrate, althought a man will. In addition, the man will carry his family with him in either direction of emigration. Therefore, each of the age groups defined above is divided into two parts, males and females, and the parameters refer to each of these categories.

In order to evaluate the employment strains in both channels, masculine and feminine, the demand for employment is separated into two levels, one regarding the demand for male employment (for men only) and one relating to indistinct employment (for men or women), according to the situation of the labor market at the time.

In accordance with the above considerations, model S 3 was disaggregated and model S 4 was thus obtained. For disaggregating the population levels use was made of the diagram shown in figure 10. The age groups established are included in table I.. Thus, model S 4 was obtained and includes 64 levels.

Acknowledgment

Discussions with Mr. Eugenio Galdon, Mr. Juan R. de la Rua and Miss Carmela Martin of PREYSER, are gratefully acknowledged.

R E F E R E N C E S

1.- J.W. Forrester

Industrial Dynamics , M.I.T. Press (1961)

2.- J.W. Forrester

Principles of Systems , Wright-Allen Press (1968)

3.- H.R. Hamilton et alters.

Systems Simulation for Regional Analysis: An application to River - Planning. , M.I.T. Press (1969).

4.- J.J. Hellman

Migration in a Developing Contry : a Systems Study : The Stimulation and retention of agricultural migrants.

Ph D. Thesis, M.I.T. (1972)

APPENDIX A : TWO-LEVEL MODEL. S.1 - VARIABLE DEFINITION

NAME	T	DEFINITION
AEEN	A	AUXILIARY ECUATION FOR EFECTIVE NEED (PERSONS/YEAR)
E	L	EMPLOYMENT (PERSONS)
EI	C	EMPLOYMENT INITIAL (PERSONS)
ENFB	A	EMPLOYMENT IN THE NEW FACTORY BUILDING (PERSON/ YEAR)
ENFBT	T	EMPLOYMENT IN THE NEW FACTORY BUILDING TABLE (PERSON/ YEAR)
ENLF	A	EFECTIVE NEED FOR LABOR FORCE (PERSONS / YEAR)
EPS	A	EMPLOYMENT IN POPULATION SERVICES (PERSONS / YEAR)
ESRN	N	EMPLOYMENT IN SERVICES RATE NORMAL (PERSONS/PERSONS-YEAR)
FMD	N	FAMILLY DIMENSION PER MIGRANT (DIMENSIONLESS)
FENF	A	FIXED EMPLOYMENT IN THE NEW FACTORY (PERSONS / YEAR)
FENFT	T	FIXED EMPLOYMENT IN THE NEW FACTORY TABLE (PERS / YEAR)
IPLY	A	INCREASING POPULATION FROM LAST YEAR (PERSONS)
LF	A	LABOR FORCE (PERSONS)
LFPF	N	LABOR FORCE PARTICIPATION FRACTION (DIMENSIONLESS)
LYP	A	LAST YEAR POPULATION (PERSONS)
NBR	N	NET BIRTH RATE (BIRTHS / PERSONS - YEAR)
NBY	R	NET BIRTHS PER YEAR (PERSONS / YEAR)
NDR	N	NET DEATH RATE (DEATHS/PERSON-YEAR)
NDY	R	NET DEATHS PER YEAR (PERSON / YEAR)
NEY	R	NET EMPLOYMENTS PER YEAR (PERSONS/ YEAR)
NLF	A	NEED FOR LABOR FORCE (PERSONS / YEAR)
NMY	R	NET MIGRANTS PER YEAR (PERSONS / YEAR)
P	L	POPULATION (PERSONS)
TAPD	N	TIME AVERAGE POPULATION DELAY (YEARS)
ULF	A	UNEMPLOYED LABOR FORCE (PERSONS / YEAR)
UPR	N	UNEMPLOYED POPULATION RATE (DIMENSIONLESS)

APPENDIX B : FIVE - LEVEL MODEL S.2 - VARIABLE DEFINITION

NAME	T	DEFINITION
AEEN	A	AUXILIARY ECUACION FOR EFECTIVE NEED (PERSONS/YEARS)
E	L	EMPLOYMENT (PERSONS)
EI	C	EMPLOYMENT INITIAL (PERSONS)
ENFB	A	EMPLOYMENT IN THE NEW FACTORY BUILDING (PERSONS/YEAR)
ENFBT	T	EMPLOYMENT IN THE NEW FACTORY BUILDING TABLE (PER/YEAR)
ENLF	A	EFECTIVE NEED FOR LABOR FORCE (PERSONS/YEAR)
EPS	A	EMPLOYMENT IN POPULATION SERVICES (PERSONS/YEAR)
ESRN	N	EMPLOYMENT IN SERVICES RATE NORMAL (PERSONS/PERSONS-YEAR)
FDM	N	FAMILY DIMENSION PER MIGRANT (DIMENSIONLESS)
FENF	A	FIXED EMPLOYMENT IN THE NEW FACTORY (PERSONS/YEAR)
FENFT	T	FIXED EMPLOYMENT IN THE NEW FACTORY TABLE (PERS./YEARS)
H	L	HOUSEHOLDS (HOUSEHOLDS)
HUC	L	HOUSEHOLDS UNDER CONSTRUCTION (HOUSEHOLDS)
IHCLY	A	INCREASING FOR HOUSEHOLDS UNDER CONSTRUCTION FROM LAST YEAR(HOUSEH
IPLY	A	INCREASING POPULATION FROM LAST YEAR (PERSONS)
LF	A	LABOR FORCE (PERSONS)
LFPF	A	LABOR FORCE PARTICIPATION FRACTION (DIMENSIONLESS)
LTH	C	LIFE TIME FOR HOUSEHOLDS (YEARS)
LYHUC	A	LAST YEAR HOUSEHOLDS UNDER CONSTRUCTION (HOUSEHOLDS)
LYP	A	LAST YEAR POPULATION (PERSONS)
NBEY	R	NET BUILDING EMPLOYMENT PER YEAR (PERSONS/YEAR)
NBER	N	NET BUILDING EMPLOYMENT RATE (PERSONS/HOUSEHOLDS-YEAR)
NBR	N	NET BIRTH RATE (BIRTHS/PERSONS-YEAR)
NBY	R	NET BIRTHS PER YEAR (PERSONS/YEAR)
NC	L	NEED FOR CONSTRUCTION (HOUSEHOLDS)
NCY	R	NEED FOR CONSTRUCTION PER YEAR (HOUSEHOLDS/YEAR)
NDR	N	NET DEATH RATE (DEATHS/PERSONS-YEAR)
NDY	R	NET DEATHS PER YEAR (PERSONS/YEAR)

NAME	T	DEFINITION
NEY	R	NET EMPLOYMENTS PER YEAR (PERSONS/YEAR)
NHCR	N	NEED FOR HOUSEHOLD CONSTRUCTION RATE (HOUSEHOLD/PERSONS YEAR)
NHPY	R	NET HOUSEHOLDS PER YEAR (HOUSEHOLDS/YEAR)
NHRR	N	NEED FOR HOUSEHOLD RENOVATION RATE (HOUSEHOLD/PERSONS-YEAR)
NLF	A	NEED FOR LABOR FORCE (PERSONS/YEAR)
NMY	R	NET MIGRANTS PER YEAR (PERSONS/YEAR)
NPHR	N	NORMAL PERSONS PER HOUSEHOLD RATE (PERSONS/HOUSEHOLD)
NRY	R	NEED FOR RENOVATION PER YEAR (HOUSEHOLDS/YEAR)
P	L	POPULATION (PERSONS)
TACD	N	TIME AVERAGE FOR CONSTRUCTION DELAY (YEARS)
TALYC	N	TIME AVERAGE FOR LAST YEAR CONSTRUCTION (YEARS)
TAPD	N	TIME AVERAGE POPULATION DELAY (YEARS)
TC	N	TIME UNDER CONSTRUCTION
UHHY	R	UN-HABITABLE HOUSEHOLDS PER YEAR (HOUSEHOLDS/YEAR)
ULF	A	UNEMPLOYED LABOR FORCE (PERSONS/YEAR)
UPR	N	UNEMPLOYED POPULATION RATE (DIMENSIONLESS)

APPENDIX C : EIGHT - LEVEL MODEL S.3 - VARIABLE DEFINITION

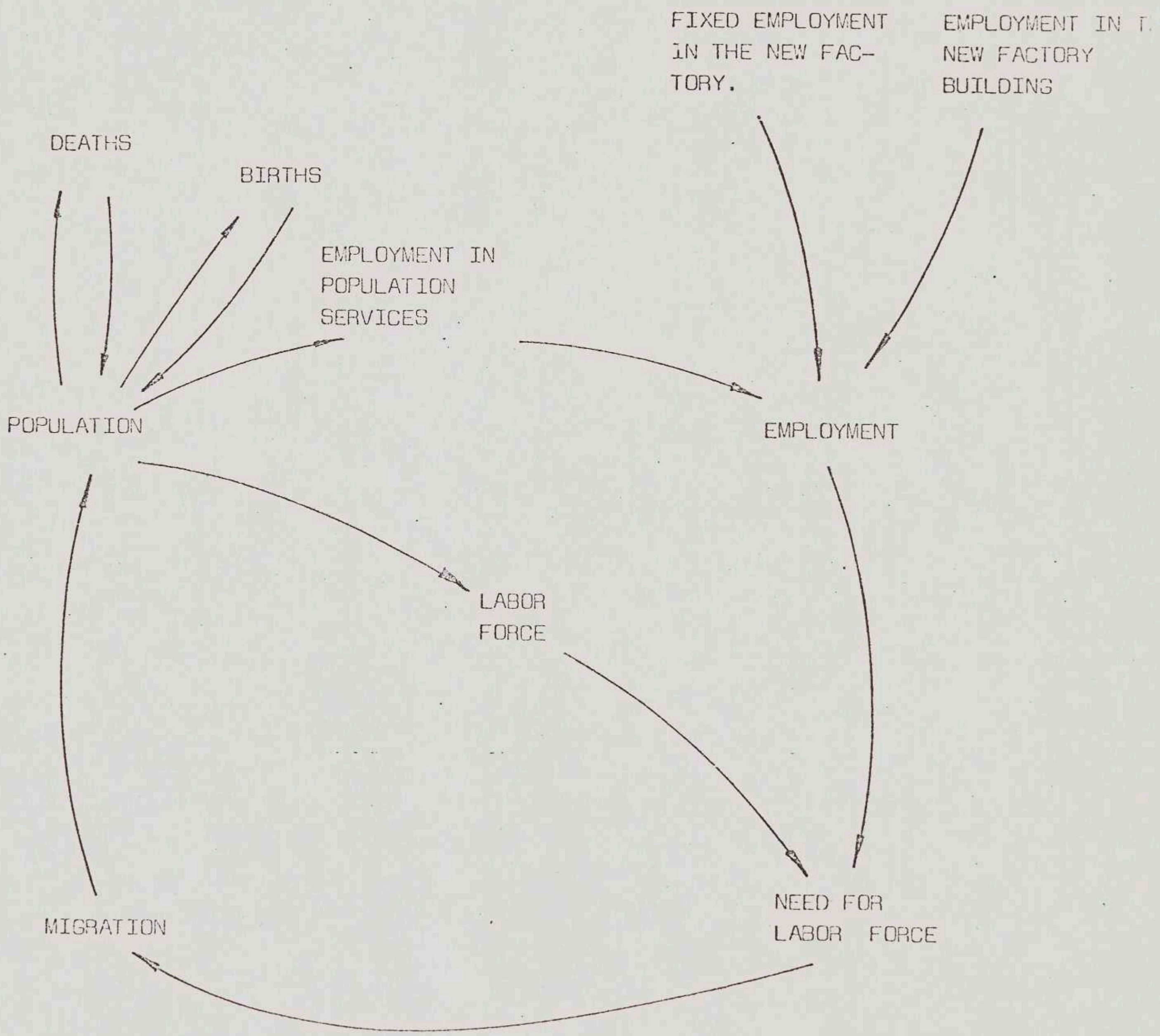
BER	N	BUILDING EMPLOYMENT RATE (PERSONS/HOUSEHOLD-YEAR)
BEY	R	BUILDING EMPLOYMENT PER YEAR (PERSONS/YEAR)
BNRFP	N	BIRTH NORMAL RATE OF FIXED POPULATION(PERSONS/PERSONS-YEAR)
BRM	A	BIRTH RATE MULTIPLIER (DIMENSIONLESS)
BRMT	T	BIRTH RATE MULTIPLIER TABLE (DIMENSIONLESS)
BRNP	N	BIRTH RATE NON-PERMANENT POPULATION (PERSONS/ PERSONS-YEAR)
BYFP	R	BIRTHS PER YEAR OF FIXED POPULATION (PERSONS/YEAR)
BYNP	R	BIRTHS PER YEAR NON-PERMANENT POPULATION (PERSONS/YEAR)
CFR	N	CONSTRUCTION TO FIXED POPULATION RATE (HOUSEHOLDS/PERSON-YEAR)
CNR	N	CONSTRUCTION TO NO-PERMANENT POPULATION RATE (HOUSEHOLDS/PERSON-Y)
DNRFP	N	DEATH NORMAL RATE OF FIXED POPULATION (PERSONS/PERSONS-YEAR)
DRM	A	DEATH RATE MULTIPLIER (DIMENSIONLESS)
DRMT	T	DEATH RATE MULTIPLIER TABLE (DIMENSIONLESS)
DRNP	N	DEATH RATE NON-PERMANENT POPULATION (PERSONS/PERSONS-YEAR)
DYFP	R	DEATHS PER YEAR FIXED POPULATION (PERSONS/YEAR)
DYNP	R	DEATHS PER YEAR NON-PERMANENT POPULATION (PERSONS/YEAR)
EFPS	A	EMPLOYMENT IN FIXED POPULATION SERVICES(PERSONS/YEAR)
EFSNR	N	EMPLOYMENT IN FIXED POPULATION SERVICES NORMAL RATE (DIMENSIONLESS
ENLF	A	EFECTIVE NEED FOR LABOR FORCE (PERSONS/YEAR)
ENPSR	N	EMPLOYMENT IN NON-PERMANENT POPULATION SERVICES RATE(DIMENSIONLESS
ENPS	A	EMPLOYMENT IN NON-PERMANENT POPULATION SERVICES (PERSONS/YEAR)
ESRM	A	EMPLOYMENT SERVICES RATE MULTIPLIER(DIMENSIONLESS)
ESRMT	T	EMPLOYMENT SERVICES RATE MULTIPLIER TABLE (DIMENSIONLESS)
FDFP	N	FAMILY DIMENSION AT FIXED POPULATION (DIMENSIONLESS)
FDNP	N	FAMILY DIMENSION NON-PERMANENT POPULATION (DIMENSIONLESS)
FE	L	FIXED EMPLOYMENT (PERSONS)
FEI	C	FIXED EMPLOYMENT INITIAL (PERSONS)
FENF	A	FIXED EMPLOYMENT IN THE NEW FACTORY (PERSONS/ YEAR)
FENFT	T.	FIXED EMPLOYMENT IN THE NEW FACTORY TABLE (PERSONS/YEAR)

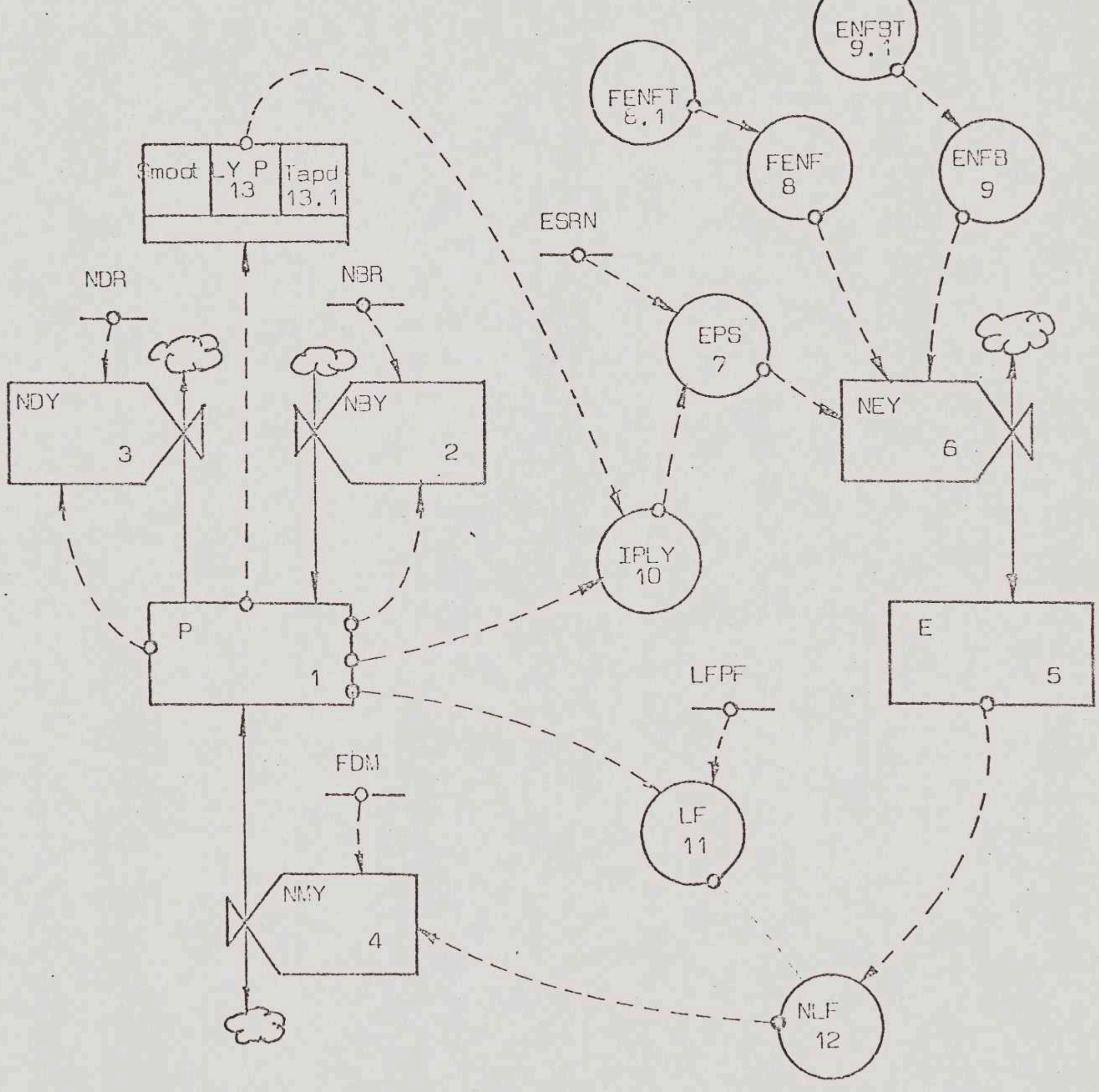
FEY	R	FIXED EMPLOYMENTS PER YEAR (PERSONS/YEAR)
FP	L	FIXED POPULATION (PERSONS)
FPI	C	FIXED POPULATION INITIAL (PERSONS)
H	L	HOUSEHOLDS (HOUSEHOLDS)
HI	C	HOUSEHOLDS INITIAL (HOUSEHOLDS)
HP	A	HOUSEHOLD POLICY (HOUSEHOLDS/YEAR)
HPD	A	HOUSEHOLD POLICY DELAY (HOUSEHOLDS/YEAR)
HPT	T	HOUSEHOLD POLICY TABLE (HOUSEHOLDS/YEAR)
HPY	R	HOUSEHOLD POLICY PER YEAR (HOUSEHOLDS/YEAR)
HSR	N	HOUSEHOLDS VS SERVICES RATE (DIMENSIONLESS)
HSUC	L	HOUSEHOLDS AND SERVICES UNDER CONSTRUCTION (HOUSEHOLDS)
HSUCI	C	HOUSEHOLDS AND SERVICES UNDER CONSTRUCTION INITIAL (HOUSEHOLDS)
ICLY	A	INCREASING FOR CONSTRUCTION FROM LAST YEAR (HOUSEHOLDS)
IFP	A	INCREASING FIXED POPULATION (PERSONS)
INP	A	INCREASING NON-PERMANENT POPULATION (PERSONS)
LF	A	LABOR FORCE (PERSONS)
LFPNR	N	LABOR FORCE PARTICIPATION NORMAL RATE (DIMENSIONLESS)
LRM	A	LABOR RATE MULTIPLIER (DIMENSIONLESS)
LRMT	T	LABOR RATE MULTIPLIER TABLE (DIMENSIONLESS)
LTH	C	LIFE-TIME FOR HOUSEHOLDS (YEARS)
LTS	C	LIFE-TIME FOR SERVICES (YEARS)
LYFP	A	LAST YEAR FIXED POPULATION (PERSONS)
LYHSC	A	LAST YEAR HOUSEHOLDS AND SERVICES UNDER CONSTRUCTION (HOUSEHOLDS)
LYNP	A	LAST YEAR NON-PERMANENT POPULATION (PERSONS)
MYFP	R	MIGRATION PER YEAR TO FIXED POPULATION (PERSONS/YEAR)
MYNP	R	MIGRATIONS PER YEAR TO NON-PERMANENT POPULATION (PERSONS/YEAR)
NC	L	NEED FOR CONSTRUCTION (HOUSEHOLDS)
NCI	C	NEED FOR CONSTRUCTION INITIAL (HOUSEHOLDS)
NCFP	R	NEED FOR CONSTRUCTION TO FIXED POPULATION (HOUSEHOLDS/YEAR)
NCNP	R	NEED FOR CONSTRUCTION TO NON-PERMANENT POPULATION(HOUSEHOLDS/YEAR)
NE	L	NON-DURABLE EMPLOYMENT (PERSONS)

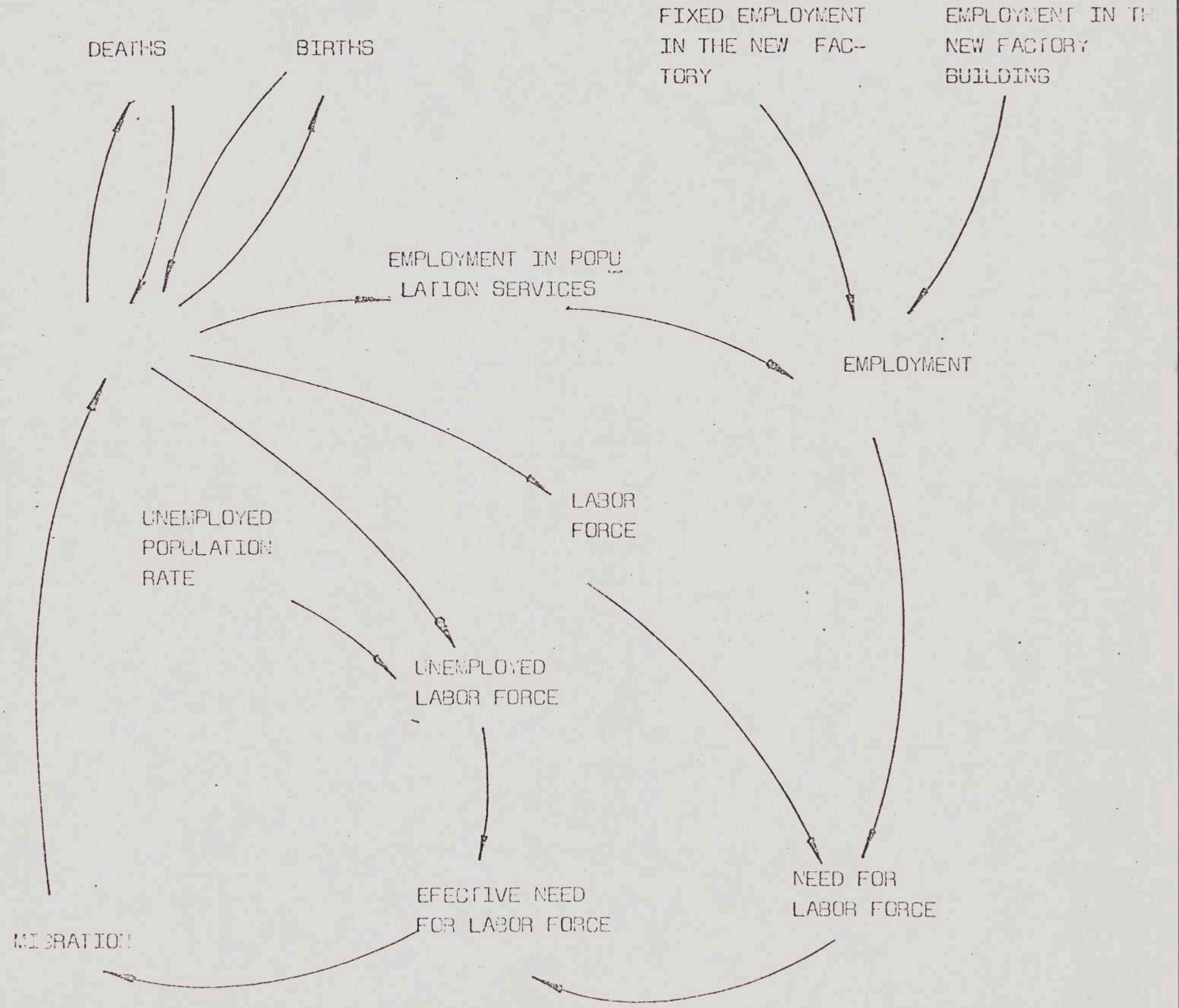
NENF	A	NON-DURABLE EMPLOYMENT IN THE NEW FACTORY (PERSONS/YEAR)
NENFT	T	NON-DURABLE EMPLOYMENT IN THE NEW FACTORY TABLE (PERSONS/YEAR)
NEY	R	NON-DURABLE EMPLOYMENT PER YEAR (PERSONS/YEAR)
NHY	R	NET HOUSEHOLDS PER YEAR (HOUSEHOLDS/YEAR)
NLF	A	NEED FOR LABOR FORCE (PERSONS/YEAR)
NNLF	A	NEED FOR NON-PERMANENT LABOR FORCE (PERSONS/YEAR)
NP	L	NON-PERMANENT POPULATION (PERSONS)
NRY	R	NEED FOR RENOVATION PER YEAR (HOUSEHOLDS/PERSONS-YEAR)
NSHP	R	NEED SATISFACTION FOR HOUSEHOLD POLICY (HOUSEHOLDS/YEAR)
NSM	R	NEED SATISFACTION FOR MODEL (HOUSEHOLDS/YEARS)
NSY	R	NET SERVICES PER YEAR (HOUSEHOLDS/YEAR)
PHNR	N	PERSONS PER HOUSEHOLDS NORMAL RATE (DIMENSIONLESS)
RRH	N	RENOVATION RATE FOR HOUSEHOLDS (YEARS)
RRS	N	RENOVATION RATE FOR SERVICES (YEARS)
S	L	SERVICES (HOUSEHOLDS)
SHR	N	SERVICES VS HOUSEHOLDS RATE (DIMENSIONLESS)
SI	C	SERVICES INITIAL
TACD	N	TIME AVERAGE FOR CONSTRUCTION DELAY (YEARS)
TAFP	N	TIME AVERAGE FIXED POPULATION (YEARS)
TAHPD	N	TIME AVERAGE HOUSEHOLD POLICY DELAY (HOUSEHOLD/YEAR)
TAHSC	C	TIME AVERAGE HOUSEHOLDS AND SERVICES UNDER CONSTRUCTION (YEARS)
TANP	N	TIME AVERAGE NON-PERMANENT POPULATION (PERSONS)
TCH	N	TIME UNDER CONSTRUCTION FOR HOUSEHOLDS (YEARS)
TCS	N	TIME UNDER CONSTRUCTION FOR SERVICES (YEARS)
UHHY	R	UN-HABITABLE HOUSEHOLDS PER YEAR (HOUSEHOLDS/YEAR)
UHSY	R	UN-HABITABLE SERVICES PER YEAR (HOUSEHOLDS/YEAR)
ULF	A	UN-EMPLOYMENT LABOR FORCE (PERSONS)
UPR	A	UN-EMPLOYMENT POPULATION RATE (DIMENSIONLESS)
UPRT	T	UN-EMPLOYMENT POPULATION RATE TABLE (DIMENSIONLESS)

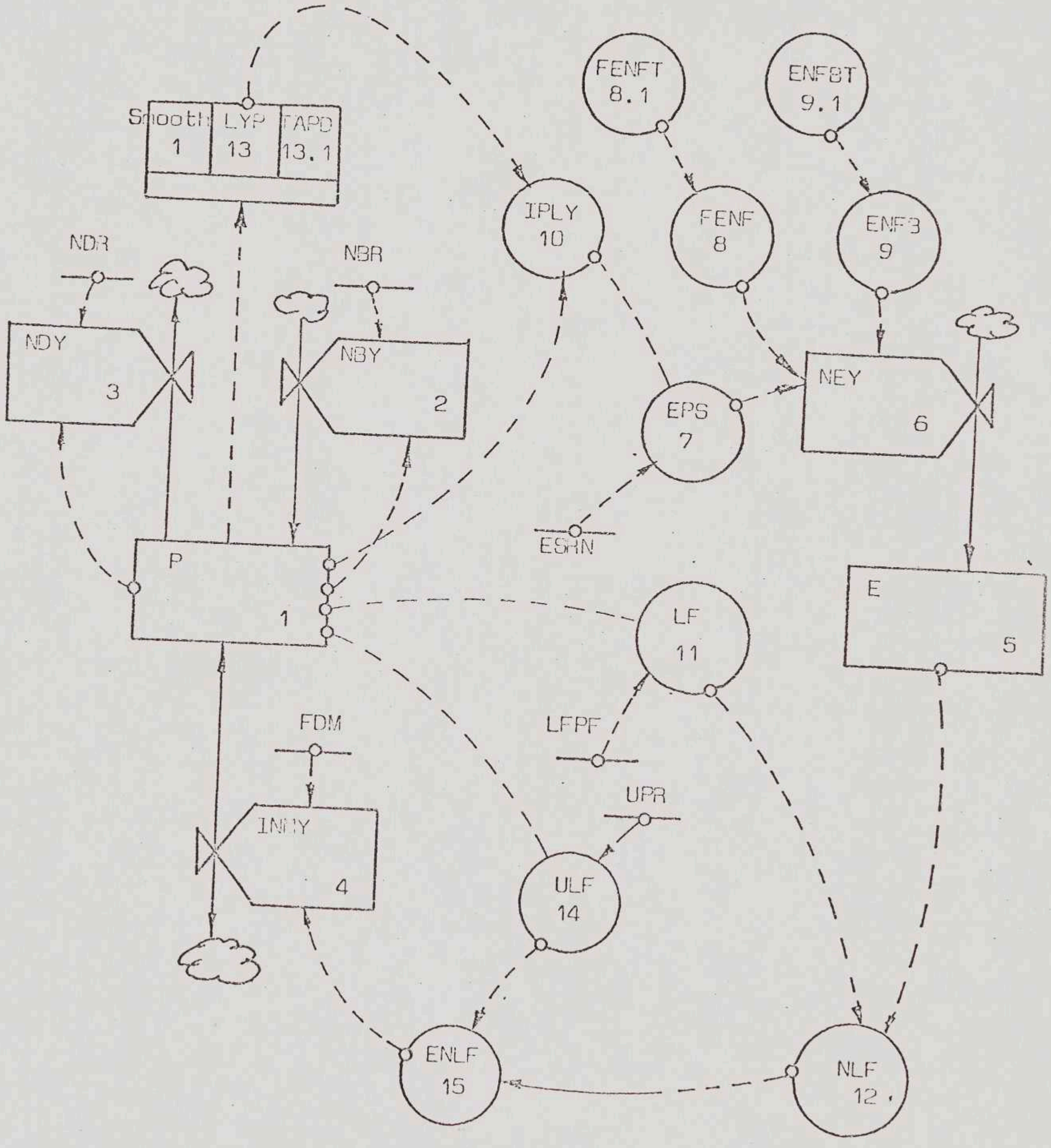
TABLE I

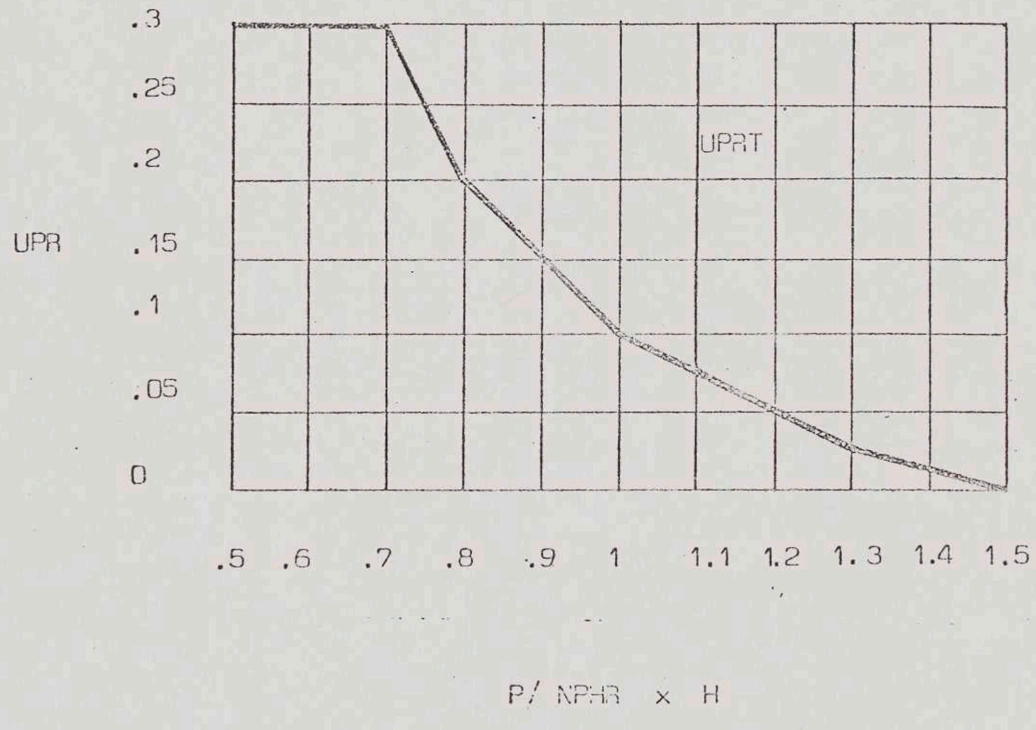
AGED LIMITS	POPULATION			
	FIXED		NON PERMANET	
	MALE	FEMALE	MALE	FEMALE
0 - 4	FPMA	FPFA	NPMA	NPFA
5 - 9	FPMB	FPFB	NPMB	NPFB
10 - 14	FPMC	FPFC	NPMC	NPFC
15 - 19	FPMD	FPFD	NPMD	NPFD
20 - 24	FPME	FPFE	NPME	NPFE
25 - 29	FPMF	FPFF	NPMF	NPFF
30 - 34	FPMG	FPFG	NPMG	NPFG
35 - 39	FPMH	FPFH	NPMH	NPFH
40 - 44	FPMI	FPFI	NPMI	NPFI
45 - 49	FPMJ	FPFJ	NPMJ	NPFJ
50 - 54	FPMK	FPFK	NPMK	NPFK
55 - 59	FPML	FPFL	NPML	NPFL
60 - 64	FPMM	FPFM	NPMM	NPFM
65	FPMN	FPFN	NPMN	NPFN

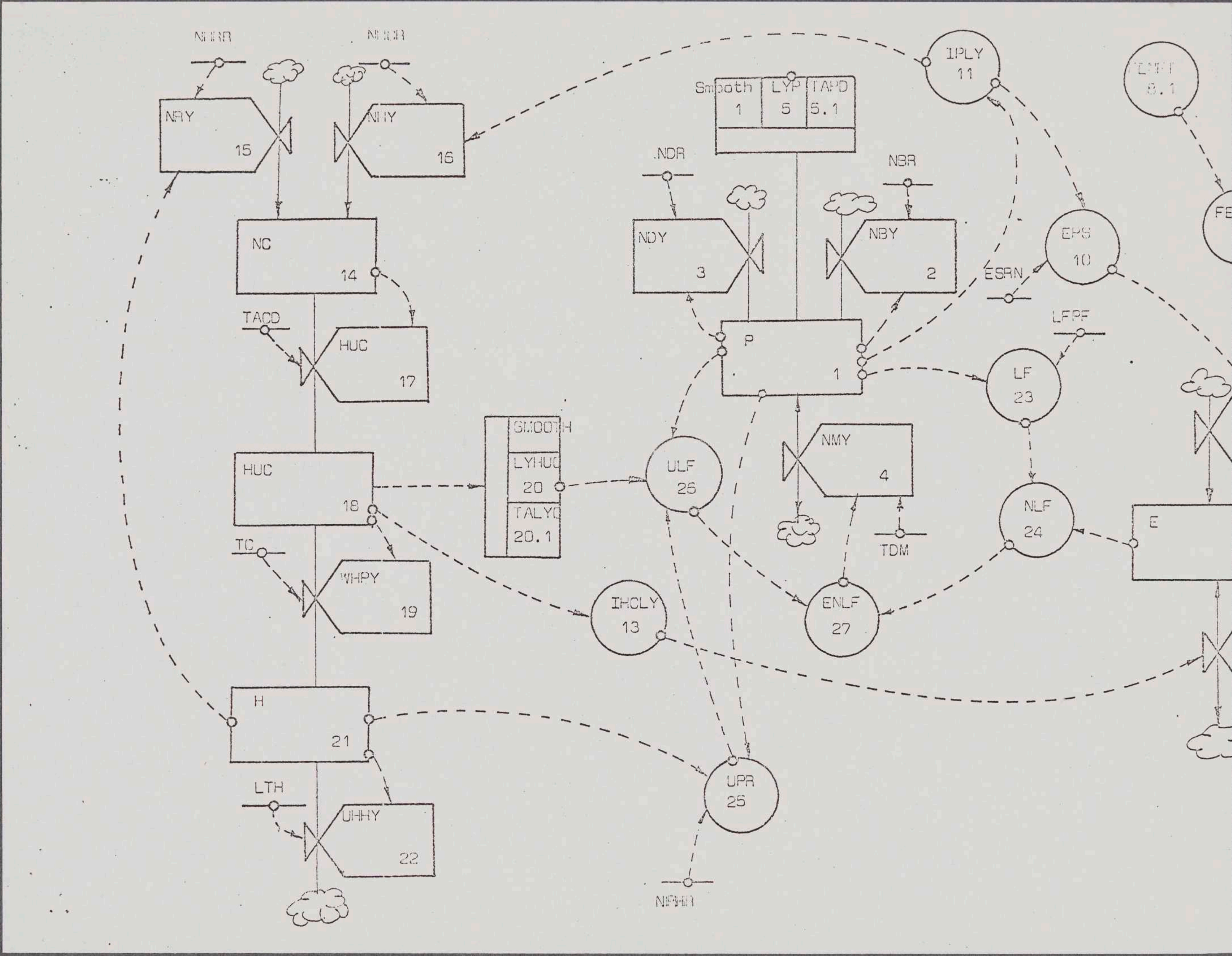

FIXED EMPLOYMENT IN THE NEW FACTORY.
EMPLOYMENT IN T NEW FACTORY BUILDING
DEATHS
BIRTHS
EMPLOYMENT IN POPULATION SERVICES
POPULATION
EMPLOYMENT
LABOR FORCE
NEED FOR LABOR FORCE
MIGRATION

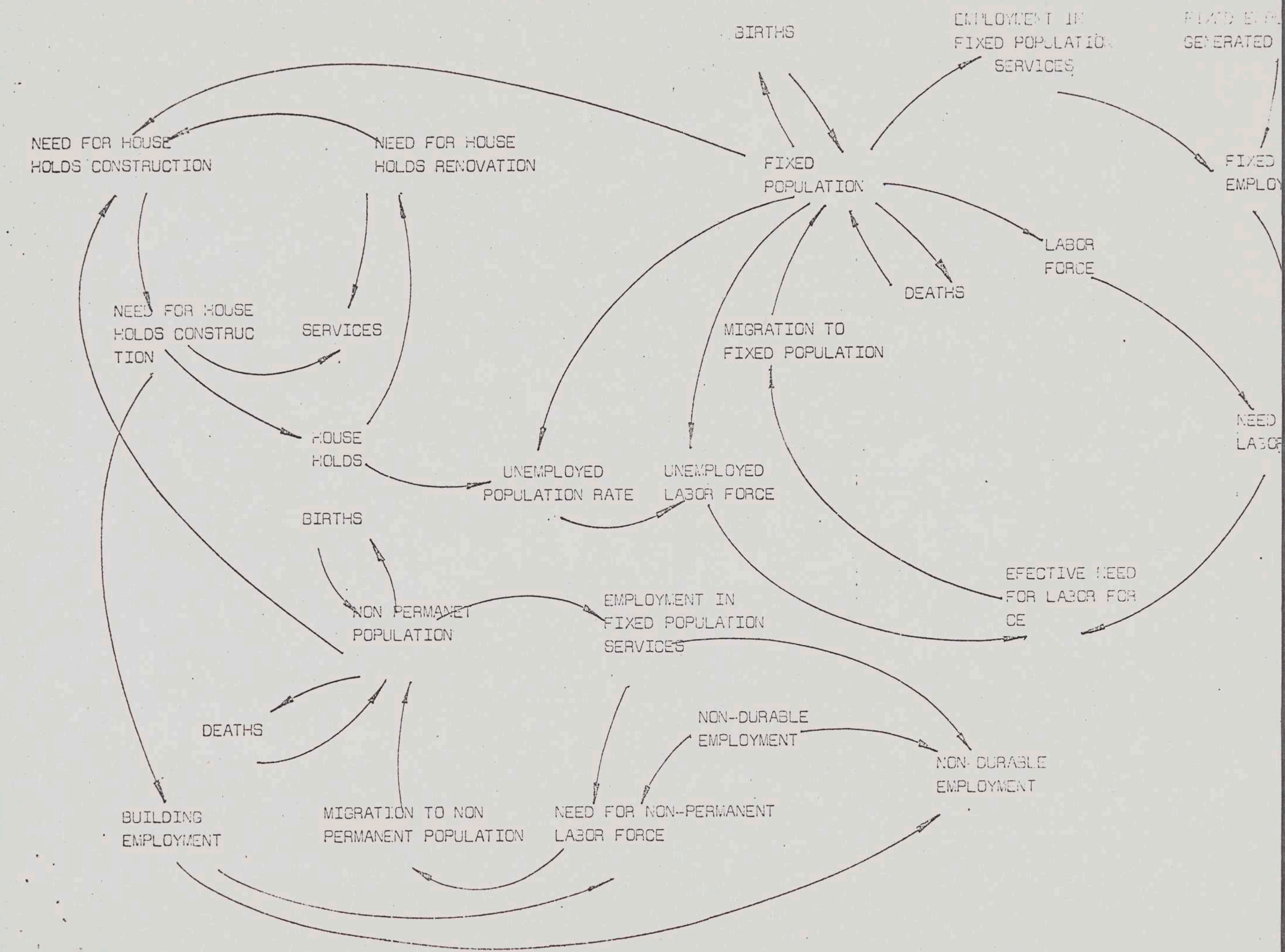

Smoot
LY P
13
Tapd
13.1
FENFT
8.1
ENFBT
9.1
FENF
8
ENFB
9
ESRN
NDR
NBR
EPS
7
NDY
3
NBY
2
NEY
6
IPLY
10
P
1
E
5
LFPF
FDM
LF
11
NMY
4
NLF
12

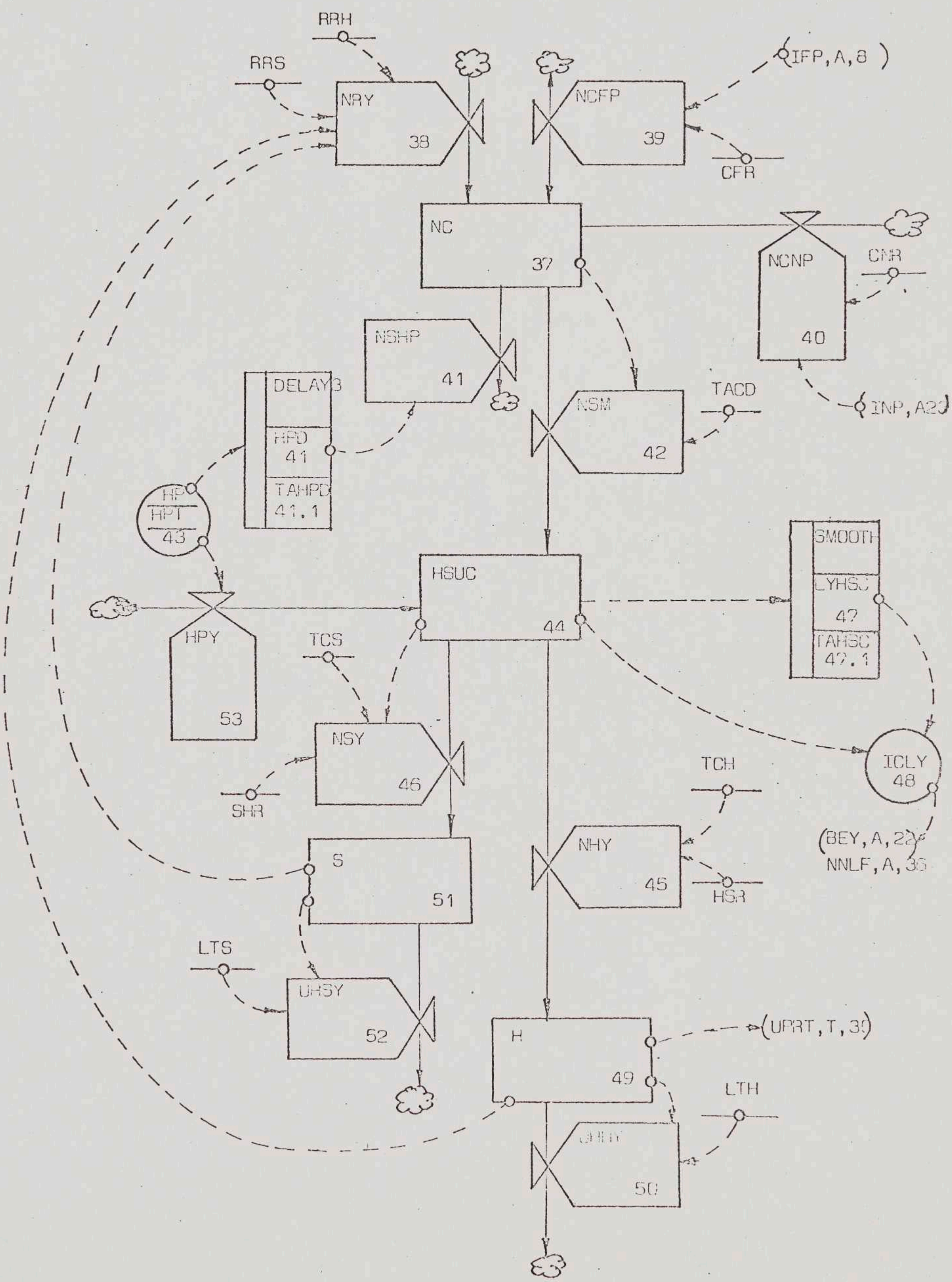

DEATHS
BIRTHS
FIXED EMPLOYMENT IN THE NEW FAC-TORY
EMPLOYMENT IN TH NEW FACTORY BUILDING
EMPLOYMENT IN POPU LATION SERVICES
EMPLOYMENT
LABOR FORCE
UNEMPLOYED POPULATION RATE
UNEMPLOYED LABOR FORCE
EFECTIVE NEED FOR LABOR FORCE
NEED FOR LABOR FORCE
MIGRATION

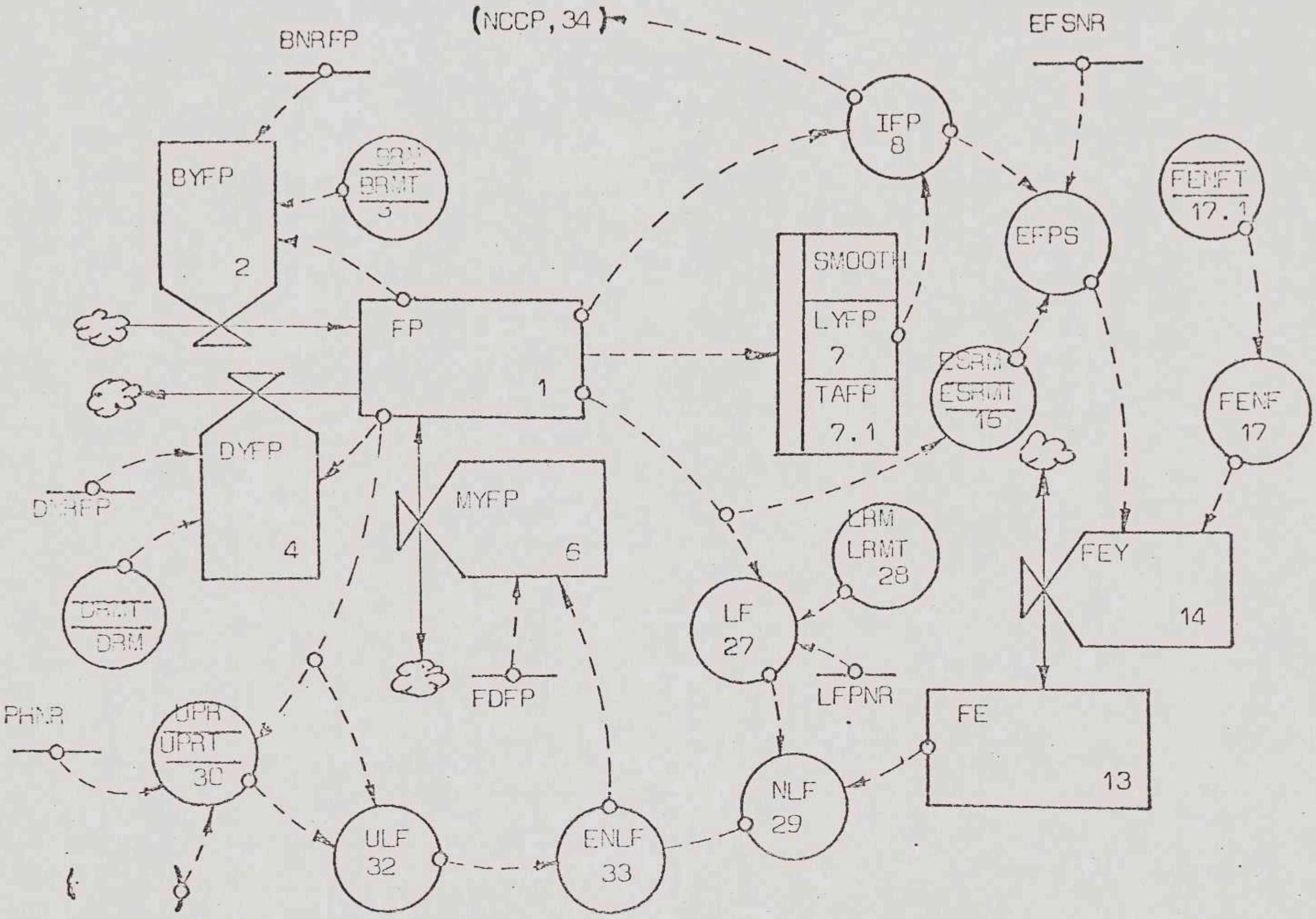

Smooth 1
LYP 13
TAPD 13.1
FENFT 8.1
ENFBT 9.1
IPLY 10
FENF 8
ENFB 9
NDR
NBR
NDY 3
NBY 2
NEY 6
EPS 7
ESRN
P 1
E 5
LF 11
FDM
LFPF
UPR
INRY 4
ULF 14
ENLF 15
NLF 12

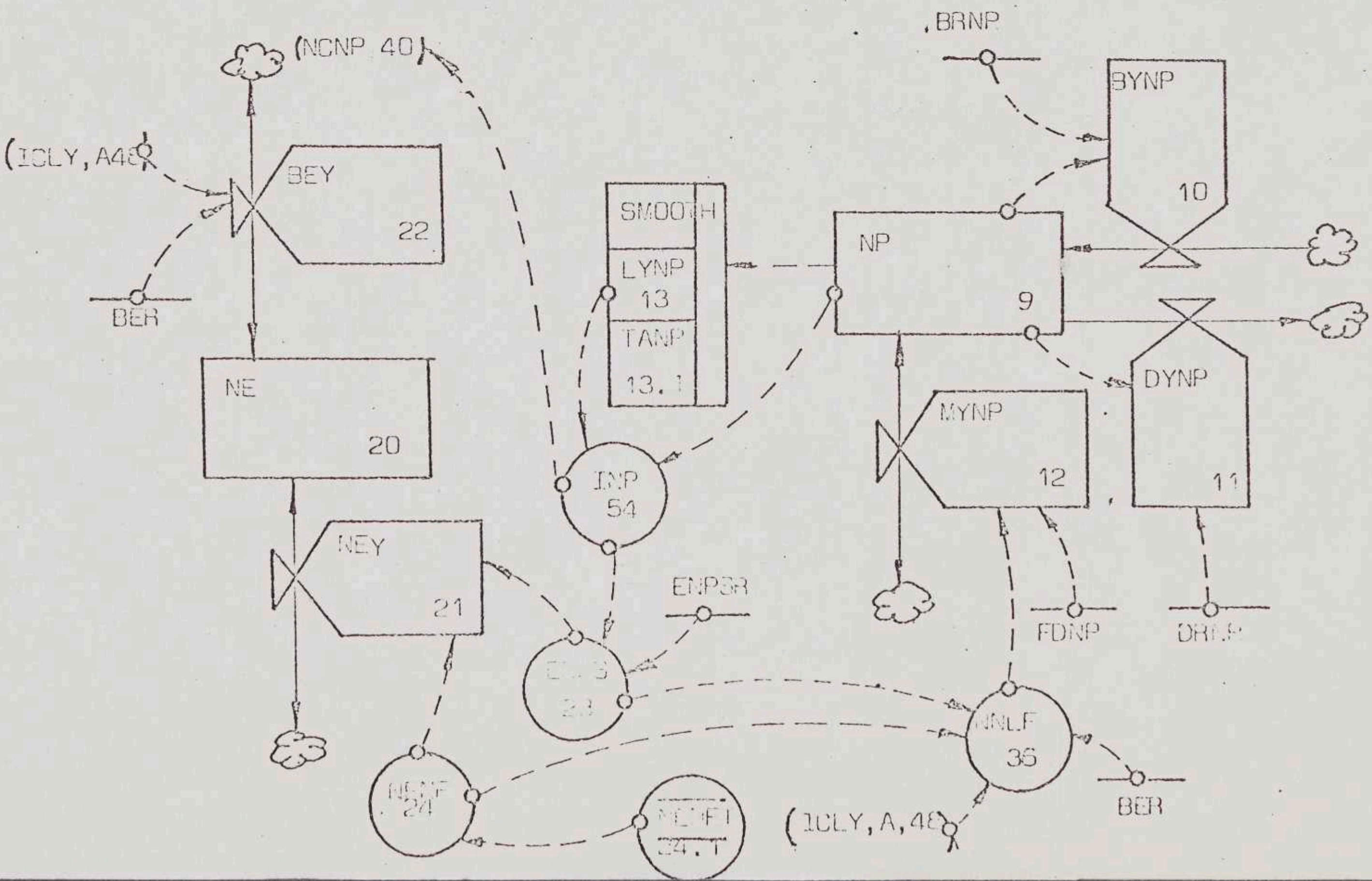

.3
.25
.2
UPR
.15
.1
.05
0
UPRT
.5
.6
.7
.8
.9
1
1.1
1.2
1.3
1.4
1.5
P/ NPHR x H

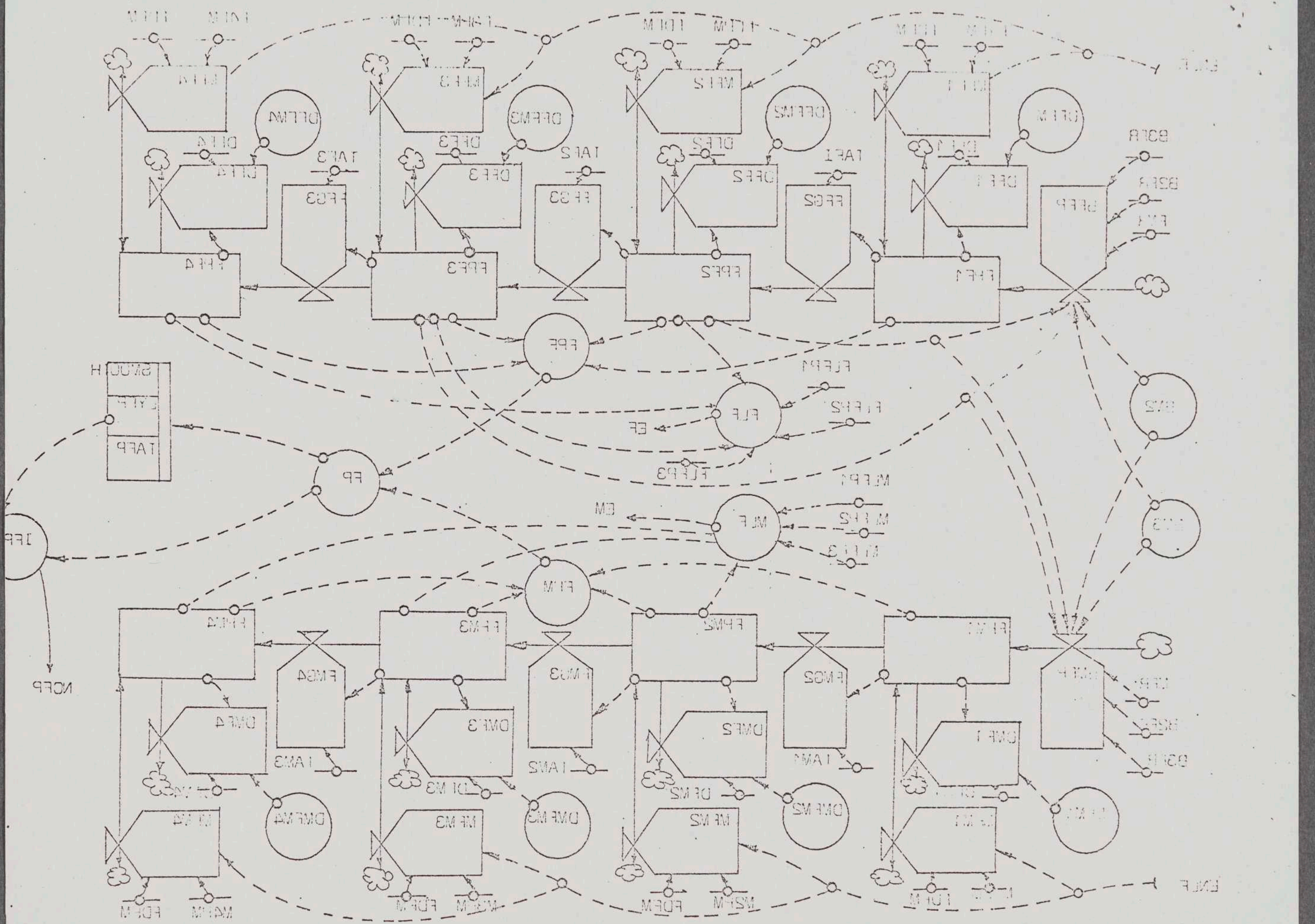

NRY
15
16
Smooth
1
LYP
5
TAPD
5.1
IPLY
11
NDR
NBR
NC
14
NDY
3
NBY
2
EPS
10
ESRN
TACD
HUC
17
P
1
LFPF
LF
23
SMOOTH
LYHUC
20
TALYC
20.1
HUC
18
ULF
NMY
4
TDM
NLF
24
E
TC
WHPY
19
IHCLY
13
ENLF
27
H
21
LTH
UPR
25
UHHY
22


BIRTHS
EMPLOYMENT IN FIXED POPULATION SERVICES
GENERATED
NEED FOR HOUSE HOLDS CONSTRUCTION
NEED FOR HOUSE HOLDS RENOVATION
FIXED POPULATION
FIXED
EMPLOY
LABOR FORCE
DEATHS
NEED FOR HOUSE HOLDS CONSTRUC TION
SERVICES
MIGRATION TO FIXED POPULATION
NEED
LABOR
HOUSE HOLDS
UNEMPLOYED POPULATION RATE
UNEMPLOYED LABOR FORCE
BIRTHS
EFECTIVE NEED FOR LABOR FOR CE
NON PERMANET POPULATION
EMPLOYMENT IN FIXED POPULATION SERVICES
NON-DURABLE EMPLOYMENT
DEATHS
NON-DURABLE EMPLOYMENT
BUILDING EMPLOYMENT
MIGRATION TO NON PERMANENT POPULATION
NEED FOR NON-PERMANENT LABOR FORCE

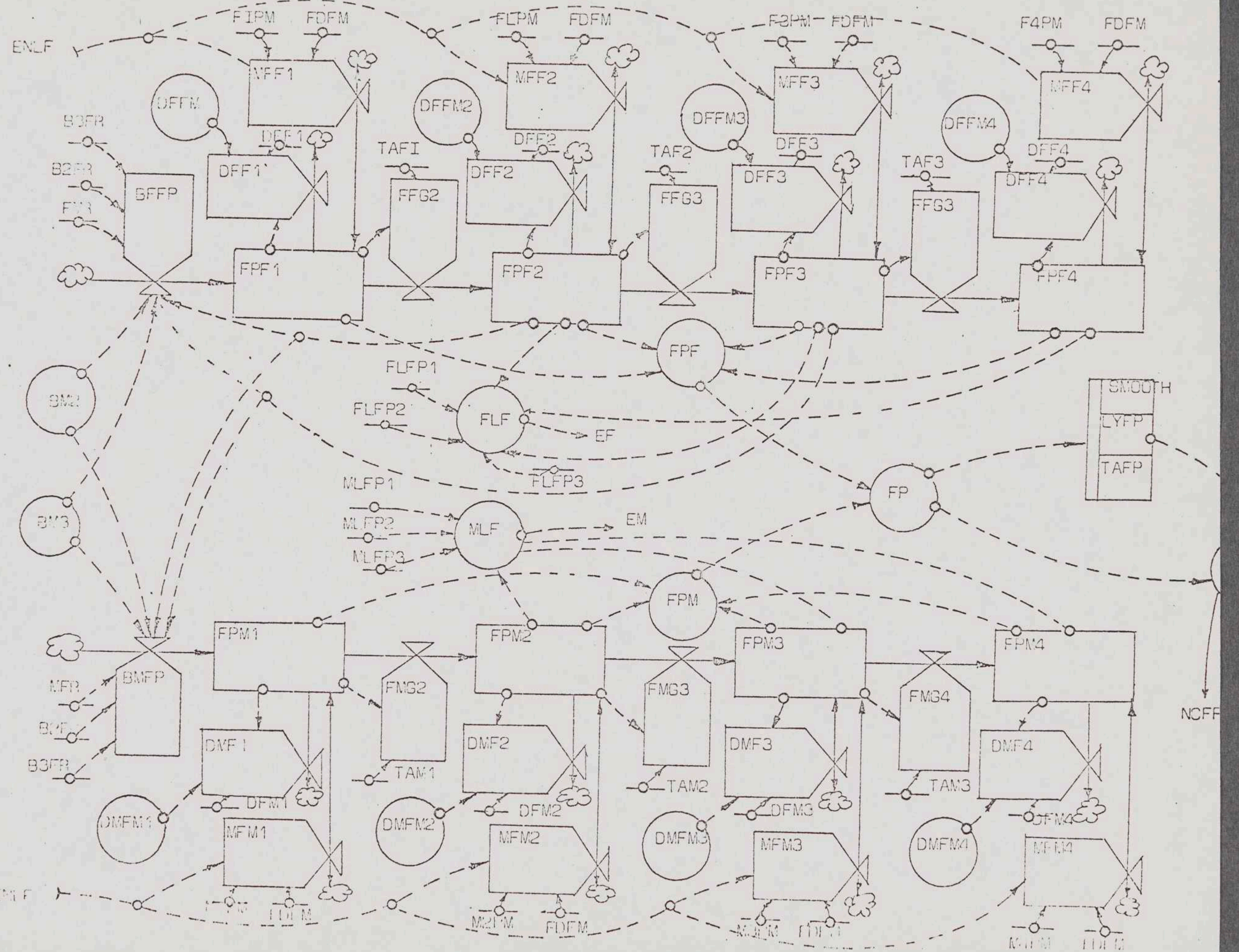

RRH
RRS
NRY
38
NCFP
39
(IFP,A,8)
CFR
NC
37
NCNP
40
CNR
(INP,A20)
NSHP
41
DELAY3
RPD
41
TAHPD
41.1
NSM
42
TACD
HP
HPT
43
SMOOTH
LYHSC
47
TAHSC
47.1
HSUC
44
HPY
53
TCS
NSY
46
SHR
ICLY
48
TCH
NHY
45
HSR
(BEY,A,22
NNLF,A,36
S
51
LTS
UHSY
52
H
49
(UPRT,T,39)
LTH
50


(NCCP, 34)
BNRFP
EFSNR
BYFP
2
IFP
8
FENFT
17.1
EFPS
SMOOTH
LYFP
7
TAFP
7.1
FP
1
ESRM
ESRMT
15
FENF
17
DYFP
4
MYFP
6
LRM
LRMT
28
FEY
14
DRMT
DRM
LF
27
FDFP
LFPNR
FE
13
PHNR
UPR
UPRT
30
NLF
29
ULF
32
ENLF
33


(NCNP 40)
BRNP
BYNP
10
BEY
22
SMOOTH
LYNP
13
TANP
13.1
NP
9
BER
NE
20
DYNP
MYNP
12
11
INP
54
NEY
21
ENPSR
FDNP
NNLF
36
BER
(ICLY, A, 48)



FPF1
FPF2
FPF3
FPF4
DFF1
DFF2
DFF3
DFF4
DFFM2
DFFM3
DFFM4
TAF1
TAF2
TAF3
FFG2
FFG3
FPF
FLF
EF
FP
MLF
EM
FPM
FPM1
FPM2
FPM3
FPM4
FMG2
FMG3
FMG4
DMF1
DMF2
DMF3
DMF4
DMFM2
DMFM3
DMFM4
MFM2
MFM3
TAM1
TAM2
TAM3
FDFM
ENLF
NOFP
TAFP



ENLF
F1PM
FDFM
FLPM
FDFM
F3PM
FDFM
F4PM
FDFM
MFF2
MFF3
MFF4
DFFM
DFFM2
DFFM3
DFFM4
DFF1
DFF2
DFF3
DFF4
B3FR
B2FR
TAFI
TAF2
TAF3
BFFP
FFG2
FFG3
FFG3
FPF1
FPF2
FPF3
FPF4
FPF
FLFP1
FLFP2
FLF
EF
FLFP3
SMOOTH
LYFP
TAFP
FP
MLFP1
MLF
EM
FPM
FPM1
FPM2
FPM3
FPM4
FMG2
FMG3
FMG4
BMFP
MFR
B3FR
DMF2
DMF3
DMF4
TAM1
TAM2
TAM3
DFM1
DFM2
DFM3
DMFM2
DMFM4
MFM1
MFM2
MFM3
M2PM
FDFM
NCFF

Spain
SD Centers

ESCUELA TECNICA SUPERIOR
DE
INGENIEROS INDUSTRIALES
DE SEVILLA

AVDA. REINA MERCEDES, S/N.
TELS. 61 11 50 - 61 11 54 - 61 11 58

SEVILLA, August 16, 1975

Profesores

Prof. J. Aracil
Esc. Tec. Sup. Ing. Industriales
Avda. Reina Mercedes s/n
Sevilla (Spain)

Destinatario:

Professor Jay W. Forrester
M.I.T. System Dynamics Group
E40-253
50 Memorial Drive
Cambridge, Massachusetts 02139

Dear Professor Forrester,

I have been advised to write you by Mr. Jean D. Lebel, who I met recently in France, and who, I believe, has written you mentioning a model we have built.

As Mr. Lebel perhaps mentioned we have developed, using Systems Dynamics, a model of the demographic impact of a new factory in a underdeveloped area. This model has been actually applied by urban planners to forecast the demographic evolution of a small town in the Spanish mediterranean coast where a new factory has been built.

I include herewith a copy of a paper, reporting the model, witch shuold de presented to the III International Congress on Cybernetics adn Systems to be held in Bucharest, Romania, next weeks.

We shall appreciate very much any comment on our work.

Yours faithfully,

Javier Aracil

P.S. I aknowledge receipt of your paper "Understanding Social and Economic Change in the United States" witch seems to me very challenging.

System Dynamics Centers, Active 3 of 4

netherlands" ✓
✓ SD Centers

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

July 15, 1974

Jay W. Forrester
Germeshausen Professor

Professor Dr. Jan Tinbergen
Erasmus University
Wytemaweg 2A, P.B. 1738
Rotterdam
THE NETHERLANDS

Dear Professor Tinbergen:

As you may know, since the Project on my World Dynamics book and The Club of Rome Project on The Limits to Growth, we have been working on a much more extensive program in applying system dynamics to social and economic change at the national level.

Enclosed is a description written by three members of my staff. If you find this of interest, we could send additional information as it becomes available.

Although economists, especially in the United States, have not looked favorably on our system dynamics approach, perhaps the uncertainty about present national and international conditions justifies a new look at economic behavior. I would be pleased to receive any comments you care to make.

Sincerely yours,

JWF*eac
Encl: "The National Socio-Economic Model" by Gilbert W. Low, Nathaniel J. Mass, and Peter M. Senge (D-2006-3)

8/12/74
Netherlands

Prof. J. TINBERGEN

DEN HAAG, August 7, 1974
HAVIKLAAN 31
TELEFOON 39 48 84

Dear Professor Forrester,

Thank you for yours of July 15 and the annex which I read with interest. I am one of those who have taken seriously your work, and hope for a fruitful future co-operation between yourself and econometricians. I shall be glad to be kept informed about the progress of your model. As you may know, some of my countrymen and I have been involved in attempts to develop some aspects of World 3 and are in regular contact with Dr Peccei.

As a separate subject I have been dealing recently with a study on income distribution and just finished a small book about it.

Netherlands
SD Centers

For this reason one specific question I would have rightaway to your team is how they look at trade union policies: what aims will they assume trade unions are after? In my own continent an additional question is what democratic socialist parties are aiming at; in American terms I presume that question might be: what are liberal and radical politicians – as far as the latter have influence – after?

I will put you on the mailing list of some publications you might be interested in.

Yours sincerely,

J. Tinbergen

/ SD- Active Centers
Romania

July 1, 1975

Dr. Mihai Botez, Director
International Center of Methodology
for Future and Development Studies
3-5 Mihail Moxa
Bucharest, ROMANIA

Dear Dr. Botez:

When I returned to Cambridge after being unavoidably detained, Professor Mass told me of his interesting visit with you. I regret having missed the opportunity of talking with you Friday. When your plans for returning in the fall are firmed up, please let me know when you will be here, and I shall try to see you.

Sincerely yours,

eac

MASSACHUSETTS INSTITUTE OF TECHNOLOGY - Registry of Guests, Room 7-121

SCHEDULE OF APPOINTMENTS

NAME: Dr. Mihai BOTEZ

Appointment June 27 at 2:00

DATE OF VISIT: 6/26 & 6/27/75

HOTEL: The Lenox

ESCORT-INTERPRETER:

TITLE: Director of the International Center of Methodology for Future and Development Studies

ADDRESS: Bucharest, ROMANIA

SPONSOR: IIE and BCIV

TO BE RECEIVED BY:	ROOM	HOUR
6/26/75		
Professor Eugene B. Skolnikoff Director, Center for International Studies	E53-473	11:00 a.m.
Professor Nazli Choucri Field Departmentof Political Science	E53-493	12 noon For Lunch
6/27/75		
✓ Professor Jay W. Forrester Sloan School of Management	E53-454C	2:00 p.m.

DATE: 6/23/75
EXTENSION: 3-2851

Carolyn B. Cox, Director
Registry of Guests

BOTEZ

6/26

Institute of International Education
Washington Office
1709 NEW YORK AVENUE N.W.
WASHINGTON, D.C. 20006
(202) 872 9060

BIOGRAPHICAL DATA: Dr. Mihai BOTEZ
Director of the International Center of Methodology for Future and Development Studies
Bucharest, Romania

PROGRAM OFFICER: William Topolsky

Dr. Botez is a participant in the International Visitor Program, Bureau of Educational and Cultural Affairs, U.S. Department of State. Visiting the United States from May 26 to June 25, 1975.

PRESENT POSITIONS:

1. Director of the International Center of Methodology for Future and Development Studies
2. Executive Secretary of the Romanian National Commission for Future Studies
3. Professor of Mathematics, University of Bucharest

PAST POSITIONS:

1. Research Associate, Institute of Mathematics Romanian Academy of Science (1963-64)
2. Research Associate, Center for Mathematical Statistics, Romanian Academy of Science (1964-67)
3. Chief, Department for Operations Research, Mathematics in Management, Data Processing (1967-70)

TRAVELS ABROAD: Study and research trips to France, West Germany, Italy, U.S.S.R., Denmark, Poland, Bulgaria, Belgium.

-OVER-

EDUCATION:	1. Ph.D. in Mathematics, Institute for Mathematics of the Romanian Academy of Science (1966)
	2. M.A., University of Bucharest (1963)
	3. Training in Data Processing, Systems Analysis, and Programming, IBM Belgium Branch, Brussels (1968)
	4. Training in Operations Research, Institute for Statistics, Free University of Brussels (1968)
	5. Training in Education for Data Processing, IBM-ROECE, Vienna Branch (1970)
KNOWLEDGE OF ENGLISH:	Good. Dr. Botez also speaks French and Romanian.
MARITAL STATUS:	Married.
ADDRESS:	3-5 Mihail Moxa, Bucharest.
DATE OF BIRTH:	November 18, 1940, Bucharest

PUBLICATIONS AND PAPERS

Selected List

a) FUTURE STUDIES

1. A Systems Approach to Operational Forecasting, paper submitted to European Conference of Experts in Research & Development, Paris 1970.

2. Future-Oriented Thinking. Construction and Operations Research on Possible Futures, paper submitted to National Symposium "Future Research & Long-Range Planning", Piatra-Neamt, Romania, 1971 (printed in the volume of Symposium documents).

3. Modèles opérationels dans les recherches prospectives, paper submitted to International Congress of Logic, Methodology and Philosophy of Science, Bucharest, 1971.

4. An Introduction to Prospective Research, CIDSP - Publishing House, 1971, 89 pag.

5. Sur la méthodologie de la créativité, paper submitted to International Colloquim "Creativity in Futures Research", Klagenfurt (Austria), 1971.

6. Perspectives des ordinateurs dans l'enseignement et dans la recherche scientifique, paper presented at the International Congress "Science and Technology of Year 2000", Paris 1971 (mimeographed).

7. Futures Research in an Operational Perspective, Viitorul Social, 2, 1972, p. 548-555.

8. A Course in Prognosis (published under the care of Mihai C. Botez) co-author, CIDSP - Publishing House, Bucharest, 1972, 485 pag.

9. Mathematical Methods in Futures Research, paper submitted to International Seminar on Forecasting, Riniya, Poland, 1972.

10. Some Observations on Man-Society Interactions, paper presented at the Rome Special World Conference on Futures Research, 1973, printed in Conference Documents "Human Needs, New Societies, Supportive Technologies", vol. 2.

11. Mathematics for Forecasting, University Press, Bucharest, 1974, 97 pag.

12. Prediction and Postdiction in Decision Making, paper submitted to International Seminar "Mathematical Approaches in International Relations", Brasov, Romania, 1974.

13. A Methodological Structure for Systems Design, Seminar on Systems Management, Bucharest, 1974.

14. Forecasting - Open Planning - Systems Design. Problematique and Methodology. A book on forecasting methodology and design. 320 pag. IRADES, Rome, Italy (under print)

15. The Methodology of Previsional Management of Large Territorial Systems, paper submitted to International Seminar on Systems Thinking in Management, Bucharest, 1974.

16. Forecasting and Conflicts, 330 pag., Editura Militara, Bucharest, 1974 (co-author)

17. The Dynamics of Change, 280 pag., (M.C. Botez Editor), Editura Stiintifica, Bucharest (under print)

b) OPERATION RESEARCH

18. Finite Extended Random Automata, International Congress of Data Processing, Bucharest, 1967.

19. Random Discrete Models in Operations Research, Congress of "Mathematiciens d'expression latine", Bucharest, 1969.

20. Sur un modèle de réparations de l'équipement, Cahiers du Centre d'Etude de Recherche opérationelle, Bruxelles, 11.II.1969, p.69-74.

21. A Course in Operations Research, Lecture Notes, Academy for Economic Studies Press, 1970 (1st edition), 1971 (2nd edition).

22. Water Requirements and the Management of Water Ressources (co-author), 1972, CIDSP - Publishing House, Bucharest, 1974.

23. Oil Crisis - A Methodological Structure (co-author), CIDSP - Publishing House, Bucharest, 1973.

24. Elements of Describing International Situations. Modelling and Open Modelling, in "Mathematical Approaches to International Relations" (M. Malita editor), Reidel Publishing House, Amsterdam, New York, (under print)

c) PROBABILITY THEORY

25. Quelques remarques sur la loi forte des grands nombres pour les systèmes à liaisons complètes, Bull. Math. de la Soc. Sci. Math. de la RSR, 8(56), no. 3-4, 1964.

26. Un theorème limite à plusieurs dimensions pour les systèmes aléatoires à liaisons complètes (co-author), DAN SSSR, 1965,

27. On the Ergodic Behaviour of Discrete Random Processes (co-author), Rev. Roum. Math. Pures et Appl., X, 7, 1965.

28. Sur la convergence des series des variables aléatoires formant un 1er processus (co-author), C.R. Acad.Sci. Paris, 260 p., 1965.

29. Sur quelques types des lois-limite. Bull.Math. de la Soc. Sci. Math. de la RSR, 10 (58), 3, 1966.

30. Théorie ergodique pour les systèmes à liaisons complètes. Bull. Math. de la Soc.Sci.Math. de la RSR, 11 (59), 1, 1967.

31. Sur l'ergodicite des systèmes à liaisons complètes. Atti dell Rend. dei Accad. Nat. dei Lincei, cl. Sci. Fis. Mat. Nat., VII, XLII, 6, 1967.

32. On Some Properties in Quadratic Mean (co-author). Paper presented at the International Congress of "Mathematiciens d'expression Latine", Bucharest, 1969.

d) MATHEMATICAL STATISTICS

33. Sur quelques problèmes nonparamétriques pour les systèmes aléatoires à liaisons complètes. Revue Roum. Math. Pures et Appl., X, 9, 1965.

34. On a Method of Estimation for Systems with Complete Connections. Stud.Cerc. Mat., 1, 18, 1966.

35. On a Theorem of a A.I. Khinching (co-author). Annals of the University of the University of Bucharest, 1969.

36. On a Class of Random Linear Models and Their Forecasting, in "General Systems Theory Reports", CIDSP, Bucharest, 1974.

*
* *

37. Problems of the Social and Economical Prognosis Under the Conditions of the Revolution in Science and Technology, in "The Revolution in Science and Technology and the Progress", volume published by the Academy of Social and Political Sciences, Editura Politica, Bucharest, 1974.

38. Creativity and Management, in "Introduction to Social Management Science" (S. Tamas ed.), Bucharest, Editura Politica, 1974.

39. The Revolution in Science and Technology and the Future of Humans. Paper published in "The Revolution in Science and Technology and Contemporary Social Development", volume issued in preparation of the International Congress of Sociology, Toronto, Bucharest, Editura Academiei, 1974.

①

INTERNATIONAL CENTER OF

f+d methodology

FOR FUTURE AND DEVELOPMENT STUDIES

To Prof. Jay Forrester,
with the best wishes

June 2, 1975

M C Botez

Bucharest 8
3-5, M. Moxa Street
Romania

SELECTED PAPERS

MIHAI C. BOTEZ
MARIANA CELAC
PAUL DIMITRIU

GLOBAL MODELLING. A CRITICAL APPROACH

GLOBAL MODELLING. A CRITICAL APPROACH

M.C.Botez, M.Celac, P.Dimitriu

1. Global modelling is a response of science in the 8th decade of our century to difficulties generated by:

(a) the increasing complexity of problems confronting society: large dimensions, interconnexions between scientific-technological, economic, social and human aspects, a planetary character of social resources and responsibilities.

(b) the high social dynamics rates, due to the scientific and technical advance (the scientific and technical revolution), to social mutations and to interactions between such revolutionary processes: the ambivalent effects of mutations in science and technology, the increasing surprise elements owing to the summation of such effects, the development imbalances, the problems of social and human control over the world dynamics.

(c) the need for rigour in investigating social dynamics problems, to obtain really useful results for political decision in a world in an accelerated interdependence and motion.

The adjective global appearing in the expression global modelling refers to the study of the whole world, in contrast to general social modelling.

Due to (a), global modelling is naturally included in the scope of the general systems theory; due to (b), in the field of prospective research and of prognosis; finally, (c) underlines the rigorous compass of developments which require structural-quantitative methods (mathematical and computer science).

Therefore, global modelling is at the crossroad of systems approach and of prospective approach, cultivated in the perspective of the structural-quantitative modelling of world dynamics. What do such delimitations imply? What results have been obtained? Can we talk of the dynamics of global modelling itself, to detect trends? What are the open problems in this modern field of interdisciplinary concerns, of such a stringent importance and efficiency? These are questions which the present notes try to answer.

2. The answer to the first of the above questions relates to the theoretical and axiomatic backgrounds of global modelling. In our opinion, rigour imposes two postulates, analyzed below.

The first postulate states that the world is a system (possibly a large system, in the meaning assigned in the literature).[x] The proposition is not unanimously accepted. Many authors claim that the world is not a system, but rather a pre-system, a configuration which fails to follow a unique objective and to operate - or to be adjusted - in a unitary manner. This may be true (although an unique objective might be found, if we tried hard: survival, coexistence, cooperation or development, while elements exist in the world behaviour, justifying the unity diversity). But a statement and its discussion are meaningless without rigorously defining the systems concept. In this work we shall mean by system a set of interdependent elements, their interrelationships (or structure) being described by information and decision concepts.[xx] This definition may be shown to include as particular cases the principal definitions used nowadays in systems studies (such as cybernetics, referring to in-

x) M.D.Mesarovic, D.Macko, Y.Takahara, Theory of Hierarchical Multilevel Systems, Academic Press, New York and London, 1970.
xx) cf. M.D.Mesarovic Systems Concepts, UNESCO Project "Scientific Thought", 1969.

puts, outputs, states, transfer functions, or normative, introducing a unifying objective etc.). Thus, in this general acceptation, the system outlook does not suppose a unique objective, a unique management centre, a unitary response to stimuli or a uniform behaviour - elements which would actually justify all the cautions with regard to the systems character of the world as a whole. Let us remember that, thus understood, the world is a system; in practice, the latest developments make definitely use of explicitly sophisticated systems models, such as multi-objectives and multilevel systems, multi-hierarchical, decentralized systems, etc.

The second postulate states that the (world) system may be represented by a model. A rigorous analysis shows that this proposition is not trivial, either. Modern developments of the theory of representations have pointed to the fact that a model of an object A is another object A^{M} which enables an observer (or model-maker) H to obtain, through A^{M} the information considered as pertinent with regard to A. Thus a model includes an implicit point of view - that of the modeller-observer. While almost unimportant in natural sciences - where we can talk of a perfect objectivity in the specific sense of neutrality and consensus -, this observation strongly marks, in my opinion, the models of social, and particularly of political processes. And the study of the world system strongly highlights this aspect. For, the world system can evidently not be represented from outside, any description of it involves (ideological, social, professional) options of the authors of models or of the points of view which they represent. A model constructed by specialists belonging to the developed capitalist world will thus implicitely include its options and values projected over the world system; a model constructed by scientists alone risks to cultivate a rationalistic-elite outlook, a.s.o. Naturally, not all approximations from various points of view are equivalent: from our marxist point of view on the regularities of social development and of progress, we shall specify that modelling from the stands of progressive forces is objective in principle (in the marxist meaning of the term) obviously without this simple fact certifying in itself the value of approximation, or annaling up to total reduction the value of other models.x)

Apart from such limits in principle, the representation of the world system dynamics by a model faces a number of concrete difficulties pertaining to the study of results obtained in modelling techniques, to the collection and processing capability and to the ability of handling large data masses, assumptions and ideas generated by world system, a.s.o. The advantage of studying the model (over the experiment in the social political practice) consists in the simplifications operated thereby: but such simplifications may distort reality! What are the elements of the present world system? This is a problem involving axiological assumptions: in the European Middle Ages, a hypothetical world model would have certainly included elements related to the religious value, considered to be a supreme value; other contexts would have obviously suggested altern-

x) This is why we prefer a different postulate to this global modelling postulate: the world system may be represented not by a model, but by a family of models, developed from different stands, which neither "sum up", nor "reject" each other automatically, but are in a dialogue relation, in the meaning of "open multimodelling" (Cf.M.C.Botez, Some observations on man-society relationship, paper read at the Special World Conference for Future Research in Rome 1973) published in the proceedings of the Conference, vol.2.

ate elements, a.s.o. The bourgeois revolution itself must "have had", implicitely, a model of its values, of its society, of its world and of its dynamics. The number of examples can be increased. It is clear that the choice of parameters representing the world system is not incidental, that a problem including ideological and political aspects appears here. And, by the way, this fact should be also mentioned in the case of models resorting only to economic and technological parameters. A classification of elements sets again numerous difficulties of principle. It results from the systems definition that the canonical model of a controllable and goal-seeking system comprises on the one hand elements with regularity-governed dynamics (a.e. exogenous) - described by information concepts - and on the other hand, decision and control elements (a.e. endogenous) - described by decision concepts; the former require explorative approaches, the latter, predominantly normative approaches. Social systems introduce then objectives, directly. The relationships between elements define the system's structure. The study of the system's evolution, starting from explorative hypotheses referring to the dynamics of the elements and of the structure, is called explorative. The study of the system's evolution starting from hypotheses referring to the objectives pursued is called normative study. The definition shows that both explorative and normative studies at the level of the global system involve interdependent explorative and normative approaches at the elements level. In practice, however, in the particular case of the world system too, such problems are very difficult. What are the regular elements of the world system? Do resources, population, science and technology develop according to regularities, supported by own motives? In an age in which resources and their assignment are continually changing, in which the demographic policy proves to be a component of the development policy and in which scientific and technical advance is more and more related to social order, the answers are not easy to provide. They often involve basic ideological and political options. Thus, a marxist model of social evolution should evidence a series of regularities postulated by historical materialism, such as those referring to the dynamics of capitalism, to national and social liberation movements and their role, to the role of private ownership, etc.; such elements are certainly missing from models prepared by researchers with other orientations. What would concretely be the decision elements of the world system? Today, decisions are known to be made at the state level; therefore, a world decision is a vector with a component number equaling the number of states. Yet, the possible decision spaces of various states are highly differing from each other and involve political aspects (force, groups, etc.) as well as social aspects: for instance, the possible decision space is larger for a sovereign, independent state and increases if the latter operates according to the principle of socialist order.x) Global models - at least models developed so far - are the result of efforts made by a number of scientists who do certainly not represent political decision factors: for this reason the practice of global modelling includes suppositions with regard to decisions - built up according to general logic rules, plausibility principles, etc. Is it possible to claim that no subjective factors, with a

x) Indeed, socialist ownership of production means, an homogeneous economic base, unity of objectives and of political action - characteristic of the socialist state - create conditions for specific decision and action - and the potential expansion of the space of possible options and decisions constitutes in our opinion a basic element of this specific feature.

strong ideological and political impact interfere here? The answer is obvious. However, models advanced so far prefer an aggregate point of view instead of a local study of the context and of decisions. The behaviour as a whole of the system is followed, summing up or mediating, at various levels, the elements of various natures in relatively stable parameters. The perspective of such a behavioural study is prevailingly explorative. But how can the system's behaviour be concretely investigated? Are the available intuitive means, when analysing the whole by components and reconstructing it, sufficient to obtain lucid and operating pictures on the system's behaviour? Most comments focus precisely on the need for new tools, expected to support intuition in this undertaking. Limit attitudes are not missing, either. For instance, J.W.Forrester claims that "human logic" and intuition, formed and developed on local judgments and cultivating direct linear causal relations (cause-effect) are incapable of including nonlinear links (of feed-back type, for instance) which govern complex systems contexts - and this generates an inexplicable and unpredictable intuition-based behaviour, called by the American author anti-intuitive, requiring the use of analogical electronic simulation models.[x)] Even those who do not accept hands down such extreme theses emphasize the particular role played by the methodological instrumentation in the study of systems operation and behaviour. In practice, new options appear for the study methodology; and implicitly, new possibilities, for introducing subjective points of view. Finally, fundamental difficulties in global modelling stem

---

x) Cf.J.W.Forrester, Counterintuitive Behaviour of Social Systems, in Simulation, 16, 2, 1971.

from the dynamic character of the system, in relation to the (prospective) time horizon covered by research. Do the systems elements, simplified as they appear in a model developed at a certain moment, - keep their relevance over the considered prospective time horizon? In the systems theory language, does the state space remain constant? What about relationships between elements or the structure? And if negative, what new elements appear? The history of global modelling cautions against such omissions.[x)] The world system can therefore not be described by problems, but by a problématique a constant generator of interdependent problem systems. This calls for new tools. Therefore, to shape and define problématique cannot be separated from specifying the methodology used in the study of the problematics and this offers in practice a field of options to actual modelling.

Hence, let us recall that a global model implies a series of theoretical hypotheses which are the only to help overcome difficulties. Such modelling hypotheses refer to problématique (system's definition) and to methodology. We are actually facing some simplifying reductions.[xx)] However, can we measure the approximation de-

x) Indeed H.Kahn's and A.Wiener's publications regarding the world of the year 2000, issued in the 60's do not include among the elements, ecologic parameters (resources, pollution), or some political parameters (the Arab world) etc.; the Forrester-Meadows model has introduced ecological parameters and the Mesarovic-Pestel model includes some political elements too. Nevertheless, in general, the relevant character of an element is dramatically manifested by crisis - such as the ecological one; so, what can be said about these latest new models? What do they not include? Violence, or democracy, or participation? Discussions on the new world economic and political order may provide many suggestions on possible elements, omitted from the world dynamics study, so far.

xx) However, rigour requires to specify that such simplifications do not differ in principle from universally accepted simplifications today in the practice of social and political sciences. Comments, political programs, ideological discussions etc. actually propose models too - yet constructed in the set of propositions (of a certain language); they include subjective elements, points of view, options, etc.; they implicitly simplify reality - similar to quantified global models. However it could be claimed that the approach analysed in the present work provides the advantage of a measured approximation, or at least of a potentially measurable approximation, over the classical approach.

gree introduced? How? We shall elaborate on this problem below.

3. For the sake of simplification, we shall further refer to propositions regarding the problematics generated by the evolution of a system, as systems propositions. The systems definition shows that their canonical form should refer to the set of elements, to the set of links between elements, to the dynamics of elements and of the structure and, in the case of social systems, to the set of objectives and their dynamics. There results that the validity of any statement including only some elements, structures or objectives is conditioned by omitted elements. The statement is true if we refer to acknowledging systems propositions - concerning the state of the system - to retrospective systems propositions, and it can be certainly extended to prospective systems propositions, describing future evolutions of the system. Reduction means omission of the conditioning context. How should we interpret this? It can be demonstrated that formally, to omit or neglect a class of elements of a statement on the state or the evolution of a social system is equivalent to postulating the conservation of the state and structure of the omitted elements and also their influences on the "remaining" system. Thus, in particular, propositions referring only to the dynamics of science, technique, economy, population, resources, pollution etc., therefore neglecting the social-political or the ideological factor, automatically introduce the hypothesis of conserving the structure of its influences; therefore we are not dealing with omissions, buth with the implicit introduction of a maintained context, at least through the prism of the global influence on the "remainder".

The above observations evidently apply to propositions[x)] which form a global model resulting from a global modelling process. As a result of simplifications, they introduce the conditioning context; omission is equivalent to maintaining or conserving this context. A series of implicit hypotheses are hence added to explicit working hypotheses of the model - which anyhow condition the propositions forming it. Prospective propositions generated by means of the global model introduce an additional conditioning: the conditionning by the methodology used in the prospective study. For, it is known that future does not exist as such, that it is built by means of a methodology and must certainly be evaluated by an adequate methodology.

Let us thus recall that the global modelling process introduces explicit and implicit conditionings by declared working hypotheses and by its simplifying omissions; propositions forming the global model have, in turn, validities or plausibilities conditioned by the set of all hypothese involved in the modelling process; future-oriented propositions, hence prospective propositions generated by means of the global model introduce in addition conditionings referring to the methodology of the study of the future system. A complete statement of such a proposition would have the following form: if explicit hypotheses   of the model are true, as well as the implicit   ones introduced thereby - and if methodology   , is applied to the set of hypotheses, then (with probability   ) assertion   will take place.

x) It can be demonstrated that any model can be immersed into a set of propositions in a certain language (formal - for mathematical models; natural - for social-political descriptive models; lyrical - for models related to artistical rhetoricated representations etc.). These aspects are developed in the volume M.C.Botez, M.Celac, P.Dimitriu Forecasting-Open Planning. Systems Design, IRADES, Ed.Futuribili, Roma, 1975 (in press).

Conditions result for the rigorous critical analysis of a global model. It must include, as observed, the analysis of hypotheses - explicit or implicit, derived from the former, and the analysis of the methodology whereby "propositions" (or the content) of the model are generated from hypotheses. Evidently, any errors at the level of the hypothesis set entail errors in conclusions; likewise, errors at the level of the methodology, evidently generate errors in conclusions. What does an error in hypotheses mean here? A first variant is suggested by the logical incompatibility of hypotheses considered as axioms; a second variant, by the logical and functional incompleteness of hypotheses. Any world system model is certainly a simplification - yet the "world" included in the model must function! The first group of errors is easier to reveal; the second one introduces much more difficult aspects, related to the system's representation, to points of view, to the conditioning context, a.s.o. It is interesting that, at least until now, methodology "errors" have aroused few comments although it is here that one of the most important sources of approximations may be hidden. Let us finally remark that the critical analysis of propositions-result, without considering hypotheses and methodology, is at best incomplete. A proposition of a prospective scenario, for instance, cannot have a validity or a value "per se" outside the scenario including it. It will always be an element of a set of judgments constructed with a proper methodological apparatus operating on a set of hypotheses. Evidently, we may possibly "check" the veridicity of acknowledging propositions referring to the present; however, to apply similar criteria to prospective propositions is unrigorous and breaks the rules of the anticipative "game" and of the principles of prospective logic.

However, the analysis of global models cannot be considered as completed without referring to the purpose - whether or not declared - of the modelling process. For, the representation of the dynamics (and possibly of the <u>future</u> dynamics) or the world system may follow several objectives, in terms of which the modelling process and its results acquire specific shapes.

A first possible objective is to represent the operation of the world system and its behaviour. Models having such a character are descriptive models and they differ according to the time horizon in which the operation is followed (short-term, medium-term, long-term).

A second possible objective is to <u>caution</u>. The problem answered by the model is as follows: what will be the evolution of the world system, represented by the respective model <u>if</u> no intervention is made in its dynamics (respectively if parameters, structures, etc. are conserved). Based on the answer to the question "where shall we get if we "do" nothing to change our orientations" - if this "where shall we get" is undesired -, it is possible to establish strategies answering the derived question "what must we do <u>today</u>, to avoid undesired possible future states". These models clearly seem particularly important in the decision-making perspective.

A third possible objective is the prospective and <u>predictive</u> one. The problem answered by the model is "where can we get" and, based on variants, "where do we <u>wish</u> to get" (objectives of the action).

The reference to the <u>objectives</u> of the modelling process is, in our opinion, an important element in the (critical) <u>analysis</u> of the resulted model. Because it is certainly meaningless to blame a model for something that it was not intended to be! For this reason, it must be mentioned from the very beginning that operating and cautioning aspects are more numerous than predictive ones[x)] in the global models prepared so far.

To sum up, the analysis of a global model must include an analysis of hypotheses - whether or not explicit, and an analysis of the methodology, in the perspective of the objective followed by the modelling process. We shall apply these observations when presenting the map of global models developed so far.

4. The history of global modelling is not easy to make up. In fact, qualitative, descriptive models on an international situation and its trends, met in various political programs or platform documents (of communist and workers movement, of the UNO, etc.) may be interpreted as concerns preceding those comprised today under the name of "global modelling". A series of efforts for a quantitative analysis of social dynamics[xx)], are also "steps" in the methodologic field, enabling modern developments, even if they have not set as an objective the world system.

But we feel we are not wrong if we consider as the first attempt closer to what we call today "global model", the studies performed in the 60's at the Hudson Institute in USA and published

x) Which, by the way, seems to be ignored by many comments.

xx) A special place in this perspective is held by the advance of computer simulation techniques for social and political processes. Among the treated problems we mention business games (management), the evolution of international relations (in the frame of peace researches); conflict simulation (particularly in military applications), simulation of political evolutions and changes at a national level (such as that developed by the Stanford University where a revolutionary process was also simulated, called by the authors "socialist" and denominated "Spartacus"!).

under the name of the project managers - H.Kahn and A.Wiener - as "The Year 2000. A Framework for Speculation on the Next Thirty Years".x)

In the systems theory language, H.Kahn and A.Wiener propose a predictive handling of the world system evolution based on continuity at the level of elements and thence at the level of structures and objectives. In fact, the approach to problems is purely tendential: a so called long-term basic multiple tendency is identifiedxx), composed of 13 elements of various natures. This tendency it then postulated to be conserved with possible small corrections, during the next 30 years and on this base, scenarios are constructed, on the most plausible foreseeable evolution - towards the "standard world", as well as variations (called canonical) around this general world dynamic axis. Explicit hypotheses-regarding the concrete components of long-term multiple tendencies -, and the implicit, derived ones, may be logically compatible, yet they prove

x) H.Kahn, A.Wiener, The Year 2000. A Framework for Speculation on the Next Thirty Years, New York, MacMillan, 1967.

xx) The components of this multiple tendency are edifying for the aggregation and formalization degree of the model: 1. increasing "sensualist" cultures; 2. burgeois bureaucratic, meritocratic, democratic elites; 3. accumulation of scientific and technical knowledge; 4. institutionalization of the change (particularly of research, innovation and their dissemination); 5. industrialization and modernization on a world scale; 6. increasing opulence and leisure time; 7. demographic growth; 8. urbanization; 9. decline in the importance of primary and secondary vocations; 10. training and litteracy; 11. increased capacity of mass-destruction means; 12. acceleration of change; 13. more and more evident universalization of such multiple tendencies. The attempt is observed to find unitary motives and objectives of world dynamics and to build their logical consequences. Results are certainly debatable: problems pertaining to value and objectives are obviously placed under the angle of the "consumer society", the socialist world with its own problematics is totally ignored, a.s.o. The study of "omissions" - for instance the role of national and social liberation movements - would be sufficient to demonstrate, according to previous observations, the elite and incomplete nature of the developments made by American authors, actually postulating conservation and even accentuation of "dysfunctions" in the contemporary world.

to be totally incomplete when analysing the world system operation, particularly in the long run. Marxist research has emphasized from the beginning the omissions of the H.Kahn-A.Wiener model at the level of values and of objectives, as well as its political and ideological load; time has supplemented these theoretical criticisms with new arguments related to the neglect of certain problems which appear to be fundamental at the time being and which have deeply affected the "tendency" supposedly discovered by American authors (pollution - ecological crisis, oil, and in general energy and raw materials shortage - the problematics of development and the problems of the new world economic and political order etc.). This attempt has however provided the main methodological result - the method of prospective scenario writing - as well as the effort to use explorative econometrical techniques, particularly vectorial extrapolation (with corrections) and correlational procedures.

The first global model, in the proper meaning of the word relates to modern advances in the systems theory and in the study methodology of their dynamics. In contrast to the tendential approach based on continuities at the level of the system's elements, we shall meet here global approaches having a markedly structural character. Yet, we shall have to recognize again a continuity (and even conservation) postulate: not at the level of elements though, but at the level of the world system structure and of objectives (as well as of values).

The "first approximation" of world dynamics in this perspective uses simulation techniques of systems dynamics developed in USA at Massachusetts Institute of Technology under the leadership of Prof.

J.W.Forrester.[x)] In the evolution of a system, this method brings to the foreground relations between elements which globally define the behaviour, rather than elements with their tendencies. It is true, the hypothesis on the conservation of variation trends of each element included in the system is abandoned; but in turn, it is postulated that relations - or "the architecture of the system's structure" - are maintained according to a standard logic, throughout the research interval of the system's dynamics. Used in the study of local industrial or urban development problems, the method known today as "J.W.Forrester's method" was first applied to world dynamics in 1971 with the appearance of the volume "World Dynamics". The fundamentals of this approach were resumed in numerous variants: we shall therefore present it in broad lines.

The model by which J.W.Forrester represents the world system includes five elements: population, resources, capital investments (indirectly measuring the industrial development and the economic level), capital investment in agriculture (indirectly measuring food and the level of foodstuffs) and pollution.[xx)] These parameters intervene in the model by world means or expectations. What characterizes the evolution of the system is the fact that the dynamics of each element depends on the dynamics of all the other elements of the system. How is this link introduced? Each element

x) The method and its applications is found in the major works by J.W.Forrester "Industrial Dynamics", Cambridge MIT Press 1961; "Principles of Systems", Cambridge Wright Allan Press, 1968, "Urban Dynamics", Cambridge MIT Press 1969, the world system is studied in the volume "World Dynamics", Cambridge MIT Press, 1971.

xx) The initial model includes also a parameter for adjusting the average world "Quality of life" in terms of which some preferential evolution can be generated.

E_i is characterized by a value $X_i(t)$ at a certain moment t - level - and a variation rate $\frac{dX_i}{dt}(\sim k_i)$. The operation of the system is described by a differential equation system in which the dynamics of each element level is obtained from the "composition" (in a meaning which will be specified) of some "atoms" having the form

$$\frac{dX_i}{dt} = k_i X_i(t) \quad \text{(positive loop)}$$

or

$$\frac{dX_i}{dt} = k_i\left[X_i^* - X_i(t)\right] \text{ with } X_i^* \text{ - constant (negative loop)}$$

rates $\frac{dX_i}{dt}(\sim k_i)$ depending on the states and rates of all other elements of the system. We observe that these are basically exponentials with and without ceiling; their "composition" or their "coupling" means a reciprocal modification (perturbation, influencing) of variation rates according to certain formal "grammars" - quite simple in essence. The great merit of the method consists, in our opinion, in the possibility provided for effective construction and resolution of such types of differential systems. Construction takes place in stages, the links between elements are locally established depending on the common intuition: the architecture of the system is obtained as a resultant of partial interactions between elements, element pairs, etc. - and it must not necessarily be completely formalized to pass to the dynamics study. Then the system of differential equations is not resolved by classical analytical or numerical methods, but instead, by simulation.x)

x) In fact, J.W.Forrester's works contain only "discrete" variants of such developments (s.e., finite - difference equations).

Solutions are not conditioned by the form of equations which is a resultant of systems interactions and may be formally very complicated - and they may cover a practically unlimited spectrum of concrete situations. How does the system work with the constructed architecture? Let us first note that the proposed handling is functional and, possibly oriented towards caution - and it does not have a predictive character. Let us now assume that we want to follow the model's dynamics over a certain time interval. To do this, let us define for each element certain critical intervals to be avoided (concerning for instance the pollution level or the food level etc.). When the respective elements "enter" the respective zone the system will be said to be "in crisis". According to previous observations, the system evolves so that all its elements vary simultaneously and compatibly with its structure (architecture). In other words, the dynamics of an element (levels, rates, etc.) entails a certain evolution of the whole system. Let us now try to follow the consequences of a certain policy (demographic or of resource capitalization): this means to impress a <u>certain</u> evolution on an element. The described method permits an identification of all consequences caused by this policy, regarding the dynamics of all elements - and considering all systems links between them. In particular, therefore, it is possible to foresee the "crises" appearing by the penetration of other elements into "critical zones". Moreover, the system is self-regulating so as to "avoid" crises.

We have insisted on this model so much since we consider it to be the <u>matrix</u> of subsequent global developments and the natural landmark of any new investigation. J.W.Forrester's work "World Dynamics" actually describes the model presented here and reaches a conclusion which the author presents as such insisting on its anti-intuitive character: the conclusion of "Limits to growth" and of a "global equilibrium". What is this all about? The simulations of world dynamics, in J.W.Forrester's representation and with his methodology, show that the only possible strategies for _avoiding_ crises (pollution, resources, food, employment and unemployment, etc.) would consist in the limitation and control of growth (demographic and economic-industrial) and the replacement of an exponentially growing world by a stable "balanced" world.

It is easy now, after general observations on global modelling and on systems logic made in the previous paragraphs, to outline the limitations of Forrester's model. The _explicit_ hypotheses regarding the representation of world system are obviously vulnerable. Numerous researchers have emphasized the strong approximation appearing when dealing with "world expectations" - covering the great imbalances and inequalities of the present world and providing the image of a false and distorted homogeneity. Actually, the "world expectations" hide the basic motives of world conflicts and dynamics - which we can easily recognize today from the perspective of discussions on the "new economic and political order". Finally, other commentators have pointed to the arbitrariness of quantifying the levels of elements or of prescribing the levels of "crisis" or of standard-limits appearing in the system self-regulation. The _implicit_ hypotheses also offer critical arguments: because, to suppose that everything outside pollution, population, resources, food and industry will be _conserved_ within the next 30 years - even as an influence on such elements - seems hard to accept; even if we recognized that the high aggregation level of factors involved in the model assures them a higher stability than to some of their "subdivisions" - a fact which has actually been capitalized with remarkable technical skill by the renown American researcher.x) The limitations of the methodology used in the architecture of the model were less analysed. Let us pass over approximations intervening in the evidently intuitive local description of successive links between the elements of the system which then form the complex structure. The behavioural logic of the system remains however statical, stable, identical to that initially introduced in the simulation process: it is conserved in time. The rigidity in time of the model's theoretical behaviour seems to be the greatest difficulty of this methodology which postulates standard and identical reactions of the world system throughout the simulation interval. It is evident that under such conditions, the "statements" of the model - such as that referring to the "balanced world" - have debatable validities.

This type of global modelling was not introduced to the public by J.W.Forrester's work, as it might have been expected, but by the famous report "Limits to Growth" prepared by Forrester's coworkers at M.I.T. under the leadership of D.Meadows, on request of the Club of Rome. As is known, the Club of Rome is an association (or according to its own statement, a non-organization) which has undertaken to launchxx) a world debate on the problematics of man and of society in the modern world. The Meadows report resumes, with slight mo-

x) Because, surprisingly, the models appears to be very stable to possible desaggregations of factors (for instance to the introduction of a stratified population on age levels instead of a unitary population) - a rigorously demonstrated fact, by estimating of the sensitivity of results to the variation of components.

xx) and less to elucidate ...

difications, the hypotheses and the methodology of J.W.Forrester's work (the so-called "World Model 3"); yet, it highlights - in the few broadcast variants - some aspects which have not received a greater attention than other working hypotheses in "World Dynamics". The first refers to the limited character of resources, - a seemingly older hypothesis of Club of Rome specifically suggested for study by American researchers.x) The second aspect is the emphasis placed on the result - which has actually formed the title of the report. "Limits to Growth" replaces thus the sober title "World Dynamics" under which J.W.Forrester had published his studies.

Issued in 1972, the Meadows Report is, in our opinion a rhetoricated variant of J.W.Forrester's model rather than a new global model.

But the fantastic success of this best-seller has not dissipated the generally unfavourable atmosphere created around the American authors' point of view. Debates have often exceeded the borders of science, they have aroused passions and have triggered violent polemics. Discussions have tackled neo-malthusianism, irresponsive planetary elitism, premeditated computer-supported diversion or unfairness. This model was particularly blamed for what it was not intended and could not be, either: a prognosis of world dynamics. Related to other objectives than the natural ones, the model was criticized for most diverse reasons: for not "being like" the present reality - which is true -, for prescribing in a uniform and undifferentiated manner "zero growth strategies" at a world

x) It must be emphasized that this hypothesis is not essential in obtaining results justifying the "limitat of growth": the limitation appears as the only possible remedy in the hypotheses postulated by the model, even if resources are considered to be endless!

level, for not considering the scientific and the technical progress and the social innovation, etc. Let alone the important fact that, by ignoring the essence of J.W.Forrester's anti-intuitive methodology, most comments have intuitively and locally analysed some results of simulation, blaming them, after a confrontation with own images or opinions, let alone other discussions which have not been willing to see in the apparent catastrophism of Meadows Report a rhetorical formula, particularly advanced for mobilizing purposes, and have argued against the computer-based neo-fatalism. We must keep in mind only the atmosphere created around the model and the computer, surprisingly declared to be antihumanistic. In the spirit of rigour, now, when passions have worn off, let us recognize the major quality of this unpredictive dialogue-opening work in a still little known register of modern prospectology, that of rigorously measured approximation: the fact that the results of prospective studies cannot be evaluated outside a reference to the methodological apparatus, that they cannot be placed solely under the angle of intuition and that, moreover, they may contradict the current intuition influenced by the problematics of the present. Maybe this is why the authors have faced quite unruffled the often mean and violent criticisms directed against them. All right, the model does not resemble the present world - but precisely this confers to it a certain stability in time, was the reply of the Meadows group members; and the high aggregation degree, at least theoretically, becomes thus a long-term quality of the model. The problems of scientific-technological or social progress may not be explicitely "set" because, in the opinion of the American authors, the "response time" of the system is too long and the global sensitivity too reduced to basically change the conclusions of simulation. In the same perspective, the rigidity of the theoretical behaviour becomes an advantage - as a long-term stable mean. Evidently, the discussion on hypotheses remains open.

The Club of Rome has however not only strictly scientific goals, it also wants action. Its declared objective is to launch a large debate on the evolution of the contemporary world and to trigger the planetary conscience to words concerted action. Violent criticisms against the Meadows report have thus apparently affected the initiators of the report much more that its serene and scientific authors. With such an antihumanistic connotation, with such polemics it is however difficult to gain the confidence of public opinion. The first to underline that the Meadows report is not a report of the Club of Rome but a report presented to the Club of Rome - the first of a series - were the very spokesmen of the Club. They have thus broken away from pessimistic predictive interpretations of the Forrester-Meadows model, declared to be the first approximation of human and world problematics. And they have initiated, themselves, with great political skill, the replica to the Meadows variant: the "second order" approximation of the world dynamics, the Mesarovic-Pestel[x)] report whose main results are broadcast in the volume "Mankind at the Turning Point"[xx)] (translated into French under the title "Strategie pour demain").

From the first moment, learning their lesson from the fate of

x) At experts level, discussed at the International Institute of Applied Systems in Laxenburg - Austria, in the Spring of 1974.

xx) "Mankind at the Turning Point" by Mihajlo Mesarovic and Eduard Pestel, The Second Report to the Club of Rome, E.P.Dutton & Co,Inc / Reader's Digest Press, New York, 1974.

the preceding Meadows report, the authors define the object of study, which is not essentially predictive. "The principal objective of our project was to develop a planning and decision-aiding tool which can be used to analyse in concrete terms the present and future world crises which The Club of Rome identified collectively as the "problematique humaine", and to assess alternative policies and strategies for the solution of such crises as well as for the resolution of conflicts arising among the various world regions from the inequalities between and within different parts of the world", runs the abstract forwarded to the Session of Club of Rome held in Western Berlin in October 1974. It adds: "The project has therefore diagnostic as well as therapeutic aims; however, its purpose is not directed at predicting the future evolution of the world." Compared to all previous attempts at a global modelling, the authors think that three following new elements appear:

(a) Keeping its global character, the model includes the diversities and inequalities of the modern world which are often sources of the world problematics: thus, the world is "disintegrated" into a number of ten regions considered to be relatively homogeneous and interrelated.

(b) The model keeps into account the conscious human factor which will not react mechanically and standardized to <u>any</u> "crisis" but may control the world problématique by political and social activities. Political decisions are thus called to play an important role within the model. This enables tests of various strategies meant to solve crises and an evaluation of long-term consequences of various alternatives.

(c) The model fails to propose "optimistic" and "pessimistic" variants and "refrains" from such types of evaluations, following only a lucid and accurate description of the world system operation faced with present and possible shortages.

Two components can be identified within the frame of the world system by introducing such elements: an objective component, being described in logical terms, and represented in principle on a computer (called "computer model") and a subjective component with a markedly intuitive and uncertain character, due to the logic of political decisions which is harder to formalize and to analyse under the conditions of modern world diversity. The computer model relies on the theory of large dimension complex systems with multi-levels and hierarchical structures (a theory numbering McMesarovic among its "parents" and uses the results of an interdisciplinary handling (including, for instance, elements of psychology, economic and political sciences, physics, biology, etc.). The regions (considered relatively homogeneous) in which the world system is disintegrated and whose reciprocal interaction defines its behaviour, are the following (in the order indicated by the authors): North America, Western Europe, Japan, Australia and the other developed capitalist countries with a market economy, Eastern Europe socialist countries (USSR included), Latin America, North Africa and Middle East, Tropical Africa, South and South East Asia and P.R. China. Each of the 10 regions is in turn modelled as a multilevel system. Two elements were considered when defining such levels: a most faithful possible description of the operation of the respective subsystems and of their relationships, and the possibility of representing, by means of the introduced variables, a number of crisis-generating key-problems (such as differences in the levels of economic-social development between regions, world food short-age energy shortage, the problem of raw materials, population explosion etc.). The introduction of the subjective intuitive component and its integration into the "behaviour equations" made use of other forecasting techniques as well (which complete the simulation of the computer model) such as scenario writing (including the dia-logue and the decision making game). The manner in which intuition appears in the strongly formalized simulation texture deserves a special analysis.

In fact, Forrester too introduced intuition yet at a local level, when he programmed the "responses" of the system's elements: his model merely exploited univocally and in a standardized manner the "initial intuition stock" relative to which it actually remain-ed closed. The Mesarovic-Pestel model abandons this restriction. It also introduces intuition and here intuition intervenes only at a local level, in scenarios referring to the dynamics of regions; yet it is no more pre-programmed and standardized; this model remains therefore open to intuition. This is a great methodological breack-through which would have justified in itself the whole project. We are indeed rather far from the uniform methodology by which the variants of the "Limits of growth" were generated: the second re-port proposes a refined methodological structure, integrating in-tuitive modelling by problems, scenario technique, decision-making game and simulation. If the Meadows report was actually a monologue comment to development variants priorly constructed by a computer, the Mesarovic-Pestel report is not a result of a monologue in front of the computer, it is the result of a real dialogue with the computer.

Therefore, summing up, what does this report include? A description of the world, trying to present it as it is - and of system relations between various regions and various parameters, and also a representation of the world system behaviour. This approach enables the study of world dynamics confronted with various problems. The world does not move by itself, but only "excited" by motive crises - the authors claim. All the variants appearing in the book are generated by these problems. Mankind faces a crisis not when the "world mean" of a parameter (for instance food or pollution) enters a critical region, such as in Forrester-Meadows models, but if this happens at a regional level. Any regional crisis becomes a world crisis - says the "second approximation". And the world system is self-regulating not as a function of preestablished criteria, like in the name of the planetary conscience and solidarity, expressed by intersections between regions. Therefore the working hypotheses are not only realistic, they are also generous. The authors report their results on some of the big problems of the contemporary world: differences of development between North and South (the name given here to developed capitalist countries and socialist countries respectively on the one hand and developing countries on the other hand) the population growth, the energy and food policy. A series of scenarios imagine variants testing the potential gravity of such crises and simulate different solutions and strategies, following their implications.

A large quantity of scientific intelligence and political fantasy is concentrated under a maximum potential in these scenarios examples of seriousness and rigour. The conclusions of these studies are final: "Crises" that have faced us lately are neither accidental nor temporary, they have a structure and a duration, being logical consequences of the past development. The solution to such crises may be found only in a global context at the level of the world system and following long-term implications of the suggested solutions. The fact requires, among other changes, a new economic order and a global resource allocation system. Any solutions must exceed sectorial or unilateral handling - such as exclusively economic ones - and must cover the whole spectrum of social and human development levels, from individual values and attitudes to ecological and environmental conditions. In any crisis-problem, cooperation is more efficient than a confrontation for all the parties involved and any unfair short-term advantages are compensated and lost in a lucid long-term outlook. Also, any delay in adopting an attitude which would recognize such principles leads to losses which affect everybody. We are thus in front of a new outlook on the world development which, by a refined rhetoric gesture, the authors have suggestively called <u>development by organic growth</u>. The world ceases to appear as a conglomerate of small units chaotically evolving and inherently getting into mutual conflicts or as an undifferentiated whole mechanically pursuing the same objectives and strategies. It appears as an organism. "The brownian growth" characteristic of the first variant and the "uniform and undifferentiated growth", or cancerous - as the authors call it - associated to the second variant are outdistanced by another type of growth which keeps into account the specific of each part of the present world "organism". In an organic growth, the <u>interactions</u> among various components regulate the various growth rates of these components. This is the <u>turning point</u> which the present world faces, in the authors' opinion: the option between chaotic or cancerous growth and the organic development.

Any marxist researcher must remark from the very beginning the dialectic character of the study. Maybe the name dialectic growth given to the solution proposed by the Mesarovic-Pestel project would have expressed more exactly the diversified and natural character of organic development. In the second place, let us mention the most remarkable scientific and methodological bearing of the study. After Forrester-Meadows models it was not easy to make a step forward on the methodological ground. Yet the jump forward is evident. Thus, the dimensions of the simulated model in the second approximation are much larger than in the first one x) (over 100,000 equations of the Mesarovic-Pestel model, versus about 480 equations of the Forrester-Meadows model) the architecture of the new model is, then, much more complex: simulations involve multi-hierarchical systems structures (with the following levels: individual, demographic and economic, technologic) and intra- and inter-level multilinks among the systems attached to various regions - whereas the Forrester-Meadows model simulations were obtained by a possibly iterated coupling of simple positive and negative loops; it is obvious that, operating with simple "loops", like the Forrester scheme, the Mesarovic-Pestel model uses much more complicated coupling techniques. The computer model appears thus much more sophisticated - although the basic, theoretical objections to the handling of the systems dynamics by

x) It suffices to mention that the extended form of the Mesarovic-Pestel model (whose developments involved over 40 great specialists in various branches of science, among which a number of Nobel prize winners, in addition to an important team of analysts and programmers) comprises 16 volumes.

simulation, formulated in the analysis of the J.W.Forrester's classical model are not outdated: we still are in the presence of a stability and conservation postulate, not at the level of elements, but of the system's structure - constructed, frankly speaking, in a more complex and more refined manner. The appearance of scenarios with a pronounced heuristic subjective character, alongside with the computer model, is an absolute novelty compared to the previous handling, although, as we shall see below, "the uniform logic" of these scenarios places them in the same field of stability and conservation hypotheses of the world system structure. However, the methodological progress is there, beyond all possible objections.x) For, many things can further be discussed indeed. Let us start with hypotheses (explicit and implicit). The world division into superstatal zones - regions - structured according to criteria of questionable economic-social homogeneity (we illustrate by the "Arab world") - seems to us rather useless as long as major decisions are made at the level of states forming the regions rather than at suprastatal levels (as specified by the authors themselves). Is it only the technical difficulties that have prevented the disintegration to the level of states? Or perhaps one should recognize in the analysis per regions the influence of the existing divisions of the present world governed by known force ratios and spheres of influence and of interests? Answers are not easy to give. And here is where criticisms will likely attack the present model. The interdependence between the elements of the present world could obviously find much more

x) In our opinion a priority should be assigned to the study of the system's sensitivity to perturbations induced by the new problems, the change in the dynamics of parameters, a.s.o.

inspired expressions than those suggested by the authors, based on oppositions between this systems concept and the independence. The strongest theoretical argument in favour of the independence was advanced by a Romanian researcher who was the first to analyse this model. "In reality, independance is precisely the necessary condition to enter valid, lasting, freely consented interdependence associations fully aware of their interests" Mircea Malița observes in a recent study on global modelling.x) The fact of postulating the conservation of the existing structure of the world subsystems and the actual structuring of such subsystems remains of course the most vulnerable part of the "organic growth" model which has evidently operated exclusively based on the values of statistical indicators. But can the dynamics of such indicators be ignored?xx) Does the static snapshot provide realistic images of the change? Revolutions and mutations exist in the world, not only evolutions. Mass creativity and participation, freed by social revolution become resources themselves, and their identification and management was disregarded by the authors of the "organic growth". Innovation (technical or social) is implicitly considered only as a factor of evolution, rather than of structural change. And the structures of "levels" of sub-systems representing various regions - identical for all regions - constantly reveal the <u>same</u> compo-

---

x) M.Malița <u>Global Models</u>, in Viața Românească, December 1974.

xx) According to the same criteria, by 1915, the evolution of Tsarist Russia and the Austro-Hungarian Empire would have probably been uniformly treated over the next 40 years...

nents.[x)] Would differences consists only in development indicators? Would no different objectives and values (ideological, political, social and individual) appear? Next, scenarios are constructed according to the same "logic" of the developed world, in the light of the same rationality criteria. Would this be the only possible variant? No specialist outside the developed countries was involved in research. And no researcher from socialist countries, either. We deal, in fact, with scenario variants for different regions, constructed however with the same logic from the perspective of the same values and from the same points of view. This is not a dialogue between differing points of view, but the multiplication of one single point of view. It is true, with much rigour.

Apparently paradoxical, the concern for a realistic representation of the existing world seems thus to constitute the major drawback of this model constructed for a long-term outlook. If the Meadows model resembles very little reality, the Mesarovic-Pestel model seems to be too much like it. Like the present one. All the behaviour reactions of the system are analyzed by means of the

---

x) Indeed, at least at a first glance, such a structural hypothesis is not obvious and it should be at least justified, if not rigorously demonstrated. Is the individual-supportive economic-social technological environment hierarchization maintained in various regions of the world? And also in the sub-systems structure, in the level weights, in the operating details of relationships between levels? Would the individual level not pass behind the demographic economic social one, for instance in regions with other traditions and cultures, in the perspective of development priorities? Only a rigorous, concrete study of each separate region, at the level of the diversities of social values and objectives may lucidly answer such questions. To postulate an identical structure of the levels of all regions remains thus not an expression of some universal human values - as suggested by the authors - but a limit stemming from the projection, of a unifying debatable point of view over the diversities of the present world (perhaps, strongly influenced by the individualism of the post-industrial society).

present logic and tools. But, while responding to crises, the system changes. With an expression first employed in future study by Professor Mircea Malița[x)] we would say that the system learns. Social practice justifies this observation. The present political logic is not identical to that 15 years ago. Suggesting that the implications of the problematics and of the present solutions may be studied by making abstraction of the change itself of the world system, the "organic growth" model does therefore not actually outdistance the hypotheses on the conservation of the present world structure. This fact must be mentioned in any analysis referring to this success of global modelling.

The Forrester-Meadows model and the Mesarovic-Pestel model represent however only the first steps in the present "explosion" of global models. We cannot conclude this panorama without recalling some of the over 10 studies being developed.[xx)]

A global model was developed in Argentina under the aegis of Bariloche Foundation, comprising a Latin-American point of view on the world dynamics. The declared "landmark" is that of developing countries, and the studied theme remains highly topical: the exploration and definition of minimum subsistence needs and of the means for assuring them. The actual model, with a multisectorial econometrical character (using Cobb-Douglas production functions on sectors) introduces the following restrictions to any development strategy (world wide or regional): expenditure for food, housing, health and education (per capita) must not drop below a

x) M.Malița, Learning Theories and Futures Research, paper presented at the IIIrd Future Research World Conference, Bucharest 1972.

xx) A review on the Club of Rome projects can be found in Tokyo Report, 1974.

certain limit and must record non-decreasing "real" curves (under inflation conditions).

A somehow dual model to the above is developed by a group of researchers in Northern Europe countries, and is known under the name of "Scandinavian model". Its objective is to explore the maximum reasonable consumption - with evident applications to future strategies of developed countries.

The famous economist Jan Tinbergen conducts an investigation on the food problem throughout the world: this seems to be an "anticipative" analysis of the next big world crisis.

A group of experts headed by Dennis Gabor, study the future of science and of technique through the prism of the new options and priorities (of social and human knowledge and action).

Finally, specialists as well as the public at large await with a great interest the first global model constructed from marxist positions which is being developed in Novosibirsk (USSR) and has been announced under the name of "Siberian model".

The series of examples could be extended.

5. What <u>trends</u> can be detected from this review of the global modelling history?

First of all, by recognizing in all the existing models the world system as an initial "starting" point, we must remark a trend of passing from more "aggregate" approaches to <u>less</u> aggregate approaches. The synthetic approach is thus doubled by analytical and morphological approaches (the meaning of the modelling process remaining the same: from a global study to local studies). Diversities introduced into unity is certainly, let's say, a dialectical conquest of global modelling. But as was previously mentioned, the aggregation degree and the lack of details can also express the "guarantee" of the long-term model stability, not only modelling difficulties. To find the lucid "measure" between aggregation and disintegration remains a further task of prospective modelling art.x)

Secondly, a trend is observed of passing from global non-specific, universal behaviour models, constructed for any problems of world dynamics, to global models oriented on specific problems (such as strategies for avoiding crises, solving food problems, etc.). An idea which gains increased acceptance is the fact that a model cannot serve, under conditions of sufficient rigour, to approximating the world dynamics for any problem generated by it and that a family of specific models, constructed from different points of view may be more useful than one single model - regardless of its intrinsic value.

Thirdly, one observes in the global modelling approach an accentuation of the prospective cautioning character with regard to the future problematics, to the detriment of the predictive and of the prescriptive character. The basic question of our time seems no more to be "how will future appear", but, "what must we do today so that future be as desired by us and by our followers".

In the fourth place, we see that the classical problematics of global models with regard to the economic growth and the ecological balance is completed by social and human aspects which require diversifications in the methodological spectrum and rehabilitate heuristics and creativity.

x) In this perspective for instance, it is not easy to specify whether the very marked disintegration proposed by the Mesarovic-Pestel model presents only advantages over the Forrester Meadows models.

In the fifth place, the centre of global modelling problematics moves from the dysfunctions of the developed capitalist society, considered so far representative for the entire human society - to the dilemmas of development and to the difficulties of installing a new world economic and political order. Related to this, we also witness a certain "democratization" of global modelling concerns, which lose their elite character and exceed the borders of highly developed countries. This also indicates a recognition of the research efficiency, in a domain which is so close to fundamental activities of the social economic and political practice. Nevertheless, rigour imposes us to emphasize that the basic postulate of the global model development until now was to cultivate the continuity hypothesis: at the level of elements, or, more recently, at the level of structures, objectives and values. The above mentioned trends are added to this fundamental hypothesis.

But, is the trend map sufficient to anticipate the future advances of global modelling? Certainly not. Prospective researchers know that in forecasting, the study of trends is necessary, yet seldom sufficient. And the utilization of trends itself raises difficult problems. We shall therefore show a few possible evolution variants of such concerns.

The first variant - a rather short-term one - is an inertial prolongation of identified trends. We shall therefore witness improvements of the developed models, new approximations - yet on similar bases x) - etc.

---

x) An example: the further disintegration of the Mesarovic-Pestel model up to the level of nation-states as real elements - actors of the present world.

The second variant which seems to be closer to the spirit of our time is placed between trends, on the "blanks". The great motives of the future evolution of global modelling seem to be hidden here.

We shall conclude these considerations by suggesting a few aspects opened by the anti-inertial perspective.

A first new possible development direction of global models may start from replacing the basic continuity hypothesis by the mutation hypothesis (scientific-technical, social etc.). This may be imagined at the level of elements, structures, objectives or values (social and perhaps human revolution).

Another new possible development direction of global models may start from the dual approach to that used until now: in other words, one starts not from synthetical aspects towards morphological ones, or from a whole towards parts, but reciprocally, from local morphological aspects to synthetic global aspects. From an initial research point, the global model becomes thus a final point.x) The "integration" of partial or local models requires however tools used by some new scientific preoccupations: the formal study of a set of models (evaluation, comparison, composition, "calculation", dialogue, etc.). In this manner, global modelling opens new perspectives to the theory of social systems representations itself. And such perspectives seem fascinating.

x) An example illustrating this possible dual approach: a world model in which the actor elements are the states: it is not obtained by further "disintegration" of the Mesarovic-Pestel model, with national scenarios simulated from outside each national reality by a restricted group of experts. National scenarios are generated at the beginning with "forces" (options, objectives, etc.) and are then correlated into a global national model. In the International Center & Methodology for Future and Development Studies of the World Future Studies Federation (Bucharest) the methodology of such a type of approach is studied.

File — System Dynamics Faculty Members File

Gr. Brit
— S.D. Active Centers

September 8, 1971

Mr. R.J.C. Roeber
Imperial College of Science
and Technology
Management Engineering Section
Exhibition Road
London SW7, England

Dear Joe:

Thank you for your letter of August 10 and the comments about social systems.

We should move from our more tangible areas of system work into the "ideas, values and effect" so that we could begin to bridge between our systems work and the classical education of history and the liberal arts. So far, we simply don't have the people or financial support to do this.

Perhaps you can help stir up some interest between classical education and the new work in systems. For some thoughts along these lines see the last section in my enclosed paper prepared for the Joint NATO and U.S. Conference on Cities in Indianapolis last May.

In your letter you do not let me know what you are now doing at Imperial College of Science and Technology. We would be interested in hearing.

Sincerely yours,

Jay W. Forrester
Professor of Management

JWF:ie
Enc. "Urban Goals and National Objectives," Indianapolis, May 1971

Air Mail

AIR MAIL

JW7 8/13/71

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
MANAGEMENT ENGINEERING SECTION

Exhibition Road London SW7 tel 01-589 5111 telex 261503
Head of Section: Professor Samuel Eilon DSc(Eng), PhD, DIC, FIMechE, FIProdE

10th August

Professor Jay Forrester,
Sloan School of Management.

Dear Jay,

It is some time since you wrote and sent some data on the world model. I had intended to write on it - and on the subject of your models "counterintuitivity" generally - but was pipped by publication of the book, having waited too long. Idiot.

I'd like to keep in touch with your work in this area, and not just as a subject for articles (although that is part of the interest). What particularly interests me is the analogy with social systems more generally defined. You model systems in which the flows are of physical quantities; I am interested in the ~~soci~~ stability of systems where the flows are of ideas, values and affect.

You once told me that any system that contained a large number of negative feedback loops interconnected would be stable, insensitive to change in the parameters within wide ranges. It is not hard to translate this into terms of the transactions that take place between people, which result in intensely stable systems - or transactions between such systems within a larger system. In a very real sense, people are "controlled" by feedback from their environment which comes in a thousand forms; groups of people are controlled in the same way. It becomes a fascinating exercise to try and isolate the loops. I have become particularly interested in the extraordinary stability of the City of London, as a financial institution, for example. The stable system that is operative is the social one. I am convinced that it has a lot to do with the City as one of the last haunts of privilege; the banking aspects of much of its business; the need for trust in banking; the trust that is engendered by shared interests and values (not to mention friends). So that the financial needs and social needs are mutually supporting.

I shall stop there. You must have been there before, many times. I only expatiated a bit to illustrate the value I have found in your models and the conclusions you have drawn from them yourself. With one slight difference. You are interested in behaviour, and ways of influencing it. I am fascinated by stability, the "Le Chatelier effect in social systems". Rather gloomily, I am becomming convinced that resistance to change in the ruling characteristic of these systems. Looking at it Darwinistically, one can see the survival value of stability and resistance to change in systems generally. But in social systems the effect of conscious choice (Huxley's distinction between inorganic/organic/social evolutionary processes) introduces influences that are counter-evolutionary. Not that this is new: pre-revolutionary France, the Khmer empire and those aristocratic families in the Amazonian tribes Levi-Strauss describes are all examples of a social stability so rigid and

IMPERIAL
COLLEGE OF
SCIENCE AND
TECHNOLOGY
MANAGEMENT
ENGINEERING
SECTION

Exhibition Road London SW7 tel 01-589 5111 telex 261503
Head of Section: Professor Samuel Eilon DSc(Eng), PhD, DIC, FIMechE, FIProdE

impermeable to outside influences as to be non-viable. There's no harm in that: it's what natural selection is all about. But the tools we are developing ~~toxx~~ today, in particular the technologies of communication, transportation and ~~xx~~ information processing raise the possibility that this fate may overtake whole modern nations. We become so ~~effixixx~~ efficient in feeding-back that we can make cohesive social groups of a size that would have been impossible in earlier days. Thus the dangers to the world are correspondingly greater.

I hadn't meant to do that - get carried away, that is. Let~~m~~ me leave you with two requests:
1. That, if you have a list of people to whom you circulate occasional papers concerning your group's work, you add me to it*
2. That, if you are passing through London, you let me know* - since I should like to talk to you about these things.

There is a third, a matter of detached curiosity. The paper you sent was studiously (or maybe unconsciously) vague about the Club of Rome. I'd be interested to know more about it.

Yours Sincerely,

Joe

Joe Roeber

* These sound more like demands than requests. I should add a 'please' to both, to get the right tone. JR.

copy filed in MH - univ x ref "Futuristics"

Dartmouth College HANOVER · NEW HAMPSHIRE · 03755

Department of Sociology · TEL. (603) 646-2554

10 June 1975

Files from the ongoing Future Studies Survey, with a Mark IV report envisaged for 1976, will now be housed at Futuremics Inc., 2850 Connecticut Avenue, Washington, D.C. 20008. Futuremics is a consulting firm and an association of professionals committed to helping individuals and organizations meet and solve problems which have a direct bearing on the future. The staff of Futuremics will assist in deeping the files up to date and refining the storage and retrieval of data, along with attending to their other information services and clearing house activities (including Future-Abstracts and the newsletter Footnotes to the Future). I shall continue in a consulting capacity with the project.

H. Wentworth Eldredge

H. Wentworth Eldredge

UNIVERSITY EDUCATION IN FUTURES STUDIES
A Mark III survey

H. Wentworth Eldredge

Following two earlier analyses (1970 and 1972), the Mark III survey of 1974 explores the extent and quality of university education in disciplines identifiable as future-oriented. The initial research revealed a somewhat stagnant situation. There is a decline in systematic futures courses at the university level, while there is now a stronger trend towards "futurisation" of conventional subjects on one hand, and to practice-oriented non-university educational activities on the other. The most significant developments appeared in long-range planning, policy studies and peace research. Representation of methodologies shows systems research as perhaps the most, and social sciences as a less important contributor. Identification of "futurism" and clarification of the concept remains the dominant problem.

The crisis of crises

Jean Monnet was reported to have said in the spring of 1973, "We must attack our problems instead of each other."[1] It would certainly seem that there are sufficient massive questions to be solved without searching for enemies in the last quarter of the 20th century as the world appears to be falling apart at the seams.

Recent events are building up a crisis or apocalyptic psychosis in the Western world which was prefigured in 1918 by Oswald Spengler, in *Die Untergang des Abendlandes* (The Downfall of the West). A philosopher from a Catholic college

Professor H. Wentworth Eldredge, Dartmouth College, Hanover, New Hampshire, USA, is a member of *Futures* Advisory Board. His article is an abridged version of the survey which was funded by the World Institute Council, Inc, of New York City; another version was published in *Fields Within Fields*, No 14, Winter, 1974–75. Dartmouth College supported the endeavour as it did the Mark I Report (Second World Future Research Conference, Kyoto, 1970, *Technological Forecasting and Social Change*, Vol 2, 133–148, 1970), and the Mark II Report (Third World Future Research Conference, Bucharest, 1972, see *Technological Forecasting and Social Change*, Vol 4, pages 387–407, 1973). Both reports were summarised respectively in *The Futurist*, Vol IV, No 5, December 1970, and Vol VI, No 6, December 1972. A brief resumé of the 1972 report also appeared in *Futures*, Vol 4, December 1972. The author is also most grateful to his assistant Elsie Sniffin for her valuable contribution and to Alan Eldredge for aid in the computations. *Futures* is grateful to the WIC for permission to publish this version.

has a preamble to his course, dealing among other things with historical dystopias:

The first question is whether there will *be* a "future of man" at all. Man is driving a high powered vehicle over rocky ground, past mountain walls and canyon abysses, through a dense fog, at breakneck speed; yet he spends most of his time looking in the *rear* view mirror. "Future shock" and the snowballing effect of change make it necessary for survival to think history forwards, not just backwards.

Clear indications on "the socialistic mood" of the communist states are not forthcoming through the old barriers (they do appear to cope better with inflationary forces). The tragic poor, poor, nations (those without oil or other leverageable resources) seemingly are too shocked as yet to act coherently.[2] Thus, most assuredly, we face a global "crisis of crises": resource depletion, galloping inflation, economic chaos, increasing pollution, the population "explosion" with growing starvation;[3] an exponential rise in nuclear danger coupled with mounting worldwide violence in chaotic callous patterns.[4] There is no question that a "Brave New World" is in the works for evil—or possibly good—threatening, by exponential change, unprepared societies in an accidental century.

It is high time we thought as organised peoples about various states of the future: tomorrow, next year, next decade and next century and possible alternatives. It would be fitting at the 200th birthday of the USA in 1976 for us here to cast up some varied "alternative possible futures" both civilised and uncivilised! Robert W. Lamson of the National Science Foundation has done just this in "Ideas for the United States Bi-Centennial Decade" which takes an operational sciences position and concentrates on how to instigate an open (participatory) yet sophisticated, comprehensive long-range (cybernetic) planning system in the federal and local governments to upgrade in a human direction the quality of American life.[5] It is clearly not America's task alone; as John McHale has noted in *The Future of the Future*, "all major problems are now world problems, and most are in no way amenable to national solutions".[6]

The order of business falls naturally into three main operations, logically in this order, but in reality all to be attacked simultaneously:

(1) *research* into every aspect of futures study—we really do not know *reliably* as much as we would like to and need to know. However, according to that experienced student, Olaf Helmer:

The widely-felt requirement for better long-range planning in the areas of social and political institutions, of the physical environment, and of international relations, has caused too many people to place too great hopes in the benefits to be derived from the new discipline of futures research. Its failure to live up to these expectations has begun to produce a backlash, in that some new doubts have been raised as to whether futures research is altogether an activity worth pursuing.[7]

(2) *education* continuing and continuous from child to "senior citizen" formal and *informal* on the future, despite the inadequacy of our knowledge and the techniques for its verification, addition and improvement.

(3) *long-range planning and the* sine qua non *delivery systems* to get what we do plan into operation, cybernetically upgraded. This, of course, is the realm of the policy sciences.[8]

The task of this survey is to report for the third time on the state of things under rubric (2): *education*, concentrating on the still tentative formal advanced education in recognised academe. However, it involves a side glance at the level of futures research; the increasing level of non-academic advanced futures education;[9] counter-culture futures "education"; and an inquiring look at long-range planning and the policy sciences peopled by the self-selected high priests of *delivery systems*, obstetricians of the future, it would seem.

A seller's market in futurism

In view of the contemporary mood, one could certainly expect that futures studies would be booming. How to cope with "The World Revolution of Our Time" was a question posed by Harold Lasswell a quarter of a century ago.[10] Future-oriented education is most assuredly active today in various forms—not necessarily labelled futurism or futures studies, much less "futuristics" or "futurology". Our survey files have been collected since 1968, and now hold some data on approximately 500 futures courses in every imaginable field—some disciplines showing more interest than others. Futuism *per se* is popularly chic, but it appears quite simply not intellectually so in 1974. "Alternative possible futures" is the watchword—or catchword—for an increasingly wide spectrum of interests, skills and professions.

For this third iteration of the survey, the definition of "futures courses" was broadened to include, wherever possible, technology forecasting/technology assessment, policy studies, demographic projection, economic forecasting, peace studies, on to utopian literature and science fiction. Moreover, it dealt with non-degree-granting programmes ranging from short seminars for corporate and governmental executives to "intentional communities" of a most imaginative and/or unconventional sort; it may well be that non-traditional learning under non-traditional time formats may prove (a) the necessary periodic retreading for all age groups demanded by exponential growth (not necessarily physical but most certainly informational); and (b) the needed further acceleration of institutional capability to cope with change.

The Mark III survey began in the summer of 1973 by mailing out approximately 1200 simple open-ended questionnaires on future courses and programmes at the university level to former respondents and to new names in the futures field, located and identified through various journals, contacts, and organisations. The survey has tended to rely increasingly on analysis and critique by self-conscious groups of their own activities; such as policy scientists, science fiction writers and teachers, the long-range planners and the war and peace study world; and did not attempt to reach independent conclusions. The intentional community/counter-culture groups (both urban and rural) too have their own encyclopedias in the process of formation. To my chagrin it proved impossible to uncover a lively nest of pure long-range demographers or economists;[11] a future prospective is assumed to be evident in the former field and seemingly impossible in the latter.

Usable returns were received (or data became available) from some 300 individuals. Subtracting the 60 inadequate addresses from the original 1200, this means about a 26·5% return—hardly striking. Has the future become "old hat"? Among those who did not reply were 153 respondents to the 1972 questionnaire and also five old contributors from 1970. A considerable number of those who did not report were from non-degree-granting technological forecasting courses and seminars outside universities. These educational variants are having an impact hard as yet to judge. "Universities" do not need "walls"; nor do they necessarily function better "closed". One feels that numerous such futures courses do exist, but this survey has proven singularly inept at locating them directly—despite the fact that they seem quite self-conscious about their own endeavours once unearthed.

The Mark III version also expanded *territorially*: a coverage of futures courses outside North America, which had been combed for five previous years, is still very patchy. Excluding Canada, with 16 course-givers at present, our files contain information on only 27 individuals outside the USA; none reported to the survey from the Third World countries.

A number of very tentative hypotheses in general explanation of the relative paucity of answers to the 1973–74 questionnaire may be advanced:

- Course-givers had nothing new to say.
- As noted already in the Mark II report, the early missionary zeal of the small original band of enthusiasts has become muted, though lots of new faces popped up.
- At a time of financial retrenchment in the academic world (especially in the USA), waving a bright banner of futurology may not be operationally valid.
- Academics do not identify themselves. There appears to be a faintly "disreputable odour" detectable in futures studies (several respondents implied as much) so that some scholars did not recognise their courses as dealing with the future—although it was difficult to see how this conclusion could logically be avoided—given the catalogue descriptions.

Four activity nodes in the futures studies' spectrum are symptomatic of the contemporary ferment: (1) government-oriented activities; (2) technological forecasting and assessment; (3) policy studies and peace research, and (4) science fiction. Neglected as organised interest centres in this brief listing—but not forgotten—are the powerful group of educationalists; architectural or physical design futurists; political forecasters; systems analysts and operational researchers; mathematical modellers; students of utopian literature and utopian community *aficionados*; and the environmentalists/ecologists. An argument could be made that both Black studies and "women's lib" studies are both to a degree future-oriented! There are even faint signs of "gerontology lib" research and courses spurred on in the USA by the American Association of Retired Persons; there has been a surfeit of future-oriented "youth studies" for decades.

Learning and teaching fashions

There is very little in the futures field that is excitingly fresh in new teaching techniques, or in people-oriented experiential learning (except, perhaps, SYNCON).[12] The standard methodological ploys explored in both the 1970 Mark I and 1972 Mark II surveys are still with us adding little to the twelve that Daniel Bell staked out a decade ago.[13] These may be conveniently grouped under five headings:

- Type A: intuitive methods and codified intuition or Delphi;
- Type B: trend extrapolation;
- Type C: development of ideal state and/or alternative possible futures scenarios;
- Type D: dynamic models; there is patently an adjunct methodology crucial to futures research in the following type:
- Type E: social indicators and the Quality of Life (QOL) index.

What new is there for the veterans of five years of futures teaching to do except to sharpen up the "past wisdom"—undoubtedly leading to diminishing returns in intellectual rewards. As in all "education", practically nothing concrete stands as evidence of accomplishment. (An arrow shot into the blue with only tenuous and oh-so-chancy "student evaluation sheets" as reward!) This researcher developed a sense that new people checked in often with excitement and the old stayed away from reporting in droves (or gave up futurism!).

An index of interest identifiable in approximately 500 courses analysed over 6 years is shown in Table 1. For the 1974 figures, the policy studies, peace study,

TABLE 1. SUBJECTS OF COURSES IN THE FUTURES FIELD

	Reports 1973–74	Cumulative 1969–74
Anthropology	4	9
Business administration	32	57
Computer science (modelling, etc)	24	27
Demography	2	2
Economics	7	10
Education	28	40
English	5	10
Engineering	17	26
Geography	7	10
History	5	8
Humanities (overlap with English)	16	19
Law	3	4
Natural sciences	13	25
Political science	19	33
Psychology*	3	3
Sociology	50	77
Theology	5	10
Urbanology (including Architecture)	15	28
Miscellaneous	58	78
Total	*313*	*476*

* Michael Marien (the World Institute, New York) reported that there were now "more than a hundred courses" in parapsychology alone.

and science fiction courses *per se* which fell into our files and counted to a certain extent in 1972 have been removed unless clearly conceived as future studies. The loose statistics gathered by these self-conscious groups suggest a possible total of an additional 1000 to 1500 individuals. There are undoubtedly other course-givers among the ecologists/environmentalists, "women's" or "Black studies", who are future-oriented or who "futurise" their work to a greater or lesser degree. From the 1969–74 cumulative total a number of courses no longer qualify; as now part of the disciplines coalescing under their own banners they have been removed. Here are some brief observations on certain fields from the latest sample:

Anthropology has not climbed aboard futures study as was hoped—at least from our evidence—despite the fact that futures sessions surfaced at national meetings.

Business administration people appear firmly convinced that for large organisations, technological, not to mention societal (including value) forecasting is of increasing importance. If the policy science groups joining both governmental and private organisations were coupled to the area of technological forecasting and technology assessment it is conceivable that their like-minded teachers would be numbered in the hundreds.

Computer sciences are having an increasing impact and will eventually play a key role in all futures study. Few individuals are "pure" computer types, but generally have a great variety of other skills and disciplines.

Economists have not eagerly rushed into "futurism". Even in the model-addicted, quantitative, econometrics sub-profession: "We also have courses in econometrics, but from my conversations with professionals in this area I think their approach is technique rather than substance."[14]

In *education*, professionals, when challenged, seem eager to develop methodological, technological (including very soft technologies in experiential learning) and structural experiments. There is a visible creativity and a variety of futures-oriented programmes. What all this amounts to is not yet certain: a number of jaundiced educational "pros" question whether "the study of the future" and the "futurising of education" make very good sense. On the other hand 13 000 members of the US Association for Supervision and Curriculum Development (ASCD) illustrated their interest by grouping their conference in California during March 1974 around three themes: "Alternative Futures", "Education for a Pluralistic Society", and "An Action Agenda for Education's Futures".

Demography. Despite the rather obvious need for this discipline within a holistic futures framework, only two demographers have popped up in the survey. Few demographers appear to be very eager to have their names linked with "futurism"—although in reality they most assuredly are generic "futurists":

> In answer to your question regarding future-oriented demographers, I am so sorry to state that I do not know of any formal organisation. At the risk of doing an injustice to my colleagues, my impression is that few if any are genuinely concerned. Most demographic work on the future follows either the routine extrapolation of recent trends, using the component (birth, death rate) method or is heavily into the doomsday prophecy approach on what I would consider flimsy evidence. It might be of some interest to you that I compared your lists [of future interested persons] with the 1972 Directory of the Population Association of America members and found only a few duplicated entries.[15]

Sociology. Rallying from an obsession with static structural analysis, the sociological community is slowly revising itself into an active concern with societal change (socio-cultural change) and with an activist stance—both endemic in futurism. Thus the numerous new recruits who along with the political scientists appear to be the leading futurisers of traditional courses either by introducing a short section at the end of a term, or a continuous slanting of material.

Key methodologies

As expressed before in these surveys, there will never be any reliable prognostics until there is reliable sociocultural change theory basic to forecasting. The sociologists or anthropologists should be engaged in this. A business school dean observed:

I am puzzled by the fact that sociologists have abandoned their lead in the methodology of forecasting. 35 to 50 years ago they were leading the nation. They persuaded the government to conduct the first technological forecast. I find that today's sociologists either don't know about this or are completely uninterested. You can see this in the elaborate bibliography in [Wendell] Bell's book. The work of Gilfillan and Ogburn is scarcely mentioned, and Hornell Hart is quite unappreciated. This leaves me fumbling around for someone who is a competent sociologist and will make himself a leader in encouraging the development of methods of social forecasting.

When sociologists do finally take this matter firmly in hand, let us hope that they will employ normal language rather than the jargon to which they are addicted —understandable only to the acolytes of the discipline.

A fundamental question on the purposes of futures studies was raised at the College of Europe, Bruges, Belgium, in a 20-hour course for social science majors, *Prévision et Prospective* (social forecasting and futures study): "Are futures studies part of the philosophy of history or an aid to policy makers?" The instructor, presently at the French *Commissariat Général du Plan*, reported no unusual features "except that my teaching is in good part based upon my professional experience as a government employee".

The total evidence in hand indicates that in late 1974 all the standard futures research and teaching methodologies were still in use with very little firm evidence to verify the reliability or heuristic value of any. The *validity gap* faces all futures study. However, there appears to be purposeful activity in the development of research-cum-teaching methodology at least in these areas: (a) technological forecasting and technological assessment; (b) general systems theory, systems analysis and systems dynamics; (c) Delphi and cross-impact analysis; (d) policy studies; (e) creativity and experiential learning.

Technological forecasting (TF) *and technological assessment* (TA) are making increasing inroads into both governmental and corporate planning. A leading sage of TF berates all sociologists (through me) unceasingly and probably quite correctly:[16]

The important point to convey to the sociologists is that we are receiving continual pressure from industrialists to get them some help on predicting the interaction of social change with technological change. In other words, give them some insight on social forecasting.

The finest way to test a method is to examine action results of this method in a real world situation (often neglected by social scientists who serve usually as mere analysts; *not* planners). Actually TF and TA in my estimation will fall far short unless married to systems analysis, systems dynamics and systems theory in general.

Systems research, consisting of rigorous, highly intellectual and increasingly mathematical technologies seems to be at the very roots of the alternative futures game. It is more than likely that all futurists will need to master this difficult bundle of technologies if they wish to produce more than "hot air". From the Wharton School of Business came this nugget: "I teach a seminar on forecasting methods. It is called Long-Range Forecasting: From Crystal Ball to Computer."[17]

Delphi techniques and cross-impact analysis edge into a great majority of courses in all fields. A clear externality of their use of students as "experts" is experiential learning through participation.

Experiential learning creativity and scenarios teaching which can hardly be classed as "hard" technology, are mostly based on a notion: "Doing something sticks in the consciousness better than reading about it". Museums of the future growing in both Denmark and Wisconsin are early attempts in the direction of "living in the future".

At the far, soft or "left" pole of activities in futures studies the gamut of educational gimmicks used to stir up client students seems endless: simulations; telephone interviews; movies; TV scripts; participatory planning, poetry readings; forming a collective; expressive dancing; technological cum groupthink jamborees such as SYNCON and the WORLD GAME; a voodoo experience; scenario building; intentional communes for future living; "happenings"; confrontation/encounter sessions; role playing; modelling; brain storming; free-form courses; nature worship; a futures fair; a personal life history projection; visits to "futuristic" locations such as California; video tapes; survival training and solos; individual obituaries etc. What does this *ersatz* and real experience add up to? Do glorious and valuable thoughts emerge? To this survey no answer has as yet been "revealed".

Flexibility characterises many futures courses even in the hard science area. The Dean of Harvard's Division of Engineering and Applied Physics in a General Education course (mixed graduate and undergraduate) on technology assessment reported:

Unfortunately, I do not have a mimeographed syllabus. Last year the organization of the lectures was fairly informal. I intended to change as I went along, according to the interests of the class or questions raised by it.

A good example of a free-swinging natural scientist at work is this report from the University of Illinois at Urbana-Champaign:

In the past, I have had 8-mm movies, TV scripts, poetry, paintings, and science fiction, as well as documented factual monographs and extensive bibliographies. Student reaction to this course has, in general, been good. Most of them feel that their ability [opportunity?] to be creative at the undergraduate level [is slight] and that this is the one chance they will [have].

From the UK Open University (Faculty of Technology, Oxford Research Unit) come details on "A course involving students in project-work in community-participation in designing their lives . . . the student activities are part of a larger course 2nd level—'Urban Development'. A book growing out of this work, *Community Participation in City Decision Making*, is specifically futures oriented."

One seminar in philosophy on "Alternate Futures" heads its course prospectus with the catchy headline "*There is no map of the future because nobody who goes there ever comes back*" with "no single book for all—instead a sharing situation in which we have sessions to compare reading directions".

A two-day aerospace programme, future-oriented towards space travel, was carried out on Simpson[19] campus "during the summer of 1973 reaching a total attendance of 725 people. It was conducted through the National Balloon Races that brought 100 000 people to our campus and 10 000 to the Skylab displays provided by NASA." The instructor responsible for this course offers a regular course on the sociology of aerospace.

Many future-oriented university courses now include "real life" learning experiences similar to what might be offered under a "paracurriculum". A member of the World Future Society, who is actively engaged in providing such learning situations for his students, is Frank Ogden of the Ontario College of Arts in Toronto. To open students' eyes and immunise them to future shock, Ogden puts them through 50 to 75 radically different experiences in a short time. The students take flying lessons, work in a poultry shop plucking chickens, wrestle with an alligator, inhale helium, train in brain-wave control, conduct a funeral service, and eat rattlesnake meat. No evaluation whatsoever is available on the results of such gyrations—if any.

A questing anthropological futurist is taking his graduate class from the Far West to Arcosanti[20] to aid physically in "building the future" with their own hands. One believer in "future shock" attracted the initial attention of his undergraduate seminar by requesting each to write his individual obituary. Several balked. A number of courses conducted usually by humanists search out *sci-fi* or utopian alternatives of hope or gloom for possible future alternatives.

Probably the most startling in scale and technology is the SYNCON technique[12] developed through the Committee on the Future, Washington based and amply funded. This envelops everyone in an insistent interaction net. A gadgeted physical format of initial separation by concerns synthesises to creative alternatives and operational suggestions; it has already interested governments (at the state and national levels in the USA and Jamaica) and a number of big name futuristic seers including Herman Kahn. Too complex for ordinary classroom use, SYNCON could and is being adopted in lesser forms.

We are told, with the decline of the university during the coming Dark Age, to look for "new monasteries"—communities for cultural-spiritual survival. Lindisfarne (the medieval community performing a similar function in the original Dark Ages) recently set up on Long Island by William Irwin Thompson (*The Edge of History*) and Gene Fairly has as its objective to work at the "interface between esoteric and exoteric". A conference in August 1974 at Lindisfarne was devoted to planetary culture with Soleri and others; that summer's programme included Sufi and dream workshops, T'ai Chi, Yoga, "Explorations in Mysticism and Science", and "The Transformation of Human Culture."[21] Various purposeful communities exist outside the parameter of "regular" university education. They abound with their own listings, jargon and bibliography, generally of the non-straight world; they probably number less than the publicity engendered would indicate (even the astronomically inflated figure of 100 000 American commune members would form less than 0·005% of the US population).

The interesting and probably significant programme of *Earthrise*, a non-profit organisation with connections to the Rhode Island School of Design, Brown University, Roger Williams College and the University Without Walls takes a "creatist" (rather than a fatalist) view of futures.[22]

The national Endowment for the Humanities has backed a course by newspaper directed from the University of California at San Diego, "America and the Future of Man". 5000 students enrolled for it during 1973–74 in extension courses and for regular academic credit all over the USA with lectures by leading establishment futurists and some non-futurists appearing regularly in 258 newspapers.[23]

Despite all the fuss and fury catalogued here, a 1973 MA thesis, "Survey of Selected College Level Courses",[24] from a sample of about 40 co-operating course-givers concluded: "Traditional methods and techniques of instruction were used more often and rated higher by instructors of futuristic courses." The analysis of our 300 courses—a sample equally unscientific—in no way contradicts this conclusion.

Strategies: programmes versus "futurising"

There is a strategic quasi-methodological problem in futures education: whether the "futurising" of regular courses is preferable to a specific future studies programme. In policy studies, TF/TA, and peace studies—with the first named generally at the post-graduate level—there appears to be clear evidence of the choice of a *programme* as the best vehicle. Typical of a number of policy studies operations is a report on Stanford University's Programme in Values, Technology and Society (VTS) for undergraduates, describing a core of 4 courses with 13 others of specific relevance: ". . . the Administrative Committee is deeply concerned with exercising quality control over its limited number of offerings. It does not intend to allow VTS to become an umbrella for a pastiche of disconnected offerings". TF/TA along with systems research appears to require such grouped or programmatic treatment. Let this be called *Strategy A*, for the inauguration and teaching of futures studies: a programme in the field or discipline.

For instance, the Portland State University systems science PhD programme includes clearly identifiable futures courses. A "Futuristics Education Programme" at the University of Massachusetts for a Doctor of Education, with no full-time futures faculty, it appears, has its programme members work in three general areas: long-range social forecasting; the future of education; the developments of future-oriented education. "In practice the programme is a happy anarchy, with 15 grad students each designing and following his own individualised programme" from at least 10 future-oriented courses and seminars plus outside electives. There is a considerable free-swinging offering of undergraduate courses in addition. At the same university the Division of Continuing Education had a series of 28 "Toward Tomorrow" workshops on alternative possibilities. One hard-working "proposer" in a private New Jersey institution has yet to get his programme implemented; while another in the same state at a public institution seems still to be making headway with his 4 undergraduate courses "Programme for the Study of the Future" centring around history and social science. With the same strategy, a policy-oriented "Centre for Comparative Studies of Post-Industrial Society" is developing at the University of Wisconsin with both undergraduate and graduate programmes; and a multidisciplinary formal programme at the University of Michigan on "Science, Technology and Future Studies" at the undergraduate and possibly graduate levels. Cornell's "Programme on Science, Technology and Society" has 11 graduate and undergraduate courses. At a more moderate level Southampton College, New York, an outpost of Long Island University, has "Future Studies, with a long-range goal for mankind focus" consisting of 4 courses for undergraduates; 3 in natural science with "Future Studies I" as the general introduction. These examples touch on most of the types of variants in the grouped fields.

Strategy B—the "futurising" of standard courses—is clearly very widespread and only the tip of the iceberg was glimpsed through the survey. Examples are: "Sociology of the Future"; "Political Science and the Future"; "Bioethics"; "Utopias and the Future" or "Science Fiction" (English or philosophy department); and "Technology Assessment" in biology, chemistry or physics.

This futures leavening is one of the ways to avoid the real or fancied opprobrium of teaching the "frill" or "fad" of "futuristics" or "futurology". Zbigniew Brzezinski, author of that excellent probe into international futures *Between Two Ages: America's Role in the Techmetronic Era*[25] reported through a secretary that he did not teach the future. Wilbert Moore remarked that he gave only a "command performance" on occupational futures from time to time. Perceiving the emergent trend towards dealing with the future *by dealing with the present*, Daniel Bell, folk hero of American intellectual futurism and author of one of 1973's most discussed and ponderous tomes, *The Coming of Post-Industrial Society; A Venture in Social Forecasting*[26] reported that,

As you know, I do not believe there is any entity as "the Future" or a *field* called "Futurism" or a science called "Futurology". I believe that one has to build projects, forecasts, speculations, into whatever one does in sociological work. I do not see "futures courses" as independent fields of study. I usually give two seminars on Culture and Social Structure and on Social Change and in them I seek to discuss structural trends which may or may not, depending on specified conditions, continue to operate in "the Future".[27]

Strategy A and *Strategy B* are not mutually exclusive and our experience indicates that a useful rewarding mix, *Strategy C*, combining both, does exist. I like the wisdom contained in the phrasing "the inevitable future orientation of teaching and research in a professional school of architecture".[28] The environmental/ecological courses, so popular today, are automatically futurised in one fashion or another; that position is obviously endemic. Here is a typical small victory—this time in a History Department:[29]

I thought you would like to have a copy of my future history course proposal. The course was approved by our Curriculum Instruction Committee last Monday . . . I have been given a reduced instructional load for the next semester in order to develop the course.

But several eager teachers from the Mark II period reported sadly that nothing had come of their attempts to introduce a futures course in an old "department of the line".

The problem of attachment

Education in future studies appears to be suffering from an identity crisis today. Without greater sophistication in forecasting, the whole structure of the future education endeavour rests on shaky ground and can fizzle out in fuss and feathers: of "interest" but hardly significant. A professor of architecture (a presumably creative, intuitive field based on engineering) reports: "I'm not giving, nor particularly interested in, futures-oriented courses. Most of them seem either fantasy or sci-fi oriented."[30] May not some of the intellectuals already be in flight?

I do not know how I got on these lists. Probably, it is because, for a time, I was Director of a fairly large effort to do something in long-range futures for education. But deep inside of me, I have no confidence that that approach is helpful except as it contributes to fresh insights to other more conventional kinds of studies. I have some students who are assembling undergraduate majors in the area of "future studies", but their work is made up entirely of rather conventional studies already in the curriculum. In these days, I have no faith in the future of future studies as such.[31]

Not so pessimistic is a professor of computer sciences at Purdue University:

I am no longer involved in teaching future oriented courses. The one I was involved with (The Impact of Science on Society) seemed to be well received by a few students, but enrolments (from the School of Science) were too low to make it a viable course. I have just finished an elementary Computer Science text . . . which has a considerable emphasis on considering the future. In particular, there is a complete chapter exploring the future of computers and their impact on society. In spite of the lack of success with my course, I feel that future studies have a future here. My course suffered from several problems (lack of publicity, limited audience—only Jr and Sr Science majors, not usable as a humanities elective for Science students) which I think could be avoided under different circumstances.

The guts of long-range planning (always cybernetic) are the still more tentative forecasting methodologies. As Daniel Bell observed, present actions have future results. There is a noticeable shunning of fancy claims:

I should add that I have decided *not* to offer the Political Futures course again. The reasons for this are several. The decline in student interest and in student willingness to engage in self-motivated, non-career related educational enterprises is certainly a part. As important has been my own dissatisfaction with future studies, and the development of my own research interests. I am now incorporating a future dimension in a variety of other courses. . . . But the emphasis will not be on forecasting *per se*, but on contemporary change processes and their public policy implications.[32]

Although I am intensely interested and spend quite a lot of time studying the general area [of futures study], I teach no courses in the area. I use the information, though, in indirect ways in the courses I teach, *for the future is* determined by what we do today.[33]

The question which ties the course together is, how to make better predictions about the outcomes of interventions.[34]

Lessons from the survey

Future studies *per se* have grown steadily as university courses. Our "sampling" techniques are most primitive, but a 50% increase every two years might be a reasonable guess estimate. There must be at the very least 1000 "pure" examples labelled "futures course" by now. This does not, however, approach the explosion of Black studies, environmental/ecological studies or even women's studies[35] in the USA.

The most significant developments in future studies have appeared not so named. Long-range planning and policy studies courses have some 80 *programmes* in operation and from catalogue descriptions many seemed excellent; peace studies 40. Important methodological developments in TF/TA, general systems theory, systems analysis, systems dynamics, modelling, gaming, computer sciences are probing the future and have seemingly been more productive than futurism. If Delphi and cross-impact matrices are "futurism", then some credit is due the "pure" field more or less labelled "futurism".

If all future-oriented courses were lumped (although not remotely entitled futurism) it would amount to a considerable figure: environment/ecology; TF/TA; *sci fi*; long-range planning; policy sciences (public and private); general systems theory; systems analysis and dynamics; utopian thought and eschatology, etc. Other than for the ego-enhancement of futurists, do future-oriented courses need to be labelled "futurism"? The important task is to gain the ability and instil the desire to deal with the present in a fashion truly to improve the human prospect—the courses examined by us do not suggest an immediate quantum jump in such a direction.

European universities—from very incomplete evidence—appear generally not to have welcomed future studies as "teachable material". This does not appear to be the case, however, in such technical areas as computer studies and TF. The tradition of European scholarship is to teach a corpus of knowledge; future studies is assuredly not yet that elegant by any stretch of the imagination. Americans and Canadians seem not so "timid" or "foolhardy", but have attempted to aid students in learning *what no one knows for sure.*

The Achilles heel of futures studies and futures education is still social forecasting (especially value forecasting) about which little is known and little is being reliably learned. Moreover, it is not clear to many that social forecasting is an advanced—though soft—form of TF. Societal indicators still remain in their infancy; they are basic to value monitoring as well as planning and decision making.

Futures studies have a poor intellectual image. Have futurists themselves as well as their publicists promised more than can be delivered? Futurist programmes would have hard enough work in this penurious period of American higher education in any case.

Mature academic minds seem to be shifting to a concern with the present coped with in a fashion that opens and does not close off future options. This is a subtle change in stance.

Some seasoned future-oriented instructors are losing faith in futurism (assuming they had some originally) and, after dipping their toes in those shallow waters during the past, are withdrawing. But new fresh faces rush in to replenish and extend the ranks. Teachers are teaching, but what is the core of hard knowledge?

There is much to-do about "creativity" but no one quite knows precisely how to foster it. "Creativity" in many guises seems to be located outside the confines of regular academic futures courses. The catalogue of odd teaching ploys or gimmicks is now extensive and much publicised.[36] What's new? Both the counter-culture at one extreme in odd learning situations and at the other the practice-oriented TF and similar courses get results (obviously of differing value) beyond the walls of academe. Possibly the great opportunity for futures-oriented learning is outside the university.

For the interim, futurising existing courses and programmes seems a preferable strategy for futures-oriented educators. It could be of great value intellectually to go beyond the simple *status quo* of existing disciplines.

It becomes increasingly clear that the field of future studies needs definition, probably in the direction of the need to train first-rate holistic practitioners. There is also need for a methodical recruitment and encouragement of superior young scholars.

Future studies are on a developmental plateau. Market research in who needs what sort of futurism could usefully be employed both for reality and image. Systems theory should be applied to the jobs at hand. The preliminary sociology of future studies to understand the quirks of the fields/disciplines involved and their practitioners must be carried further.[37] With guidance from TF/TA (including the TF of social technologies) a "wise" plan or plans (modelled where possible through systems dynamics) must be adopted through policy studies, and an operationally better input for decision making must be achieved. Whether such a complicated mix, both in the public and private sector and from the local to the international in scope, is entitled "futurism" or not is of little importance. The capability and the reality are more important for man's hope than the name.

Notes and references

1. Peter G. Peterson, "Global Economics Will Change Global Politics: The Investment Revolution", *The Center Report*, April 1974, pages 5–7
2. A contemporary echo of Spengler in modern systems language is the readable *The Coming Dark Age* by the Italian, Roberto Vacca (New York, Doubleday, 1973), who sees the domino effect of systems' collapse: too many fragile institutions unable to cope with the overload of exponential growth
3. W. and P. Paddock, *Famine 1975!* (New York, Little, Brown and Co, 1967). Not far off the mark—published seven years ago
4. *Cf* Erich Fromm, *The Anatomy of Human Destructiveness* (New York, Holt, Rinehart and Winston, Inc, 1974)
5. Draft, 28 August 1973. Office of Exploratory Research and Problem Assessment, National Science Foundation
6. Quoted in the excellent unpublished short paper, "Some Major Issues of the International Future", by Frank Snowden Hopkins, distributed by the World Future Society, Washington, DC
7. See Olaf Helmer, "An Agenda for Futures Research", in this issue of *Futures*, pages 3–14

8. *Cf* Yehezkel Dror's classic statement "Prolegomena to Policy Sciences", Rand Corporation, P-4283, January 1970, in which he marshalls the arguments for an involved research and experimental programme, improved decision machinery and on delivery systems always with a futures orientation. The encouragement of "heresy" in creativity and the reality of "irrationality" and its understanding in a rational fashion are novel aspects of this brilliant essay.
9. An argument can be made that adult education, especially through sessions conducted by think-tanks and consultant firms, is superior in many ways to the pure academic fare. Certainly the motivation of mid-career business management is high! See W. W. Simmons (Planning Consultant, 22 Greenwich Plaza, Connecticut, 06830) marshalling in "Exploratory Planning Briefs" (mimeo, 129 pages), an excellent short summary of the state of the art of long-range planning with the line-up of corporations, governments, services, agencies, educational institutions involved. The innovative New School for Social Research in New York City has been working at a broad adult education programme in "Futuristics" during the past two years.
10. *The World Revolution of our Time: A Framework for Basic Policy Research* (Stanford, California, Stanford University Press for the Hoover Institute Studies, 1951), a seminal effort for policy studies.
11. I would appreciate correction, especially from economists/econometricians. Anthony Lewis, *The New York Times*'s leading "people-oriented" editorial columnist of gloom, noted on 29 December 1973 with transparent glee, that E. F. Schumacher, an economist, stated of his colleagues that mostly they spend their time "optimising the arrangements of the deck-chairs on the Titanic".
12. *SYNCON: A Proposal for a Positive Future*, descriptive pamphlet available from the Committee on the Future, 2325 Porter Street, Washington, DC, USA
13. *Daedalus 93* (Summer 1964), "Twelve Modes of Prediction—a preliminary sorting of approaches in the social sciences", pages 845 ff. Cross-impact analysis, a recent departure, could be grouped with B and C, even A.
14. An extension economist in "Farm Management and Public Affairs" at a branch of North Caroline State University, presumably not among the profession's power elite, no matter how astute.
15. A future-oriented sociologist in a south-western university and author of a just published study of population and power.
16. Personal communication
17. University of Pennsylvania instructor now on leave at the Institute for Futures Research in Stockholm, and writing a book by that title.
18. No one has reported the "mind-expanding" use of drugs as part of a futures course
19. Simpson College, Indianola, Iowa
20. Design utopianist, Paolo Soleri's megastructure/mini city for 3000 in the Arizona desert. Soleri uses "student labour" who pay for this privilege—no doubt a future experience—in a continuing series of six week workshops. This undoubtedly is one of the more interesting "urban" variants.
21. Lindisfarne, Box 1395, Southampton, NY, 11968 (516–283–8210 or 212–PL2–1373). *Building for Attunement* is a booklet on setting up new monasteries. $0.50, Paul Shewan, W 623 26th Spokane, Washington DC, 99203 USA
22. *Earthrise Newsletter* 09 reviews the various seminars conducted by the co-directors since the summer of 1971. *Earthrise*, PO Box 120, Annex Station, Providence, Rhode Island, 02901. The *World Game* of Buckminster Fuller plays a part here.
23. For details, see Richard L. Roe, Publishers, Inc, 415 North Highway 101,

Solan Beach, California, 92075, or Courses by Newspaper, University Extension, University of California, San Diego, PO Box 109, La Jolla, California, 92037
24. Edward Pytlik, University of Maryland, Department of Industrial Education, College of Education, College Park, Maryland, 20742. An abstract of the survey is available
25. New York, A Viking Compass Book, 1970
26. New York, Basic Books, Inc., 1973
27. Personal communication
28. Washington State University, Program of Landscape Architecture
29. A small middle western community college; an instructor reporting on his course entitled "Future Studies"
30. University of Minnesota
31. Professor of Education, Syracuse University. An individual cognisant of this programme was of the opinion that the programme "failed", that it did not contribute fresh insights of considerable importance, and that the instructor, in addition to lacking faith, also lacked imagination.
32. University of Wisconsin, Madison
33. Professor of Engineering, University of Oklahoma, Columbia University
34. Professor of Art and Education, Teachers College, Columbia University
35. Know, Inc., Box 10197, Pittsburgh, Pa, has available *Female Studies I* with 17 course syllabuses and a later *Female Studies II* with 67! All this fostered under the spreading umbrella of the Modern Language Association Clearing House on Female Studies (the MLA also shelters *sci fi*). Cheryl M. Fields in "Women's Studies Gain: 2000 Courses Offered this Year", *The Chronicle of Higher Education* Vol 12, No 17, 1973, page 6. It is unclear how this estimate was arrived at.
36. *A Handbook on Teaching the Future* is in train at the World Institute Council.
37. *Viz* Wendell Bell and James A. Mau, eds, *The Sociology of the Future* (New York, Russell Sage Foundation, 1971)

File Spain

-SD- Other Centers Spain

ESCUELA TECNICA SUPERIOR
DE
INGENIEROS INDUSTRIALES
DE SEVILLA

Profesores

Prof. J. Aracil
Esc. Téc. Sup. Ing. Industriales
Avda. Reina Mercedes, s/n
Sevilla - 12 (Spain)

AVDA. REINA MERCEDES, S/N.
TELS. 61 11 50 - 61 11 54 - 61 11 58

SEVILLA, July 3 , 1975

Destinatario:

Professor Jay W. Forrester
M. I. T.
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Mass. 02139
U. S. A.

Dear Professor Forrester,

Last summer I participated in the Advanced Study Institute on Social Systems Dynamics held in Dartmouth. Ever since we are organizing a working group on Systems Dynamics. Our main field of interest is the Regional and Urban Modelling and Planning. For example, we have built a model of the demographic impact of a new factory wich should be presented in a paper submitted to the III International Congress on Cybernetic and Systems to be hold this summer in Bucharest - (Romania).

We have a Research Group in the University of Seville (Spain). Previously we have worked on Automatic Control but we are now focusing on Systems approach to socioeconomic problems. We - are deeply interested on Systems Dynamics Methodology.

In Dartmouth you have prounounced two lectures on a new and challenging model of a National Economy. We should very - much appreciate any Report, reprint or information on this model.

Yours faithfully,

Javier Aracil

J. Aracil

Houston paper was sent 7/14/75

file Spain

ESCUELA TECNICA SUPERIOR
DE
INGENIEROS INDUSTRIALES
DE SEVILLA

Profesores

Prof. J. Aracil
Esc. Téc. Sup. Ing. Industriales
Avda. Reina Mercedes, s/n
Sevilla - 12 (Spain)

AVDA. REINA MERCEDES, S/N.
TELS. 61 11 50 - 61 11 54 - 61 11 58

SEVILLA, July 3 , 1975

Destinatario:

Professor Jay W. Forrester
M. I. T.
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Mass. 02139
U. S. A.

Dear Professor Forrester,

Last summer I participated in the Advanced Study Institute on Social Systems Dynamics held in Dartmouth. Ever since we are organizing a working group on Systems Dynamics. Our main field of interest is the Regional and Urban Modelling and Planning. For example, we have built a model of the demographic impact of a new factory wich should be presented in a paper submitted to the III International Congress on Cybernetic and Systems to be hold this summer in Bucharest - (Romania).

We have a Research Group in the University of Seville (Spain). Previously we have worked on Automatic Control but we are now focusing on Systems approach to socioeconomic problems. We - are deeply interested on Systems Dynamics Methodology.

In Dartmouth you have prounounced two lectures on a new and challenging model of a National Economy. We should very - much appreciate any Report, reprint or information on this model.

Yours faithfully,

Houston paper was sent 7/14/75

Luis Aracil

J. Aracil

Switzerland
S.D. Centers

October 9, 1973

System Dynamics Group
Building E40-253

MEMORANDUM

TO: Professor Jay W. Forrester

FROM: Mr. Robert P. Greene

RE: Switzerland - Dr. Guelfo G. Poretti

Jorgan Randers and I had lunch on Friday, September 21 with Dr. Poretti and Professor Jona, a friend of Poretti's, from the State University of New York at Stoneybrook.

Dr. Poretti is chairman of a committee appointed by the Scientific Secretary of the Government of Switzerland which has the reponsibility for establishing a new university in the Italian-speaking region of Switzerland. Poretti has decided that one of the attractions of this new university will be a System Dynamics Center. His purpose in visiting MIT was to determine how to go about establishing this center and to meet with any of our staff who might be interested in joining this new venture.

Jorgen and I explained the time scale necessary for developing a core staff of trained system dynamacists using the "Meadows model" and the "Randers model". We suggested Poretti identify candidates for the MIT Ph.D. program and possibly someone who might fit into a post-doctoral program.

We explained the summer session program to them and there was some interest in sponsoring a two week program in Bern. John Miller talked to them since he might be available this spring if he completes his thesis and travels through Europe as he now plans.

They will also contact Wilbert Wils who might have a long-term interest.

There is obviously considerable interest throughout the world in system dynamics and in many respects it would seem that European governments are financially more committed to developing the field than our own government. We may all have to move to Switzerland or Japan!

RPG/bb

EAC
Should he be
added to
"People interested
in S.D."?

DR. GUELFO G. PORETTI

DIPL. PHYSIKER ETH

UNIVERSITÄT BERN - LEITER DES RADIUMINSTITUTES

RECORD OF TELEPHONE CALLS

Date and Time: 4:45

Name of Caller: Prof. Jona
Tel. No.:
Affiliation: Material Science Dept
Address: Stoney Brook NY
p

Dr. Poretti *

MESSAGE: Advice/Speaking/Writing/Other (Appointment to Discuss)
Date Anticipated: Sept 21-22
Place/Periodical:
Topic:
Length:
Audience/Circulation:

Others Involved:

Additional Information: Is in charge of setting up an institute on system dynamics in Switzerland. Want guidance on what, etc to include in this

wants to meet someone - suggested Greene
Dr Poretti & Prof Jona will meet with Greene +
Remarks: Randers on Friday 9/21 for lunch

Signature of person taking message

REPLY:

Refer to:

DISPOSITION:

* Scientific Secy - for study of establishing an S.D. Institute in Bern

Speaking Declined - Univ
Great Britain - Univ
System Dy Centers

December 7, 1973

Dr. K. J. Durrands
Rector
The Polytechnic
Queensgate
Huddersfield HD1 3DH
England

Dear Dr. Durrands:

Thank you very much for your invitation of November 28 to speak at your conference in April. Unfortunately, I am so deeply involved now in the project on modeling social and economic change in the United States with its emphasis on the forces underlying inflation that I am not accepting any more speaking engagements until we have substantial progress behind us.

I was interested to learn of your Systems Department and the Systems Degree which you are offering. It is hoped that your conferences will persuade other colleges to stress the importance of system dynamics.

Sincerely,

JWF:ie

THE POLYTECHNIC
QUEENSGATE, HUDDERSFIELD HD1 3DH
TELEPHONE 0484 30501

~~Director~~ Rector
K J DURRANDS
MSc C Eng F I Mech E M I E E

12/5/73
Airmail

Our Ref R/MAB/A.20 Your Ref Date 28 November 1973

Professor J W Forrester
Massachusetts Institute of Technology
CAMBRIDGE
MAO2139
USA

Dear Professor Forrester

I am writing to you in your capacity as a most eminent figure in Social and Industrial mathematical modelling.

This Polytechnic, situated in Huddersfield, contains an active Systems Department, being the first in the country to offer an Honours Degree in Systems Engineering. The department will shortly be commencing post-graduate courses in Systems, and several short courses.

It is in connection with one of these conferences that I am writing to you. We are holding a three-day conference from 17th to 19th April, 1974, entitled "Mathematic Modelling for Industrial Systems". We are approaching eminent figures in this country in the field, together with our own staff, to present short papers on various related topics.

It would be a great honour for our Polytechnic if, in spite of your many committments, you would consider being the main speaker at this conference. We would, of course, pay all expenses and fees for such a lecture.

We feel it is important that useful industrially oriented conferences are held in other parts of the United Kingdom than London, especially here in the North, where most of the country's industry is sited, and appropriately at the College first to offer a Systems Degree in this country.

I hope you can accept our invitation, and look forward to your reply.

Yours sincerely

Kenneth Durrands

K J Durrands
Rector

Ryan
Mass

sent to Ryan 6/30/75 who will fwd to Mass

SD interests
6/25/75

UNIVERSITY OF BRADFORD

MANAGEMENT CENTRE EMM LANE BRADFORD YORKSHIRE BD9 4JL TELEPHONE 42299

Director and Leasco Professor of Management and Information Sciences: **J C HIGGINS** MA MSc C Eng MIEE M Inst P

Please reply to: System Dynamics Research Group
University of Bradford
Richmond Road
Bradford
Yorkshire BD7 1DP
Telephone 33466

RGC/BA

23rd May, 1975.

Professor J.W. Forrester,
Alfred P. Sloan School of Management,
Massachusetts Institute of Technology,
50 Memorial Drive,
Cambridge,
Massachusetts 02139,
U.S.A.

Dear Professor Forrester,

I recently received the 1974 Newsletter and I was pleased to see that you are still going strong and getting involved in the model of the U.S. economy. You may care to know that Professor J. Wescott of Imperial College is currently engaged in a similar project in which he is applying optimal control theory to an econometric model of the U.K. economy. Although there are differences in his project and the one which you are doing you may find it useful to have some contact with him as he is one of the few persons I have ever met who can talk sense about econometrics.

We, ourselves, continue to be very busy and we are in the process of expanding to approximately 20 research staff and PhD Students. We have received substantial support from the British Government for a study of Natural Resource Usage and I enclose a copy of an advertisement for staff. I should be grateful if you would bring this to the attention of any of your colleagues you think might be interested. We plan to start the project next academic year which might fit in with graduation plans for one of your students.

We have also launched a journal which is intended to provide a forum for papers specifically dealing with System Dynamics. The papers will generally be short, the idea being to enable people working in System Dynamics to communicate rapidly and easily with others in the field and to cut out the very long publications of the established journals such as Management Science. I am sure that the editor would be very happy to receive a contribution from M.I.T. as we do not wish to make this an advertising platform for the Bradford Group.

Cont'd ....

I also enclose a copy of the first draft of Chapter 11 of my forthcoming book on System Dynamics which I hope to have finished within the next couple of months. The chapter describes work based on a recent consulting exercise but it has been substantially re-written to protect confidential information and to provide a vehicle for student project work.

I assume you are now fully recovered from your illness and I hope this continues to be the case. All being well I hope to make a trip to the U.S. later this year and I hope I am able to have the pleasure of calling in to see you.

I think it is true to say that we are far away the two largest groups in System Dynamics and I think it is a pity that there is so little contact of exchange between us.

Best wishes,

Yours sincerely,

Geoff.

Dr. R.G. Coyle
Director
System Dynamics Research Group

encs.

· P

KSU KANSAS STATE UNIVERSITY

6/11/74
Notre Dame
Kans. - Univ.
✓SD Centers Active

Office of the Dean
College of Engineering
Seaton Hall
Manhattan, Kansas 66506
Phone: 913 532-5590

June 6, 1974

Dr. J. W. Forrester
Massachusetts Institute of Technology
Alpha T. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts 02139

Dear Dr. Forrester:

It was pleasant to receive your letter commenting on the Notre Dame visit and requesting additional information about our class entitled Impact of Engineering Technology on Society.

I am enclosing a class description as it appears in our line schedule and also the reading list which I used in teaching two sessions of the class this past semester. The significance of the five groups from the reading list is the fact that each student was required to select at least one book from each list in making up their total of eight books to report on during the semester. I am also attaching a short series of quotes taken from the book reports which these students wrote who had selected Limits to Growth as one of the pieces of material to be read.

In addition to classroom discussion and the reading list, information was brought to the class in the form of motion pictures and television tapes. We had taped the NBC White Paper, the Energy Crisis and played the three hour program in four successive 40-minute segments, discussing each as we went along. In addition we used a film entitled Future Shock which was quite effective. There are a number of other films in that same series which we hope to get for next year. These films are issued through McGraw-Hill Film Rental Library at Highstown, New Jersey.

The class has now been in session for about four years and for at least the past two years Limits to Growth has been one of the major source books used in all sessions.

I hope this information will prove helpful and I will pass along to my colleagues your interest in other similar courses which might have an impact in the area of the management of our larger social systems.

Give my regards to Mrs. Forrester.

Cordially,

Dwight A. Nesmith

Dwight A. Nesmith
Associate Professor
Engineering

DAN/jmr

Enclosure

TECHNOLOGY COURSES FOR NON-ENGINEERING STUDENTS

500 202 INTRODUCTION TO ENVIRONMENTAL TECHNOLOGY (3)

Weekly Topics Include:

1. Growth and Limits to Growth; Natural Resources of the Earth
2. Material and Energy Balance Concepts; Flow of Materials and Energy in the Biosphere
3. Energy Conversion; Energy and Power in an Industrial Society
4. Petroleum, Natural Gas, and Coal Technology and Use; Conversion of Chemical Energy to Electric Power
5. Hydroelectric and Nuclear Power Plants
6. Energy Conservation; Utility Planning; Future Methods
7. Movement of Pollutants Through the Biosphere; Introduction to Meteorology
8. Technology of Air Pollution Control; Sources and Effects of Air Pollution
9. Air Pollution Control from Automobile and Electric Power Plant Combustion
10. Potable Water Treatment and Purification;
11. Wastewater Treatment and Desalination
12. Sources and Effects of Water Pollution; Thermal Pollution
13. Solid Waste Technology; Sources, Disposal, and Recycle
14. Economic, Political, and Legal Aspects of Environmental Technology
15. Energy, Environmental Technology, Natural Resources, and the Future

Tours of facilities such as the KSU power plant and the nuclear reactor are also part of the course.

Prerequisites - None   Grade - Letter or Cr/Ncr

Instructors - Erickson, Eckhoff

Line Numbers -

5371 Lecture	Thurs.	7:00-8:40 p.m.
5372 Rec.	Thurs.	8:50-9:40 p.m.
or 5373 Rec.	Fri.	11:30 a.m.

500 250 IMPACT OF ENGG. TECHNOLOGY ON SOCIETY (3

The purpose of the course is to provide a factual background, help formulate informed opinion and provide a forum for discussion of the problems and promises of today's technological society.

This is done through the use of guest lecturers, faculty resource people, films, and student presentations on a wide range of subjects, such as:

1. Can technology be expected to solve technology's problems?
2. Technology in utopian societies.
3. Should we use salt mines for nuclear waste storage?
4. How can you know who is telling the truth when engineers disagree?
5. Should today's political problems be blamed on faster communications or can what you don't know really hurt?

No technical or scientific or mathematical background is required. The goal is to involve students from all areas of the university with all levels of experience in an examination of relations between engineering technology and society in the past, at the present time and in the forseeable future. Student sponsored programs and student discussion will be emphasized. Each section will be limited to 30 students.

Prerequisites - None   Grade - Letter or Cr/Nc

Instructors - Nesmith, Haft

Line Numbers -

5374	TT	9:05 - 10:20
5375	TT	10:30 - 11:45
5376	TT	12:05 - 1:20

READING LIST

IMPACT OF ENIGNEERING TECHNOLOGY ON SOCIETY

GROUP I (BUFF)

1. LIMITS TO GROWTH (4)
1A. THE FUTURE OF THE FUTURE (1)
2. PROFILES OF THE FUTURE (4)
2A. SURVIVING THE CITY (1)
3. TECHNOLOGICAL CHANGE (2)
3A. ENERGY AND POWER
4. BRAVE NEW WORLD (2)
5. FUTURE SHOCK (2)
6. ASSAULT ON PRIVACY (1)
7. S/S/T AND THE SONIC BOOM HANDBOOK (1)
8. THE RICHES OF THE SEA (1)
9. THE BIOLOGICAL TIME BOMB (1)

GROUP II (BROWN)

10. PROJECT SURVIVAL (2)
10A. THE POPULATION BOMB (1)
11. APPROACHING THE BENIGN ENVIRONMENT (1)
11A. THE BREATH OF LIFE (1)
12. HOW TO BE A SURVIVOR (2)
12A. OUR WORLD IN PERIL (1)
13. SCIENCE AND SURVIVAL (2)
13A. THE VOYAGE OF THE SPACESHIP BEAGLE (2)
14. NEW WORLD OR NO WORLD (1)
15. SILENT SPRING (2)
16. MOMENT IN THE SUN (2)
17. THE CLOSING CIRCLE (2)
18. OPERATING MANUAL FOR SPACESHIP EARTH (2)
19. THE DOOMSDAY BOOK (2)

GROUP III (GREEN)

20. VOYAGES (2)
20A. 13 FRENCH SCIENCE FICTION STORIES (1)
21. NINE TOMORROWS (5)
21A. THE GREEN HILLS OF EARTH (1)
22. REACH FOR TOMORROW (2)
22A. TWO VIEWS OF WONDER (1)
23. TALES OF TEN WORLDS (1)
23A. SURVIVAL PRINTOUT (Science fact: Science fiction)
24. 17 X INFINITY (1)
24A. 2020 VISION (1)
25. ORBIT 8 (1)
26. THE OTHER SIDE OF THE SKY (2)
27. ECO-FICTION (1)
28. EARTHLIGHT (1)
29. EXPEDITION TO EARTH (2)

GROUP IV (YELLOW)

30. THE NAKED APE (2)
31. IN THE SHADOW OF MAN (3)
32. AFRICAN GENESIS (1)
33. TERRITORIAL IMPERATIVE (2)
34. THE DOLPHIN - COUSIN TO MAN
35. WALDEN TWO (2)
36. THE SEA AROUND US (1)
37. UNDER THE SEA WIND (1)
38. SAVAGE LUXURY (1)
39.

GROUP V (BUFF)

40. ENCOUNTERS WITH THE ARCH DRUID (1)
41. THE RUN (1)
42. THE INFINITE RIVER (1)
43. THE LIVING SEA (2)
44. THE FRAIL OCEAN (3)
45. TWO ISLANDS (2)
46. ONLY ONE EARTH (2)
47. THE BEST NATURE WRITING OF J. W. KRUTCH (1)
48. NATURE'S YEAR (1)
49. THE WOODS (1)
50. A SAND COUNTY ALMANAC (1)
51. GOODBYE TO A RIVER (1)
52. THE PINE BARRENS (2)

Comments on LIMITS TO GROWTH by students in Impact of Engineering Technology, Kansas State University, Manhattan, KS

"This would be a good book to use as a textbook for a week or two in this class." (Ag. Jr.)

"One problem is that societies tend to make changes in response to a problem rather than to change in anticipation of a problem ... If man is to find a balance with nature, he will have to give up some freedoms in order to achieve those which are more important." (Radio-TV Sr.)

"It lays the cards on the table for all to see. It shows that even if we do wake up now, we are already in awfully deep." (Chem. Engg. Fr.)

"Some of the statistics are staggering. Everything seems to boil down to the fact that we must control population first, then solve the other problems." (Radio-TV Sr.)

"As the book pointed out, we cannot say with any certainty how much longer mankind can postpone the control of growth before we lose the opportunity for this control." (Bus. & Soc. Sci. Sr.)

"This was a simplified world model, but it did examine changes in the five factors in numerous ways that could and possibly will bring future downfall to the world if these warnings are not considered real." (Bus. Adm. So.)

"However incomplete and tenable these projections, the book emphasizes the importance of slowing 'growth' inherent in a laizze faire economy if we are to avoid the tremendous crunch, rather than a pinch, in our lavacious life style now being experienced as a result of growth in energy demand." (Bio. Sr.)

SLOAN SCHOOL OF MANAGEMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTER-OFFICE CORRESPONDENCE

Mexico
Newsletter (K. Kautzer's copy)
✓SD, Active User's of

TO: Kathy Kautzer

DATE: July 17, 1973

FROM: Emaline Cornett

SUBJECT: System Dynamics Newsletter List

FOLLOW-UP	
FILE	

Professor Forrester would like the following addresses added to the Newsletter solicitation list:

Secretaría de Educación Pública	Ing. Mario Rodríguez
Argentina y González Obregón	(DGPE 2), Venezuela No. 9 (S.E.P.)
México, 1, D.F.	México 1, D.F.
MEXICO	MEXICO

eac
cc: Mr. Greene

JWF
As requested I am adding the correspondence on this to the file I've set up "System Dynamics, Active Users of"

ORIGINATOR REMOVES THE DUPLICATE (YELLOW COPY). SENDING THE ORIGINAL AND TRIPLICATE TO CORRESPONDENT WHO RETURNS THE ORIGINAL WITH COMMENT AND RETAINS THE PINK TRIPLICATE COPY.

SLOAN SCHOOL OF MANAGEMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTER-OFFICE CORRESPONDENCE

SD, Active Users

TO EAC DATE July 13, 1973

FROM JWF

SUBJECT

FOLLOW-UP

FILE

Regarding the enclosed Mexican letter, Rodriguez and the Secretaria de Educacion Publica should be put on our System Dynamics Newsletter solicitation list and added to the file of those who are working in system dynamics.

JWF:ie
Enc. Rodriguez' 6/27 letter and my 7/13 reply

As requested ... correspondence ... "System Dynamics Active Users"

July 13, 1973

Mr. Mario Rodriguez
Project Coordinator
Secretaria de Educacion Publica
Mexico, D. F.

Dear Mr. Rodriguez:

Thank you for your letter of June 27 expressing an interest in system dynamics applied to education. From time to time we have had people here doing modeling of educational systems. However, at the present time there is no active work.

If you wish to send an outline of the work you are doing and any questions that you wish to ask, I will see if someone here in the group can correspond with you.

Sincerely yours,

JWF:ie

AIR-Spec. Delivery 7/5/73

FORMA C.-G-1 A.

SECRETARIA
DE
EDUCACION PUBLICA

México, D. F., June - 27- 1973.

MR. JAY W. FORRESTER
PROFESSOR OF INDUSTRIAL MANAGEMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE MASSACHUSETTS

The persons that signed below, are part of a project which is in charge of elaborating a simulation model for the analyzing of the dinamic behavior of the elementary education system here in Mexico. We think that it might interest you to know that we are applying the principles and methodology of Industrial Dynamics.

Until now we have been able to represent the internal structure of our system in order to analyse the effect of the policies of assignation of resources for the satisfaction of the demand of education. The system, according to the way we have mode it is very complex (our model contains 50 levels), but quite surely, during experimentation the complexity will be reduced.

We are convinced of the applicability of the Industrial Dynamics, but we have doubts about the form in which the model should be implemented. We also have doubts about some of the points referring to the fundamental philosophy of ID. Would it be possible to establish an interchange of letters, with you or some of your colaborators in order that we might receibe help in our work? .

We thank you before hand for your fine attention and remain.

Sincerely yours;

Mario Rodríguez
(Project cordinator)

Salvador González

Edmundo Chávez

Jaime de la Fuente

ING. MARIO RODRIGUEZ
(DGPE 2), VENEZUELA No. 9 (S.E.P.)
MEXICO 1, D. F.

RECEIVED
JUL 5 1973
A.M.
CAMBRIDGE A STA.
BOSTON, MA 02139

'73 JUL -5 AM 9 07
M.I.T.
MAIL SERVICE
RECEIVED

Great Britain - Univ
Sys. Dy. - Active Users of

July 20, 1973

Professor Peter Haggett
Department of Geography
University of Bristol
University Road
Bristol, BS8 1SS, England

Dear Professor Haggett:

The System Dynamics Newsletters ordered in your letter of 9 July are being sent to you in a separate mailing. The attached invoice lists the issues of the Newsletter published 1963 through 1972. You will notice that we did not publish the Newsletter in 1965.

We are pleased to send you, as requested, a copy of the paper by Nathan B. Forrester, "A Computer Approach to Environmental System Design--Dynamics of a Predator-Prey Relationship." Thank you for your interest.

Sincerely yours,

(Miss) Isabella S. Evans
Secretary to Professor Jay W. Forrester

/E
Enc. Invoice
"A Computer Approach to Environmental System Design--Dynamics of a Predator-Prey Relationship"

Air Mail

Room E40-253

INVOICE

July 20, 1973

TO: Professor Peter Haggett
Department of Geography
University of Bristol
University Road
Bristol, BS8 1SS, England

1 each System Dynamics Newsletters	1963	$1.00
	1964	1.00
	1966	1.00
	1967	1.00
	1968	1.00
	1969	1.00
	1970	1.00
	1971	1.00
	1972	2.00
		10.00
	Postage	2.50
	Total	$12.50

Please make check payable to "MIT Account 25145"
and mail with one copy of this invoice to
System Dynamics Newsletter
M.I.T., Room E40-253

/E

Air Mail 7/12/73

Department of Geography,
University of Bristol,
University Road,
Bristol,
BS8 1SS,
U.K.

9th July, 1973

Professor J.W. Forrester,
Massachusetts Institute of Technology,
Alfred P. Sloan School of Management,
50, Memorial Drive,
Cambridge,
Massachusetts, 02139,
U.S.A.

Dear Professor Forrester,

6/27 letter

Thank you for sending on the bibliography. This will be most useful and I look forward to following up its leads.

I wonder if you could pass on via your secretary, an order for such back issues of this newsletter that may be available, so that we can put them in our library?

Send and bill.

I noted with interest, an unpublished paper by Nathan B. Forrester on the dynamics of a predator/prey relationship. Is there any chance of getting a xeroxed copy of this?

Thank you again for your help.

send folder articles per JWF (is no card on this) e

Yours sincerely,

Peter Haggett

Peter Haggett
Professor of Urban and
Regional Geography

Copy

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

Jay W. Forrester
Germeshausen Professor

June 27, 1973

Mr. Peter Haggett
Professor of Urban and
Regional Geography
Department of Geography
University of Bristol
University Road
Bristol, BS8 1SS
ENGLAND

Dear Professor Haggett:

Perhaps the enclosed bibliography of system dynamics work will be useful to you. It is not complete or fully up to date.

Sincerely yours,

JWF/lle
Encl: bibliography of system dynamics work
System Dynamics Newsletter 1972

Sys. Dynamics, Active Users of Great Britain - Univs

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

Jay W. Forrester
Germeshausen Professor

June 27, 1973

Mr. Peter Haggett
Professor of Urban and
Regional Geography
Department of Geography
University of Bristol
University Road
Bristol, BS8 1SS
ENGLAND

Dear Professor Haggett:

Perhaps the enclosed bibliography of system dynamics work will be useful to you. It is not complete or fully up to date.

Sincerely yours,

JWF/lle
Encl: bibliography of system dynamics work
System Dynamics Newsletter, Vol. 10, June 1972

SYSTEM DYNAMICS BIBLIOGRAPHY

BOOKS

Forrester, Jay W. Industrial Dynamics. Cambridge: M.I.T. Press, 1961.

Forrester, Jay W. Principles of Systems. (paperback preliminary printing of first ten chapters) Cambridge: Wright-Allen Press (Room 516, 238 Main Street, Cambridge, Mass. 02142), 1968.

Forrester, Jay W. Urban Dynamics. Cambridge: M.I.T. Press, 1969.

Forrester, Jay W. World Dynamics. Cambridge: Wright-Allen Press, 1971.

Hamilton, H. R., Goldstone, S. E., Milliman, J. W., Pugh, A. L. III, Roberts, E. B., Zellner, A. Systems Simulation for Regional Analysis: An Application to River-Basin Planning. Cambridge: M.I.T. Press, 1969.

Jarmain, W. Edwin (ed.). Problems in Industrial Dynamics. Cambridge: M.I.T. Press, 1963.

Meadows, Dennis L. Dynamics of Commodity Production Cycles. Cambridge: Wright-Allen Press, 1970.

Meadows, Dennis L. et al. The Limits to Growth. Cambridge: Wright-Allen Press, 1972.

Meadows, Dennis L. and Donella H. (editors). Toward Global Equilibrium: Collected Papers. Cambridge: Wright-Allen Press, 1973.

Nord, Ole C. Growth of a New Product: Effects of Capacity-Acquisition Policies. Cambridge: M.I.T. Press, 1963. (Also available in Japanese.).

Packer, David W. Resource Acquisition in Corporate Growth. Cambridge: M.I.T. Press, 1964. (Also available in Japanese.).

Pugh, Alexander L. III. DYNAMO II User's Manual (3rd edition of DYNAMO User's Manual). Cambridge: M.I.T. Press, 1970.

Roberts, Edward B. The Dynamics of Research and Development. New York: Harper and Row, 1964. (Also available in Japanese.).

Sakakura, Shogo, and Kazuo Watanobe. Industrial Dynamics. Tokyo: Toyo Keizai Shinpo Sha, 1963. (Available in Japanese only.).

Sakakura, Shogo, and Kazuo Watanobe. Applications of Industrial Dynamics. Tokyo: Toyo Keizai Shinpo Sha, 1968. (Available in Japanese only.).

Weymar, F. Helmut. The Dynamics of the World Cocoa Market. Cambridge: M.I.T. Press, 1968.

ARTICLES

Ansoff, H. Igor and Slevin, Dennis P. "An Appreciation of Industrial Dynamics," Management Science, Vol. XIV, Number 7, March 1968, pp. 383-397.

Carlson, Bruce R. "An Industrialist Views Industrial Dynamics," Industrial Management Review, Vol. VI, Number 1, Fall 1964, pp. 15-20.

Carlson, Bruce R. "Industrial Dynamics," Management Services, May-June, 1964, pp. 32-39.

Fey, Willard R. "An Industrial Dynamics Case Study," chapter 33 of Some Theories of Organization, Albert H. Rubenstein and Chadwick J. Haberstroh (eds.), Homewood, Illinois: Richard D. Irwin, 1961.

Fey, Willard R. "An Industrial Dynamics Study of an Electronic Components Manufacturer," Transactions of the Fifth Annual Conference of the American Production and Inventory Control Society. September 1962.

Forrester, Jay W. "Industrial Dynamics: A Major Breakthrough for Decision Makers," Harvard Business Review, July-August 1958, pp. 37-66.

Forrester, Jay W. "Advertising: A Problem in Industrial Dynamics," Harvard Business Review, March-April 1959, pp. 100-110.

Forrester, Jay W. "The Impact of Feedback Control Concepts of the Management Sciences," 1960 FIER Distinguished Lecture Foundation for Instrumentation Education and Research, October 1960.

Forrester, Jay W. "Managerial Decision Making," Management and the Computer of the Future, Martin Greenberger (ed.), Cambridge: M.I.T. Press, 1962, pp. 36-68.

Forrester, Jay W. "Industrial Dynamics," The Encyclopedia of Management, Carl Heyel, (ed.) New York: Reinhold Publishing Company, 1963, pp. 313-319.

Forrester, Jay W. "Simulative Approaches for Improving Knowledge of Business Processes and Environments," Proceedings of the 13th CIOS Conference, 1963, pp. 5-9.

Forrester, Jay W. "Common Foundations Underlying Engineering and Management," I.E.E.E. Spectrum, September 1964, pp. 66-77.

Forrester, Jay W. "Modelling the Dynamic Processes of Corporate Growth," Proceedings of the IBM Scientific Symposium, December 7-9, 1964, pp. 23-42.

Forrester, Jay W. "The Structure Underlying Management Processes: Evolving Concepts in Management," Proceedings of the 24th Annual Meeting of the Academy of Management, December 28-30, 1964, pp. 58-68.

Forrester, Jay W. "Modeling of Market and Company Interactions," Proceedings of the American Marketing Association, August 31-September 3, 1965.

Forrester, Jay W. "Market Growth as Influenced by Capital Investment," Industrial Management Review, Vol. IX, Number 2, Winter 1968, pp. 83-105.

Forrester, Jay W. "Industrial Dynamics: After the First Decade," Management Science, Vol. XIV, Number 7, March 1968, pp. 398-415.

Forrester, Jay W. "Industrial Dynamics—A Response to Ansoff and Slevin," Management Science, Vol. 14, No. 9, May 1968, pp. 601-618.

Forrester, Jay W. "Systems Analysis as a Tool for Urban Planning," Proceedings of the National Academy of Engineering, October 22-23, 1969.

Forrester, Jay W. "Toward a National Urban Consensus," March 6, 1970.

Forrester, Jay W. "Counterintuitive Behavior of Social Systems," Hearings Before the Ad Hoc Subcommittee on Urban Growth of the Committee on Banking and Currency, U.S. House of Representatives, Part 3, October 7, 1970, U.S. Government Printing Office, Washington, D.C. 20402.

Also reprinted in the Technology Review, January 1971, Volume 73, Number 3, pp. 52-68.

Forrester, Nathan B. "A Computer Approach to Environmental System Design—Dynamics of a Predator-Prey Relationship," 1969. Privately published. Room E52-454, M.I.T., Cambridge, Mass.

Katz, Abraham. "An Industrial Dynamics Approach to the Management of Research and Development," I.R.E. Transactions on Engineering Management.

McPherson, L. Fillmore, III. "Organizational Change: An Industrial Dynamics Approach," Industrial Management Review, Volume VI, Number 2, Spring 1965.

Miller, Thomas G. and Leo P. Kane. "Strategies for Survival in the Aerospace Industry," Industrial Management Review, Volume VII, Number 1, Fall 1965, pp. 19-35.

Roberts, Edward B. "Exploratory and Normative Technological Forecasting: A Critical Appraisal," Working Paper No. 378-69, M.I.T., Cambridge, Massachusetts.

Roberts, Edward B. "Toward a New Theory for Research and Development," Industrial Management Review, Volume IV, Number 1, Fall 1962, pp. 29-40.

Roberts, Edward B. "Industrial Dynamics and the Design of Management Control Systems," Management Technology, December 1963, pp. 100-118.

Roberts, Edward B. "New Directions in Industrial Dynamics," Industrial Management Review, Volume VI, Number 1, Fall 1964, pp. 5-14.

Roberts, Edward B. "Research and Development Policy-Making," Technology Review, June 1964, pp. 32-36.

Roberts, Edward B. "Simulation Techniques for Understanding R & D Management," 1959 I.R.E. National Convention Record, Part 10, March 1959, pp. 38-43.

Roberts, Edward B. "A Systems Methodology for Evaluating Industrial Projects in the Context of National Strategies," Working Paper No. 141-65, M.I.T., Cambridge, Massachusetts.

Roberts, Edward B. "The Problem of Aging Organizations—A Study of R & D Units," Business Horizons, Winter 1967, pp. 51-58.

Roberts, Edward B., Abrams, Dan I., Weil, Henry B. "A Systems Study of Policy Formulation in a Vertically Integrated Firm," Management Science, Volume 14, No. 12, August 1968, pp. 674-694.

Roberts, Edward B. "Systems Analysis of Apparel Company Problems." Paper presented at the Apparel Research Foundation Conference, November 30, 1967 (copies available from Edward B. Roberts' office at M.I.T., Sloan School of Management, Cambridge, Mass.)

Roberts, Edward B. "The Systems Concept in Corporate Management Education," prepared for the General Motors Training Directors' Conference, July 27, 1966 (copies available from Edward B. Roberts' office at M.I.T., Sloan School of Management, Cambridge, Massachusetts).

Schlager, Kenneth J. "How Managers Use Industrial Dynamics," Industrial Management Review, Vol. VI, Number 1, Fall 1964, pp. 21-30.

Shimada, Toshiro. "Industrial Dynamics Model of Weekly Stock Prices: A Case Study," Bulletin of the Izumi Laboratory of Meiji University, No. 42, 1968.

Sprague, Robert C. "Industrial Dynamics: Case Example," in The Encyclopedia of Management, Carl Heyel (ed.). New York: Reinhold Publishing Company, 1963, pp. 319-322.

Swanson, Carl V. "Some Properties of Feedback Systems as a Guide to the Analysis of Complex Simulation Models," Proceedings of the Department of Defense Logistics Research Conference, Warrenton, Virginia, May 26, 1965 (copies available from Carl V. Swanson's office at M.I.T., Sloan School of Management, Cambridge, Mass.)

Swanson, Carl V. ""Dynamic Analysis in Weapon System Design and Evaluation," Proceedings of the Second Annual Technical Symposium, American Helicopter Society, November 16, 1967 (copies available from Carl V. Swanson's office at M.I.T., Sloan School of Management, Cambridge, Mass.)

Weymar, Helmut. "Industrial Dynamics: Interaction between the Firm and its Market," in Marketing and the Computer, Wroe Alderson and Stanley Shapiro (eds.), Englewood Cliffs, New Jersey: Prentice-Hall, 1963, pp. 260-276.

SLOAN SCHOOL OF MANAGEMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTER-OFFICE CORRESPONDENCE

TO: EAC

DATE: 7-28-73

FROM: JWF

SUBJECT: File--People who express an interest in system dynamics

FOLLOW-UP

FILE

7/11/73

We should be trying to maintain a file of people who express a substantial interest in system dynamics. This would be people who show more than simple curiosity. Please help me do this by getting copies of any letters into some master file. The enclosed one by Peter Haggett should go in.

JWF/lle

AIR MAIL

6/13/73

Department of Geography,
University of Bristol,
University Road,
Bristol,
BS8 1SS

8th June, 1973

Professor Jay W. Forrester,
Department of Management Studies,
Massachusetts Institute of Technology,
Cambridge,
Massachusetts,
U.S.A.

Dear Professor Forrester,

Over the last academic year, I have been running some seminars both here and in the United States, looking at some of the geographical aspects of the systems dynamics models which you and your colleagues have built up. As you will know, your writings have attracted enormous interest in western Europe and we have found that the models have proved to be a source of exceptionally lively and critical debates.

However, one of the problems I find as a lecturer is that reviews of your own work and developments of simulation models along derivative lines by other workers are spread over a surprisingly wide range of journals. It has proved somewhat difficult to keep abreast of the burgeoning Forrester and neo-Forrester literature and I am wondering if any of your students has kept a close track of these developments and compiled a bibliography? If the answer should be in the negative then please file this letter in the waste-bin: if, on the other hand, something comes readily to mind then I would appreciate any leads you can suggest.

With good wishes,

Yours sincerely,

Peter Haggett

Peter Haggett
Professor of Urban and
Regional Geography

AIRMAIL

5/24

Great Britain - Univ.

Faculty of Economic and Social Studies

University of Manchester / Manchester / M13 9PL
Telephone: 061-273 3333

Department of Decision Theory

Professor Jay W. Forrester
Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
CAMBRIDGE
Massachusetts 02139
U.S.A.

22 May 1972

Dear Professor Forrester

Many thanks for your letter with the full information. I am sure the Committee will appreciate your help in this matter and if we do decide to go ahead with any work in this area I am sure you will be pleased to be informed.

Yours sincerely

D. J. White

D. J. White

FILE—ACTIVE SYSTEM DYNAMICS CENTERS

& Great Britain-Univ.

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

May 9, 1972

Professor D. J. White
Department of Decision Theory
Faculty of Economic and Social Studies
University of Manchester
Manchester/M13 9PL, England

Dear Professor White:

Thank you for your expression of interest in our work. Additional published material will become available from time to time. The only substantial piece that is definitely in the process of publication is the following:

> Toward Global Equilibrium: Collected Papers
> Dennis L. Meadows, editor
> Wright-Allen Press, Inc., 238 Main Street,
> Cambridge, Massachusetts 02142, U.S.A.
> Available August 1972

You will find other relevant book folders enclosed.

Sincerely yours,

Jay W. Forrester
Professor of Management

JWF:ie
Enc. Book Folders: Industrial Dynamics, Urban Dynamics, World Dynamics, Principles of Systems, The Limits to Growth, Dynamics of Commodity Production Cycles

Air Mail

AIR MAIL

5/4/72

Faculty of Economic and Social Studies

University of Manchester / Manchester / M13 9PL
Telephone: 061-273 3333

Department of Decision Theory

Professor J. W. Forrester
Alfred P. Sloan School of Management
Massachussetts Institute of Technology
CAMBRIDGE
Massachussetts
U.S.A.

1 May 1972

Dear Professor Forrester

I hope you will forgive a stranger writing to you but I wonder if you could be of help to me.

The University has set up a small group to look into the state of affairs with respect to, for want of a better word, World Dynamics, as coined by yourself, and of which group I am Chairman.

The setting up of this group was stimulated by the excellent books "World Dynamics", by yourself, and "The Limits of Growth" by Dr. Meadows and several colleagues.

In the latter book I note that the research work referred to in these books is continuing, particularly at M.I.T.

Would it be possible to indicate the nature of the research the M.I.T. group is undertaking, and in what sense it contributes to the works mentioned above?

Would it also be possible to indicate the names and addresses of other people of whom you know working towards the same objectives?

I fully realise that with the fundamental importance of this work you must have been inundated with countless requests for information, and that I, like the others, have little alternative in writing directly to you if we are to begin our studies properly. I, and the University group on whose behalf I write, will be indebted to you for such information.

I am at the same time writing to Dr. Meadows to ask for his help.

In anticipation of your help.

Yours sincerely

D. J. White

D. J. White
Professor of Decision Theory

SD - other univ.

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

Memorandum

To: Dennis Meadows

From: Roger F. Naill

Subject: Visit of Sir Goronwy Hopkin Daniel

Date: August 18, 1971

We were visited today by Sir Goronwy Daniel ("Dan"), a principal at the University College of Wales. His background includes degrees in geology and anthropology, and a doctorate in economic statistics. He has spent his early years in the British Civil Service and was a member of the House of Commons, and was also involved for a brief period in town and country planning. For 17 years he was involved in energy policy making in England, including statistics, economics, and general policy decisions. When he left for his present position at the University of Wales, his group was involved in two modeling efforts. One was designated a Special Model, and was more like our aggregate models of use over time. The man heading that project now is named Forster, who is the chief statistician (Ministry of Power, Thames House, Millbeck). The second was a geographical model designed to answer spatial questions such as what kind of power plant should be built where.

John Seeger then introduced Sir Goronwy to System Dynamics and the World Group's efforts. Roger Naill described his work in natural resources and natural gas, and emphasized the importance of these types of models in policy making. Eric Zahn presented his work in food and agriculture. Sir Goronwy was quite receptive to our work, and asked questions about possible work in water resources, and whether we had looked at the implications of a major energy transition in terms of capital investment. He assured us that he would mention our work to government personnel when he returned home, and requested a copy of the natural gas and other pertinent papers when it is ready for distribution.

RFN;mrc
cc: Jay W. Forrester
John Seeger
Bill Behrens
Eric Zahn

System Dynamics Centers, Active 4 of 4

System Dynamics,
Univ. Teaching

SD-other univs.

JAN 26 1972

World Dynamics Adoptions

School	Professor & Course	No. of copies	Date
Babson College (Mass.)	Dr. Walter CArpenter (also using Principles of Systems)	30	Fall 1971
Claremont Colleges (Cal.)	Professor Rodman Environmental Studies 191	10	Fall 1971
Hofstra University	Professor W.S. Gorrill Physics Dept.	5	Fall 1971
University of Oregon	Professor John Wish MIT Dept.	15 20	Fall 1971 Winter 1972
Washington University (Kansas City, Mo.)	Dr. J. Dobbs Physics Dept.	30	Fall 1971
University of Washington	Professor Earl Bell Dept. of Urban Planning Urban Planning 542A	11	Winter 1972
NOrtheastern University	Professor Wolaver Dept. of Political Science Urban Management	15	Winter 1972
	Professor J. Seeger Dept. of Industrial Engineering Dynamics of Systems I	25	Winter 1972
University of Wisconsin	Professor Porter Zoology 101	50	Winter 1972

School	Professor & Course	# of Copies	Date
University of Missouri	Professor Glidden GA 572	15	Winter 1972
Dickinson College (Pa.)	Four instructors for course: Dr. Priscilla W. Laws Dept. of Physics & Astronomy Professor H. Wade Sesford Dept. of Sociology & Anthropology	50	Winter 1972
Indiana State University	Professor Sarah Clevenger Dept. of Life Sciences Life Science 4-580	20	Winter 1972
University of California at Berkeley	BA 211	12	Winter 1972
University of Kansas		10	Winter 1972

S.D. Teaching

July 9, 1971

Professor Dean W. Boyd
945 Lincoln Avenue
Palo Alto, California 94301

Dear Professor Boyd:

In Professor Forrester's absence from the office, let me respond to your letter of July 6 in his place. The ideas here are based both on experience with our own group and experience in teaching the course in System Dynamics at the Northeastern University Graduate School of Engineering.

The enclosed System Dynamics Newsletter concludes with a comprehensive bibliography of materials relating to the field. I have marked a few of the items which proved especially useful to me, and will enclose copies of two of the best auxiliary reprints.

The basic text to begin with, in my opinion, is Principles of Systems. I followed this in a year-long sequence with Industrial Dynamics, and then Urban Dynamics, which served as a vehicle for tying together the basic principles, the modeling techniques, and the uses to which a model could be put. In the last segment of the course, I also used critical reviews of the Urban Dynamics book from the current press, asking the students to comment on both the good and the bad points made by the model's critics.

In the last two-thirds of the course, each student prepared an individual model on a problem of his own choosing. Most of them thus learned, with appropriate frustration, that the definition of a problem and the purpose of a model are absolutely essential as first steps in the process. This is a point which seems to be learned only through "hands-on" experience. Three reasonable models emerged from the eleven students who carried the complete three-term sequence. I was not unhappy with the batting average.

Now, after sending perhaps more than you bargained for, may I ask a return favor? I should very much appreciate an outline of your course and your comments on what curriculum materials would be most desirable. In the coming months, one of my own goals is to compile such material from the various schools where System Dynamics is taught, in order to better plan our own activities in development of new curriculum materials. Thanks very much.

Sincerely,

John A. Seeger
Administrative Officer

JAS:ie

Enc. System Dynamics Newsletter 1971
World Dynamics brochure
House of Representatives testimony, October 7, 1970
"Market Growth as Influenced by Capital Investment"

AIR MAIL

JWF 7/8/71

STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA 94025
(415) 326-6200

6 July 1971

Professor Jay W. Forrester
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Professor Forrester:

I am considering sharing some of your insights about systems with my students at the University of California at Santa Cruz next fall. However, I am somewhat out of touch with the resources that are currently available pertaining to "system dynamics" (nee "industrial dynamics"). Could you or someone in your group briefly list for me available texts, case studies, computer languages, and so on. If you could respond to my home address:

945 Lincoln Ave.
Palo Alto, California 94301

I would greatly appreciate it.

Thank you for your help.

Sincerely,

Dean Boyd

Dean W. Boyd, Assistant Professor of Information and Computer Science

DB:dw

file — Uni. teaching in S.D.

July 16, 1971

Professor George R. Webb
Tulane University
Department of Mechanical Engineering
New Orleans, Louisiana 70118

Dear Professor Webb:

In Professor Forrester's absence from the MIT campus, let me thank you for your kind remarks. We are always interested in hearing of other schools' experiences in teaching system dynamics.

One of my own goals in the coming year is to collect information on teaching activities outside of MIT, in order to plan for the development of better curriculum materials. I am hoping to collect course outlines and comment on what type of material might be most useful to people in your position. If you have the chance, can you offer any advice to other teachers?

Probably you have not yet seen the new book, World Dynamics. I am enclosing here a folder describing it.

Thanks again.

Sincerely,

John A. Seeger
Administrative Officer

JAS:ie
Enc. World Dynamics folder

JWF 7/15/71

TULANE UNIVERSITY
Department of Mechanical Engineering
NEW ORLEANS, LA. 70118

July 9

Dear Dr. Forrester,

We have just used your books Urban Dynamics and Principles of Systems, and your paper on Global Dynamics, which appeared in Technology Review, in a seminar course at Tulane that is designed for both engineers and humanists (the course was taught by an English professor and two engineers). We found your material easy to teach, and as a result the discussions that occurred were stimulating and fruitful. Thank you for your part in these classes.

Sincerely yours,

George R. Webb and Jane C. Keller

30 July 1971

Professor H. Craig Davis
School of Community & Regional Planning
The University of British Columbia
Vancouver, 8, Canada

Dear Professor Davis:

I am interested to learn that you are teaching a graduate course in Quantitative Methods for Regional Planners and also, of course, pleased to know that you plan to use my books Urban Dynamics and Principles of Systems. Enclosed is a descriptive brochure of my newest book World Dynamics.

Also enclosed is a descriptive brochure on the availability of Dynamo Compiler which was obtained from Pugh-Roberts Associates who own this. Best wishes for your course.

Sincerely yours

Jay W Forrester

Jay W. Forrester
Professor of Management

m

enc. WD brochure
Dynamo availability
airmail

ms

THE UNIVERSITY OF BRITISH COLUMBIA
VANCOUVER 8, CANADA

SCHOOL OF COMMUNITY & REGIONAL PLANNING

July 22, 1971

Professor Jay Forrester
Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Professor Forrester:

I am currently teaching a graduate course in Quantitative Methods for Regional Planners and intend to incorporate into the course your books, Urban Dynamics and Principles of Systems Analysis.

In the book, Systems Analysis, you discuss the DYNAMO program. Is this program now available and if so can you please tell me how I might obtain it for use in the above course?

Sincerely,

H. Craig Davis

H. Craig Davis
Assistant Professor

HCD/jd

descriptive brochure on availability of dynamo compiler are coming from Pugh-Roberts

O.K. Send.

26 July ms

11/13/75
SD [illegible]
Univ - Tex,

November 7, 1975

Mr. Jib Fowles
Chairman, Studies of the Future
University of Houston at Clear Lake City
2700 Bay Area Blvd.
Houston, Texas 77058

Dear Mr. Fowles:

Professor Forrester has forwarded your letter to me for reply. I am enclosing some information on the doctoral program here at the Sloan School of Management as well as a handout describing graduate study in System Dynamics.

If you have any questions about any of our programs, please do not hesitate to write.

Sincerely,

(Miss) Christine Kane
Doctoral Program Coordinator

Enclosure
cc: Prof. J. Forrester

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

11/7 1975

Memo to JWF Room Ext.

Chris Kane wants to send the materials to Gib Fowler. Apparently, if I do it he will not be recorded on the computer.

However, I asked her to give me a carbon copy of her letter to him & gave her the S.D. course outline.

O.K.

from laa Room Ext.

MURAN BOSTON

11/4/75

UH CLC

University of Houston at Clear Lake City

2700 Bay Area Boulevard
Houston, Texas 77058
(713) 488-6840

October 30, 1975

Professor Jay W. Forrester
A. P. Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Professor Forrester:

I very much enjoyed your presentation at Limits to Growth 75.

I am taking the liberty of sending you some information regarding our brand new Masters degree program in 'Studies of the Future.' With twenty-two graduate students, we are the largest such program in the nation.

Several of our students are very interested in your work, and wonder if seminars are offered, or if doctoral programs are available, for them to pursue this interest.

Sincerely yours,

Jib Fowles

Jib Fowles
Chairman, Studies of the Future

JF:tas

Enclosures

Send info on PhD in S.D.

Chris Kane sending Ph.D. info + S.D. course outline

University of Houston at Clear Lake City

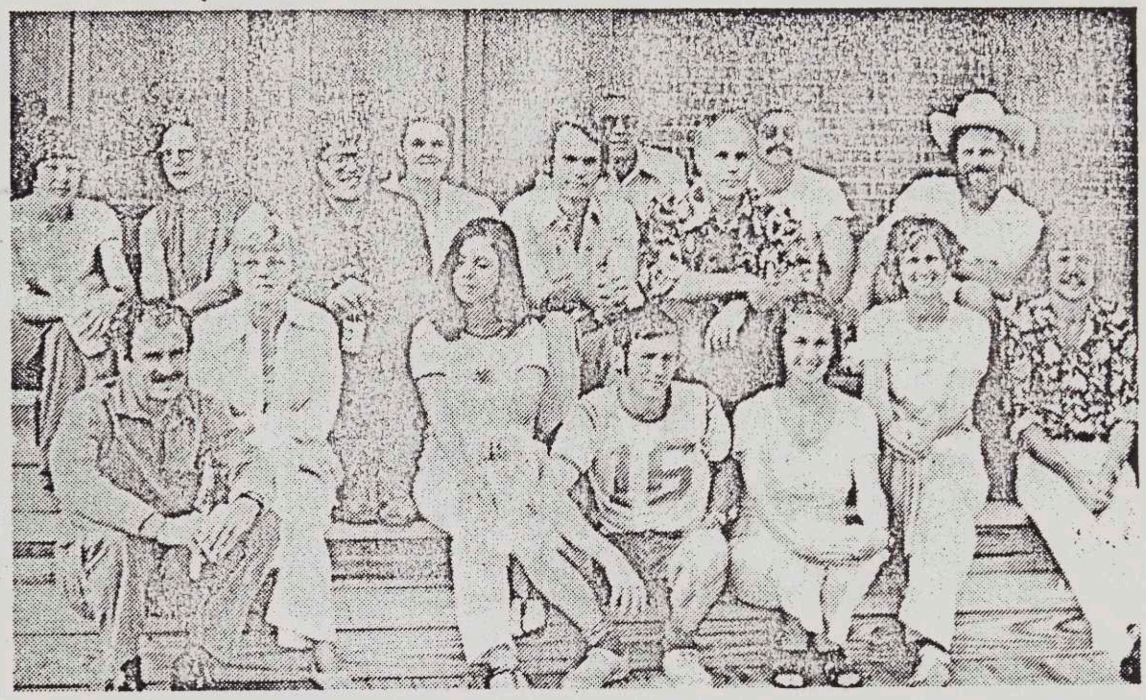
Masters of Science in

STUDIES OF THE FUTURE

Course Offerings, Fall 1975

SOCI 4136	Introduction to Futures Studies	6:00 - 9:00	Tues
SOCI 5533	Communications and Social Change	1:45 - 3:15	Mon Thur
SOCI 6334	Technology and Society in the Future	6:00 - 9:00	Wed
ENVR 5131	Environmental Management Practices	6:00 - 9:00	Tues
ENVR 5931	Environmental Impact Statements	6:00 - 9:00	Mon
GOVT 4532	Government Budget Planning and Analysis	6:00 - 9:00	Tues
GOVT 5332	Public Policy Analysis	6:00 - 9:00	Tues
GOVT 5532	Public Policy and the Study of the Future	6:00 - 9:00	Mon
GOVT 6331	Research Techniques in Government Planning	6:00 - 9:00	Thur
URBN 5131	Theory and Practice of Urban Planning	6:00 - 9:00	Wed
LITR 4536	Images of the Future in Science Fiction	6:00 - 9:00	Mon
HIST 5931	The Utopian Tradition	10:15 - 11:45	Tues Fri

for further information: Dr. Jib Fowles
Chairman, Program Committee
Studies of the Future
University of Houston at Clear Lake City
2700 Bay Area Boulevard
Houston, Texas 77058
488-0470 - Ext. 54



Futures program gets underway

CLEAR LAKE - "Our goal is perfect understanding of the future," said Dr. Jib Fowles, chairman of the master's degree program in "Studies of the Future" at the University of Houston at Clear Lake City, to a gathering of the program's students Saturday afternoon in Seabrook at their orientation session.

The 20 men and women, coming from as far away as South Dakota, are the first students in this innovative program, which begins this week when the university's new Bayou Building opens.

"OF COURSE," Fowles added "we can never understand the future perfectly. But we can get much better at it."

Fowles called the "Studies of the Future" program unique because of its subject matter, its size, the quality of its faculty and its ideal location in "the most futuristic area in the United States."

Nancy Wood of Seabrook, a student in the program and acting coordinator of the Houston chapter of the World Future Society, described the purpose of the Society and the 1975-76 program of the Houston chapter.

WOOD SAID that the first meeting of the chapter would take place October 3 at the Lunar Science Institute on NASA Rd. 1. She invited all interested people from the Clear Lake area to attend.

Bill Lammey, another student in the program and a Houston architect, described his work in designing a futuristic environmental awareness program for the Houston Independent School District.

THE WIDE rangs of students' interests, varying from corporate forecasting to educational change to ecological improvement, indicated the interdisciplinary nature of the unique graduate program.

THE CLEAR LAKE NEWS CITIZEN, Tuesday, Oct. 28, 1975

UH-CLC futurists participate in recent conference

CLEAR LAKE- A dozen UH/CLC futurists played active roles in the recent Limits to Growth '75 Conference held at the Woodlands, 22 miles north of Houston. Dr. Jib Fowles, Director of UH/CLC Future Studies Program, and 11 of his graduate students joined a host of academic, environmental and corporate celebrities in exploring the changes likely in the next quarter century.

Dr. Fowles and Dean Calvin Cannon were among the 350 conference registrants. The students bartered time and services with conference directors, exchanging clerical help, chauffeur duties, errand running and general efficientcy for a unique chance to hear some of the nation's loftiest thinkers expound. Like groupies hovering backstage at a rock concert, students joined in the small talk and banter of some of the super stars in the futures field.

Trading chores for a chance for stimulating dialogue on many topics of humanity's critical needs were graduate students Roger Carlson, Nick Clift, Walker Croft, Dick Garter, Ron Howell, Bill Lammey, Bill Redmond, Jeanne Seward, Julia Steqart, Duane Spellman, Marilyn Stovall, and Nancy Wood, Houston coordinator for the world Future Society.

The chance to mix and mingle, debate and debunk came the first night at a session involving conference participants, speakers, students and press corps in a novel and noisy game, THE FUTURES GAME, a subjective exercise in alternative possibilities, is a fast-paced interpretive planning exchange, alternatively gloomy, hopeful, funny, innovative and provocative.

Ideas bounced, rippled and flowed out of a delegate from Big Sandy, Texas, to one from Oberlunkhofen, Switzerland, from a Harvard graduate student to a producer/director from Walt Disney, from Exxon's chief economist to an administrator of the Environmental Protection Agency, from a technology professor from Israel to an Episcopalian rector.

The other days were filled with lectures, banquets, panels and debates on topics of technology, environment, agriculture, energy, architectural design, management and economic guidelines for a society in which growth factors would be stabilized by various self-imposed constraints.

Dr. Jonas Salk, discoverer of the polio vaccine and currently head of the Salk Institute for Biological Studies in San Diego, was banquet speaker on the final night when the Mitchell Prize was awarded. Donated in amounts of $10,000, $6,000, $3,000 and $1,000 by George Mitchell of Mitchell Energy and Development Corporation and his wife, Cynthia, the prize encourages papers focusing on growth trends 40 years from now.

The students are back in class now, both weary and elated with perhaps a wistful glimmer of hope for returnig to the conference two years from now with a modest acceptance speech for the next biennial $10,000 award.

PROGRAM IN STUDIES OF THE

FUTURE

UH CLC University of Houston at Clear Lake City

Program in Studies of the Future
University of Houston at Clear Lake City
2700 Bay Area Boulevard, Houston, Texas 77058

Please Post

University of Houston at Clear Lake City

FUTUR

UNIVERSITY OF HOUSTON AT CLEAR LAKE CITY

The newest university in Texas is an upper-level institution (junior, senior and graduate) uniquely structured to serve the needs of its community and of modern life. The University of Houston at Clear Lake City offers a contemporary education through multi-disciplinary programs. The new university and its graduate program in Studies of the Future are both especially suited to the thriving Houston area. Capital of the energy industry, Houston leads the way into post-industrial society. Its enterprises are prospering; its occupational profile increasingly favors the knowledge industry; leisure-time activities, exemplified by the Astrodome, are flourishing. The new campus lies halfway between downtown Houston and the scenic port of Galveston. With Armand Bayou Park on one side and NASA's Johnson Space Center on the other, the campus setting is a stimulus to the study of change.

STUDIES OF THE FUTURE

The future is the object of deepening concern. As the speed and complexity of modern life mount, the potential grows for disaster as well as for advancement. Catastrophe and opportunity have to be foreseen if we are to survive well. We must gain the clearest conception of what does—and can—lie ahead in time. Using newly-developed forecasting techniques, futurists work to improve anticipation. A fuller comprehension of things to come, leading to better plans and more appropriate actions, is the aim of the Studies of the Future graduate program at UH/CLC. To encourage comprehensive understanding, the program incorporates many modes of exploring the future. The faculty, drawn from nearly all disciplines, are scholars vitally concerned with the transition from today to tomorrow. Their combined perspectives can offer students an integrated view of the future—and a repertoire of ways for confronting it. MS candidates already engaged in forecasting and planning will find that the program introduces them to a broader range of pertinent material. The program is also intended for those with a more general interest in the problems and possibilities of life in the future. For more information: Dean, School of Human Sciences / University of Houston at Clear Lake City / 2700 Bay Area Boulevard / Houston, Texas 77058 / 713/488-0470.

COURSE OFFERINGS

Study of the Future . . . . Forecasting Techniques . . . . Forecasting by Simulation and Modeling . . . . The Future of Behavior . . . . Sociology of the Future . . . . Communications and Social Change . . . . Intentional Cultural Change . . . . Utopia: Designers and Detractors . . . . Educational Futurism . . . . Future of Education in a Changing Society . . . . Government Planning . . . . Public Policy and the Study of the Future . . . . Ecology and Public Policy . . . . Resource Allocation in the Future . . . . The Future of Energy . . . . Technology Assessment . . . . Technology and Society in the Future . . . . Technology and Ethics in the Future . . . . Business Forecasting . . . . Sales Forecasting . . . . Images of the Future in Science Fiction . . . . Radical Conceptions of the Future . . . . Apocalyptic Futures . . . . Seminar in Futures Studies

Master of Science Degree in Studies of the

RE

PARTICIPATING FACULTY

ROGER BILSTEIN. Ph.D. Ohio State University (History)

JIM BOWMAN. Ph.D. University of Oklahoma (Social Foundations of Education)

NANETTE BRUCKNER. Ph.D. City University of New York (Psychology)

JAMES COOMER. Ph.D. The University of Tennessee (Political Science)

CHRISTOPHER DEDE. Ed.D. University of Massachusetts (Science Education)

JIB FOWLES. Ph.D. New York University (Futuristics, Mass Communications)

KIM HILL. Ph.D. Rice University (Political Science)

THOMAS MCFAUL. Ph.D. Boston University (Sociology of Religion)

JAYE MILLER. Ph.D. Yale University (History)

ROSEMARY PLEDGER. D.B.A. Texas Tech University (Business Administration)

LESTER SARTORIUS. Ph.D. University of Minnesota (Business Statistics)

CURTIS SMITH. Ph.D. Syracuse University (English)

GROVER STARLING. Ph.D. University of Texas at Austin (Public Administration)

ROBERT TOPLIN. Ph.D. Rutgers University (History)

NORMAN L. WEED. Ph.D. Tulane University (Economics)

ROBERT WEGMANN. Ph.D. University of California-Santa Barbara (Sociology)

PROGRAM IN STUDIES OF THE

FUTURE

UH CLC University of Houston at Clear Lake City

Program in Studies of the Future
University of Houston at Clear Lake City
2700 Bay Area Boulevard, Houston, Texas 77058

Please Post

school file

July 16, 1971

Professor George R. Webb
Tulane University
Department of Mechanical Engineering
New Orleans, Louisiana 70118

Dear Professor Webb:

In Professor Forrester's absence from the MIT campus, let me thank you for your kind remarks. We are always interested in hearing of other schools' experiences in teaching system dynamics.

One of my own goals in the coming year is to collect information on teaching activities outside of MIT, in order to plan for the development of better curriculum materials. I am hoping to collect course outlines and comment on what type of material might be most useful to people in your position. If you have the chance, can you offer any advice to other teachers?

Probably you have not yet seen the new book, World Dynamics. I am enclosing here a folder describing it.

Thanks again.

Sincerely,

John A. Seeger
Administrative Officer

JAS:ie
Enc. World Dynamics folder

JAS CURRIC FILE

JWF 7/15/71

TULANE UNIVERSITY
Department of Mechanical Engineering
NEW ORLEANS, LA. 70118

July 9

Dear Dr. Forrester,

We have just used your books Urban Dynamics and Principles of Systems, and your paper on Global Dynamics, which appeared in Technology Review, in a seminar course at Tulane that is designed for both engineers and humanists (the course was taught by an English professor and two engineers). We found your material easy to teach, and as a result the discussions that occurred were stimulating and fruitful. Thank you for your part in these classes.

Sincerely yours,

George R. Webb and Jane C. Keller

W-A

course interest

THE UNIVERSITY OF BRITISH COLUMBIA

VANCOUVER 8, CANADA

JUL 19 10 29 AM '71

DEPARTMENT OF COMPUTER SCIENCE

July 15, 1971

M.I.T. Press
M.I.T.
Cambridge, Mass. 02142
U.S.A.

Dear Sir:

I would like to purchase a copy of "World Dynamics" by J.W. Forrester of your institution.

I am quite keen to evaluate it as a prescribed text in a Simulation course in Computer Science here at U.B.C.

Please send a copy and bill me accordingly.

Yours sincerely,

Doug Seeley

D.A.R. Seeley
Assistant Professor

DARS:os

and to prof

26 Jul
MS

File.
Prof. teaching S.D.

Prof. Don Wilhem
D/Chem. Engineering
U/Maine, Orono

26 Aug 71

he would like to see you briefly at 5 today. He is seeing Nima & Erich at 5:30.

he has a proposal ready for ? ~~re.~~ dynamics of petroleum industry (?) in India [spent 3 yrs there)

he has talked with Dana

he will see Dean Hoelscher on Mon.

Aug 26 '71

Recently returned from India
Visiting Prof Kampur- program
9 Am uni send faculty.
1962-72 program
From U. Maine.
In India under auspices of Ohio State U.
Interested in S. D. to Chem Industry
in India.
Proposal to Am Chem Soc, to simulate
Indian petroleum Industry.
2 mo ago, saw Dana Meadows
Had sent proposal to NSF, no answer.
Is a chem eng.
Has been in touch with Hoelscher, U. Pitts.
Will be there mon, maybe.
Work moving slowly, no grad students yet,
Problem is grantsmanship
Hopes to attract 2 bright Indian students.

File
Teachers of System Dynamics File

September 9, 1971

Professor S. L. Cooke, Jr.
University of Louisville
College of Arts and Sciences
Division of Natural Sciences
Louisville, Kentucky 40208

Dear Professor Cooke:

Thank you for your letter of August 26 and for sending the text by Dr. Salk. I have taken the liberty of sending him my paper on "Counterintuitive Behavior of Social Systems" which was originally presented before a Subcommittee of Congress and which first appeared in print in the January 1971 issue of the Technology Review. In reply to your question, you may reproduce copies for your students if you wish. I call your attention to the availability of reprints from the Technology Review which may cost no more and will be of better reproduction quality.

You ask about students working with the model, I presume you mean the World Dynamics model. It is fully described in my World Dynamics book for which a folder is enclosed. Also, if you have students who are seriously studying the subject they will want to work with my Principles of Systems book and perhaps also Urban Dynamics and Industrial Dynamics.

I would appreciate hearing more from you about the degree of your interest and what your students are doing. Also, I would appreciate receiving your suggestions for the kind of educational material which needs to be made available. We will be giving greater emphasis to teaching materials sometime in the near future.

Sincerely yours,

Jay W. Forrester
Professor of Management

JWF:ie
Enc: Folders: World Dynamics, Principles of Systems
Urban Dynamics, Industrial Dynamics

(Cooke material should go in the "Teachers of System Dynamics File")

JWF 8/31/71

UNIVERSITY OF LOUISVILLE
LOUISVILLE, KENTUCKY 40208

COLLEGE OF ARTS AND SCIENCES
DIVISION OF NATURAL SCIENCES

August 26, 1971

Dr. Jay W. Forrester
Professor of Management
Mass. Institute of Technology
Cambridge, Massachusetts

Dear Dr. Forrester:

O.K. but suggest Tech Rev. as source.

Your excellent article "Counterintuitive Behavior of Social Systems" in the Feb., 1971 issue of Simulation has provoked considerable interest and discussion. I would very much like to use it as the basis for a talk on the use of computers to solve contemporary problems and would like permission to reproduce at least the figures if not the entire text. We will need to make 120 copies for distribution to students.

You must have already received many compliments on this outstanding work which was beautifully presented. I hope that we might be able to let students play with a simplified version of your model after reading in your books on the subject. We have already done some simple population dynamic simulations. Any suggestions you might have would be appreciated.

An everyday example of counterintuitive behavior came to mind and may help explain the problem. That is, the fact that many people who can back a car find great difficulty in doing so when a trailer is attached.

A copy of an interesting talk by Dr. Jonas Salk is enclosed. He is advocating treating the whole problem for much more qualitative reasons than you.

Thank you.

Respectfully yours,

S. L. Cooke, Jr.
S. L. Cooke, Jr.
Professor

SLC:mas

July 26, 1972

Dr. Thomas F. Kimes, Director
Interactive Computing Services Unit
Austin College
Sherman, Texas 75090

Dear Dr. Kimes:

Thank you for your letter describing the interest of your students in the work we have done under the sponsorship of The Club of Rome. Professor Forrester has suggested that I send you the enclosed book folders as these sources provide the guidelines you requested.

Sincerely yours,

(Miss) Emaline Cornett
Secretary to Professor Forrester

eac
Enc. Book folders -- Industrial Dynamics
Principles of Systems
Urban Dynamics
World Dynamics

7/17

AUSTIN COLLEGE
founded 1849

Sherman, Texas 75090

11 July 1972

Professor Jay W. Forrester
Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Professor Forrester:

A group of undergraduate students at Austin College have asked me to write you concerning the computer-based projections you developed together with the "Club of Rome". They would like to employ your model, or one similar to it, in a course they are helping to plan for the 1972 Fall Term.

It may be that the complete model is far too sophisticated for their purposes. It would be useful, however, to have the most detailed description you can provide them. Their goal will be to incorporate the model in an interactive computer program (based on the APL language), and to compare projections based on different choices for the parameters involved.

I will appreciate any help you can provide this group in realizing their objectives. If the model is described in a paper or technical report in sufficient detail for their purposes, I would appreciate a copy of the relevant publication. If an APL version of the simulation exists, that would be better still.

Many thanks for your help; I look forward to your reply.

Sincerely,

Thomas F. Kimes

Dr. Thomas F. Kimes, Director
Interactive Computing Services Unit

TFK/km

Fully described in W.D.,
Send all book folders.

SD-Other Visitors

MEMORANDUM

TO: Jay W. Forrester

FROM: John A. Seeger

SUBJECT: Another Visitor

DATE: August 3, 1971

Mr. Wallace Forney of Dallas, Texas, called on Monday, August 2, and will call back on Friday, August 6, to see whether it is possible to arrange an appointment with you.

Mr. Forney is apparently a member of the Board of Visitors of the University of Texas Graduate School for Social Work in Austin. He wants to discuss how to begin a curriculum in computer modeling for social problems, and how to apply models to the problems of a specific program of drug control in New York City--this program under the direction of Mrs. Sidney Poitier (the actor's wife). Mrs. Poitier, according to Mr. Forney, has a great deal of "clout," and can make things happen.

Mr. Forney, the Dean of his school, and perhaps Mrs. Poitier would like to visit here after a meeting they will attend in New York. They could come Thursday afternoon, August 12, or Friday morning, August 13.

I did not mention Ed Roberts work in drugs, but could when Mr. Forney calls again. Would you be interested in seeing him?

mm

cc: Louis Alfeld

For our file
of professors
who are
teaching
Dgn.
Sup

JWF

McMASTER UNIVERSITY

HAMILTON, ONTARIO, CANADA

DEPARTMENT OF GEOGRAPHY

August 9th, 1971.

Mr. N. K. Patni, President,
Wright-Allen Press, Inc.,
238 Main Street,
CAMBRIDGE, MASSACHUSETTS, 02142,
U. S. A.

Dear Mr. Patni:

I am sorry that I have been so slow in responding to your letter of 28 October 1970, regarding the use of Forrester's Principles of Systems. I used the book in two courses, Geography 4j6 and 3x6. Part of my delay in writing is due to the use of the book in two courses, i.e., I wanted to see how the different classes could deal with the material.

Briefly, 4j6 is a fourth year course. There were 17 students in the course this past year. This course is research oriented. There are four objectives to the course: 1) introduction to systems method and theory, 2) introduction to social research methodology, 3) introduction to selected urban themes -- this year it was intra-urban migration, and 4) development and conduct of team research projects using the methodology discussed in 1) and 2). The course is for the academic year, i.e., September to April. It is divided roughly into two terms: September to December, January to April. The first term is run as a lecture-lab-seminar course. The second term is devoted to research with team members meeting with me individually as frequently as required. The topics covered and their sequence are indicated on the enclosed course outlines.

Finally, there were three exercises. Two dealt with sampling problems and data analysis. The third exercise was the development of a second-order systems model of intra-urban migration. This exercise, and the research projects, were designed to get the students to use Professor Forrester's notions. The exercise was more successful in this attempt than the research projects. The latter are based on student defined urban problems. These ranged from topics such as the resistance to change in spatial units, through the relationships between work orientation, job satisfaction, and leisure time activities, to behavioral variables affecting transportation mode choice. Generally, the students had difficulty in treating their subjects in terms of levels and rates, although there is no inherent reason for non-applicability.

.... cont'd.

Mr. N. K. Patni, August 9th, 1971.

3x6 was a third year course in which I taught the second term. The objectives of this part of the course were two: 1) introduce systems method and theory, and 2) introduce urban ecology. The topics covered and their schedule are included in the enclosed materials. The course was a lecture course meeting for an hour, three times a week. There were 85 students in the class.

The following comments about Principles of Systems are based on my experiences in these two courses. I intended to use the book as programmed-learning text on the systems method. I used it in this fashion. My first comment would be about the unevenness of the book. However, you are aware of this problem. My second comment regards the lack of discussion about wheter Professor Forrester's notions reside with respect to the large literature on systems. My third comment is based on my personal interest in urban problems. I would like to see more discussion and examples of urban systems. You mention that examples will be drawn from many fields, I hope urban studies is one of them.

Fourth, the students found conceptual leaps between the text material and workbook material. This is not particularly good from a programmed-learning standpoint. Fifth, the chapters on dynamo and integration were difficult. I am not convinced that dynamo is the most efficient language to use. The discussion on integration can be clarified greatly. Finally, I believe Chapter 2 could be placed later in the book, for example after Chapter 4, to improve the "flow of the material".

In terms of student opinion, the book was considered hard by some and not difficult by others. I think the difficulties encountered are all related to my preceding comments.

Next year, 4j6 will be offered in an altered form, i.e., the systems material will only be briefly reviewed, because all the students will have had 3x6. 3x6 has been dropped and replaced by two other courses. I am not involved with the new courses, so I don't know exactly what will be done in them.

Again, I am sorry to have been so slow in responding. I hope my comments and the enclosed materials are useful. I would appreciate receiving a copy of the new editions when they become available.

Sincerely,

J. F. Betak

John F. Betak,
Assistant Professor.

JFB/rt
Enclosures

GEOGRAPHY 4J6 and 6J6

LECTURE OUTLINE

1970-71

TOPIC		WEEK OF
1.	Development of the Systems Perspective	14/9/70
2.	Definitions: Urban Systems & Open-Closed Systems; Models and Theory	21/9/70
3.	Structuring Systems	28/9/70
4.	Mathematics & Models	5/10/70
5.	Modeling Complex Systems	12/10/70
6.	Modeling Complex Systems cont'd.	19/10/70
7.	Complex Social Systems	26/10/70
8.	Complex Social Systems cont'd.	2/11/70
9.	Urban Ecology & Intra-Urban Migration	9/11/70
10.	Intra-Urban Migration	16/11/70
11.	Intra-Urban Migration cont'd.	23/11/70
12.	Modeling Intra-Urban Migration	30/11/70

JFB/rt
17/9/70

GEOGRAPHY 4j6 and 6j6

LAB OUTLINE

1970-71

	TOPIC:	WEEK OF:
1.	Introduction & Philosophy of Scientific Investigation	21/ 9/70
2.	Philosophy of Scientific Investigation & Scientific Research Program	28/ 9/70
3.	Research Paradigm, Data Specification & Sources, Measurement	5/10/70
4.	Sample Design & Sampling	12/10/70
5.	Sampling Exercise	19/10/70
6.	Data Collection: Background Information, Field Notes & Notebook	26/10/70
7.	Data Collection: Observation & Special Techniques	2/11/70
8.	Data Collection: Questionnaires	9/11/70
9.	Data Collection: Interviews	16/11/70
10.	Data Storage, Reduction, Analysis, & Interpretation	23/11/70
11.	Data Analysis Exercise	30/11/70

JFB/rt
17/9/70

GEOGRAHIY 4j6 and 6j6

REQUIRED READING LIST

1970-71

SYSTEMS THEORY & METHODOLOGY, URBAN & SOCIAL SYSTEMS

BOULDING, K.E., "General Systems Theory - The Skeleton of Science", Management Science, 2 (1956), 197-208. Reprinted in W. Buckley, Modern Systems Research for the Behavioral Scientist. Chicago: Aldine Publ. Co., 1968, pp. 3-10.

BERRY, B.J.L., "Cities as Systems Within Systems of Cities", Papers and Proceedings R.S.A., 13 (1964), 147-63.

BERTALANFFY, L.V., "General Systems Theory - A Critical Review", General Systems, VII (1962), 1-20. Also in Buckley, op. cit., pp. 11-30.

BUCKLEY, W., "Society as a Complex Adaptive System", in Buckley, op. cit., pp. 490-513.

CADWALLDER, M.L., "The Cybernetic Analysis of Change in Complex Social Organizations", Amer. J. Soc. 65 (1959) 154-57. Also in Buckley, op. cit., pp. 437-40.

EASTON, D., "A Systems Analysis of Political Life", Ch. 2 in D. Easton, A Systems Analysis of Political Life. N.Y.: John Wiley & Sons, Inc., 1965, pp. 17-35. Also in Buckley, op. cit., pp. 429-36.

FOLEY, D.L., "An Approach to Metropolitan Spatial Structure", in M.M. Webber, et. al. Explorations Into Urban Structure. Philadelphia: Univ. of P.A. Press, 1964, pp. 21-78.

FORRESTER, J.W. Principles of Systems. Cambridge, Mass.: Wright-Allen Press, 1969.

HALL, A.D., A Methodology for Systems Engineering. Princeton, N.J.: D. Van Nostrand Co., Inc., 1962, Chapter 3, pp. 59-84.

HALL, A.D. & FAGEN, R.E., "Definition of System", General Systems, I (1956), 18-28. Also in Buckley, op. cit., pp. 81-92.

Machol, R.E. (Ed.) System Engineering Handbook. N.Y.: McGraw-Hill Book Co., 1965, Chapters 1 & 4.

Maruyama, M., "The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes", Amer. Scientist, 51 (1963), 164-79. Also in Yearbook of the Society for General Systems Research, VIII (1963), 233-41. Also in Buckley, op. cit., pp. 304-13.

.... cont'd.

VICKERS, G., "Is Adaptability Enough", _Behavioral Science_, 4 (1959), 219-34. Also in Buckley, _op. cit._, pp. 460-73.

WEBBER, M., "The Urban Place and the Non-Place Urban Realm", in Webber, _et. al._, _op. cit._, pp. 79-153.

SOCIAL SPACE & INTRA-URBAN MIGRATION

BERRY, B.J.L. & F.E. HORTON. _Geographic Perspectives on Urban Systems._ Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970, Chapters 10 & 11.

BOYCE, R.R., "Residential Mobility & Its Implications for Urban Spatial Change", _Proceedings A.A.G._, 1 (1969), 22-26.

BROWN, L.A. & E.G. MOORE, "Intra-Urban Migration: An Actor-Oriented Framework", Dept. of Geography, Northwestern University, (1968).

CLARK, W.A.V., "Information Flows & Intra-Urban Migration: An Empirical Analysis", _Proc. A.A.G._, 1 (1969), 38-42.

MOORE, E.G., a "Models of Migration & the Intra-Urban Case", _The Australian & New Zealand J. Soc._, 2 (1966), 16-37.

--------, b "The Structure of Intra-Urban Movement Rates: An Ecological Model", _Urban Studies_, 6 No. 1 (Feb. 1969), 17-33.

--------, c "The Nature of Intra-Urban Migration & Some Relevant Research Strategies", _Proc. A.A.G._, 1 (1969), 113-16.

ROSSI, P.H. _Why Families Move._ Glencoe: The Free Press, 1955.

WOLPERT, J., "Behavioral Aspects of the Decision to Migrate", _Papers R.S.A._, 15 (1965, 159-69.

YAPA, L., M. POLESE & J. WOLPERT, "Interdependence of Commuting & Migration", _Proc., A.A.G._, 1 (1969), 163-68.

SOCIAL RESEARCH METHODOLOGY

SELTIZE, C., et. al. _Research Methods in Social Relations._ N.Y.: Holt, Rinehart and Winston, Revised One-Vol. edition, 1967. Chs. 1-11 & 14.

CAMPBELL, C.T. & STANLEY, J.C., "Experimental & Quazi-Experimental Designs for Research & Teaching", in N. L. Gage (Ed.) _Handbook of Research on Teaching._ Chi.: Rand McNally & Co., 1963, also Rand McNally Reprint.

FESTINGER, L. & KATZ, D. _Research Methods in the Behavioral Sciences._ N.Y.: Holt, Rinehart & Winston, 1953, pp. 56-97, Part III, & Part IV.

RUBENSTEIN, A.H. & HABERSTRON, C.J., (Eds.) _Some Theories of Organization._ Homewood, Ill.: Richard D. Irwin, Inc., & The Dorsey Press, 1966, pp. 685-703.

.... cont'd.

WEBB, E.J. et. al. Unobtrusive Measures: Non-Reactive Research in the Social Sciences. Chi.: Rand McNally & Co., 1966, whole book.

MILLER, D.C. Handbook of Research Design & Social Measurement. N.Y.: David McKay Co., Inc., 1964, Browse Part I; Part II & Part III.

BACKSTROM, C.H. & HURSH, G.D. Survey Research. Evanston, Ill.: Northwestern Univ. Press, 1963, whole book.

STEPHAN, F.F. & McCARTHY, P.J. Sampling Opinions. N.Y.: John Wiley & Sons, Inc., 1958, Part I & Part III.

JANDA, K. Data Processing. Evanston, Ill.: Northwestern Univ. Press, 1965, Chs. V-VIII.

GEOGRAPHY 4J6 and 6J6

LECTURE READING SCHEDULE

1970-71

	AUTHOR	ASSIGNMENT	WEEK OF
1.	Forrester, J.W. (J.W.F.)	Chs. 1, W1, 2 & W2	14/ 9/70
2.	J.W.F.	Chs. 3,W3,	21/ 9/70
	Hall, A.D. & Fagen, R.E. (A.D.H. & R.E.F.)	Complete article	
	Boulding, K.E. (K.E.B.)	Complete article	
	Bertalanffy, L.V. (L.V.B.)	Complete article	
3.	J.W.F.	Chs. 4, W4	28/ 9/70
	A.D.H.	Ch. 3	
	Machol, R.E. (R.E.M.)	Ch. 1	
4.	J.W.F.	Chs. 5, W5, 6 & W6	5/10/70
5.	J.W.F.	Chs. 7, W7, 8, W8, 9, W9	12/10/70
6.	J.W.F.	Chs. 10, W10	19/10/70
	Maruyama, M. (M.M.)	Complete article	
7.	Buckley, W. (W.B.)	Complete article	26/10/70
	Cadwallder, M.L. (M.L.C.)	Complete article	
	Easton, D. (D.E.)	Ch. 2 or complete article	
	Vickers, G. (G.V.)	Complete Article	
	R.E.M.	Ch. 4	
8.	Berry, B.J.L. (B.J.L.B.)	Complete article	2/11/70
	Foley, D.F. (D.F.F.)	Complete article	
	Webber, M. (M.W.)	Complete article	

.... cont'd.

9.	B.J.L.B. & Horton, F.E. (F.E.H.)	Ch. 10	9/11/70
	Wolpert, J. (J.W.)	Complete article	
10.	B.J.L.B. & F.E.H.	Ch. 11	16/11/70
	Rossi, P.H. (P.H.R.)	Whole book	
11.	P.H.R.	Whole book	23/11/70
	Boyce, R.R. (R.R.B.)	Complete article	
	Clark, W.A.V. (W.A.V.C.)	Complete article	
	Yapa, L., M. Polese & J.W.	Complete article	
12.	Brown, L.A. & E.G. Moore (L.A.B. & E.G.M.)	Complete paper	30/11/70
	E.G.M. a	Complete article	
	E.G.M. b	Complete article	
	E.G.M. c	Complete article	

JFB/rt
17/9/70

GEOGRAPHY 4j6 and 6j6

LAB READING SCHEDULE

1970-71

	AUTHOR	ASSIGNMENT	WEEK OF
1.	Selltiz, et. al. (S.)	Chs. 1 & 14	21/ 9/70
2.	S.	pp. 26-40	28/ 9/70
3.	S.	pp. 41-48, Chs. 3-5	5/10/70
	Campbell, D.T. & J.C. Stanley (D.T.C. & J.C.S.)	whole book	
	Festinger, L. & D. Katz (L.F. & D.K.)	pp. 471-535	
	Backstrom, C.H. & G.D. Hursh (C.H.B. & G.D.H.)	pp. 66-72	
	Webb, E.J. et. al. (E.J.W.)	Chs. 1 & 2	
4.	Stephan, F.F. & P.J. McCarthy (F.F.S. & P.J.M.)	CHs. 1-5, 14-22	12/10/70
	G.H.B. & G.D.H.	Ch. XI	
	Miller, D.C. (D.C.M.)	pp. 46-50	
5.	F.F.S. & P.J.M.	Chs. 1-5, 14-22	19/10/70
	C.H.B. & G.D.H.	Ch. XI	
6.	S.	Ch. 9	26/10/70
	E.J.W.	Ch. 3 & 4	
	L.F. & D.K.	pp. 56-97	
7.	S.	Ch. 6	2/11/70
	E.J.W.	Chs. 5 & 6	
8.	S.	Chs. 7, 8, & 10	9/11/70
	C.H.B. & G.D.H.	pp. 72-110, Chs. IV-V	
	L.F. & D.K.	Part III	
	D.C.M.	Part III	

.... cont'd

	AUTHOR	ASSIGNMENT	WEEK OF
9.	S.	Chs. 7, 8, & 10	16/11/70
	C.H.B. & G.D.H.	pp. 72-110, CHS. IV-V	
	L.F. & D.K.	Part III	
	D.C.M.	Part III	
10.	Janda, K. (K.J.)	Chs. V-VIII	23/11/70
	S.	Ch. 11	
	C.H.B. & G.D.H.	Ch. VI	
	D.C.M.	Part II	
11.	K.J.	Chs. V-VIII	30/11/70
	S.	Ch. 11	
	C.H.B. & G.D.H.	Ch. VI	
	D.C.M.	Part II	

JFB/rt
17/9/70

GEOGRAPHY 4j6 and 6j6

MARKING SCHEDULE

1970-71

COMPONENT	WEIGHT
Exercises	15%
Individual Research Proposal	25%
Team Research Report & Defense	55%
Final Exam	5%
	100%

JFB/rt
17/9/70

M E M O

TO: Geography 4j6 and 6j6 FROM: John F. Betak

RE: Individual Research Proposal and Team Project

You have two project for the year. They are comprised of an individual research proposal and a team project. The requirements and specifications for each follow.

Individual Research Proposal:

You will submit a research proposal on or before noon November 17, 1970. Your proposal may be on any area in urban geography, preferably your own area of interest. In this proposal you will make use of the Systems methodology to formulate your problem, and, insofar as possible, develop a "systems model" of the phenomenon of interest. You will also utilize the materials on research methodology to discuss how your propositions may be tested.

Proposal Specifications:

1) Typed, double-spaced, on 8-1/2 x 11 white bond paper.

2) Maximum length, 10 pages, excluding bibliography.

3) Two copies (original and copy) to be submitted -- the copy will be returned with comments.

4) Cover sheet format:

Title
Author
University
Department
Course Number
Date

5) Standard footnote and bibliography format.

6) Content:

a) Statement of your interest.
b) Statement of your research problem.
c) "Model" of phenomenon.
d) Logico-deductive construct leading to:
e) Testable propositions.
f) Suggested instruments for testing propositions, including:
  (1) Specification of types of data to be gathered.
  (2) Format for data storage.
  (3) Tests to be used on data, including how the tests relate to the propositions.
  (4) Analysis format for data.
g) Footnotes and bibliography supporting your propositions and methods.

.... cont'd.

Team Project:

The class will be divided into research teams on November 24th, 1970. These teams will, in the course of the following five months, develop a research proposal, develop instruments to test the propositions, pilot test the instruments, conduct a preliminary field investigation -- gathering the requisite data for preliminary testing of the propositions, tabulate and analyze the data, present an oral defense of the research, and submit a written report on the research.

Outline and Schedule:

1) Research proposal and propositions (Due noon December 8, 1970)

Based upon the general research area decided upon by your group, in consultation with J. F. Betak, formulate a research proposal (based on the same format as the individual proposals) which contains:

a. Three researchable questions.
b. Two testable propositions for each question (a total of six) from which your actual field propositions may be selected, again in consultation with J. F. Betak.
c. A listing of all the variables involved in your propositions, with operational definitions, potential indicators, and methods of measurement.

2) Research instruments and data format (Due noon January 15, 1971)

a. Based on your team's research questions and propositions (No. 1), design and develop four instruments:
   1. Check-off type questionnaire.
   2. Fill-in and short essay questionnaire.
   3. Combination of (1) and (2).
   4. One special instrument (Q-sort, observation instrument, etc.).
b. Select pre-test subjects for pilot testing instruments. They should be as close to the real subjects (without being them) you will study in the field as you can get. Discuss with J. F. Betak how to find these subjects. Clear the selection of all subjects with J. F. Betak.
c. Administer the instruments in some predetermined sequence to a sample of pre-test subjects.
d. Discuss the instruments with the subjects after they have been completed. Get their reactions to the questions, the format, the problems they had with them.
e. Revise and re-administer the instruments to another sample of pre-test subjects.
f. Hand in all versions of the instruments with your and the subjects' comments and the data analysis.
g. Hand in a description of your proposed methods of handling your data with examples of how you plan to reduce and analyze your data, including the testing of your propositions.

.... cont'd.

3 3) Field Work, tabulation and analysis of data (January & February).

Weekly or bi-weekly touch-base sessions with J. F. Betak.

4) Summary of research (Due noon March 5, 1971)

Three page, typed and dittoed (30 copies), summary of your research. One copy to each member of the class, the remainder to be turned into J. F. Betak. The summary will contain a statement of the problem, an outline of the propositions, an outline of the methodology, an outline of the preliminary results.

5) Oral team defense (March 1971, dates t.b.a.)

Each team will expand upon and discuss the work outlined in its summary. The teams will present their remarks for an hour. The floor will be opened for discussion for another hour. The manner of presentation is up to each team.

6) Written research report (Due noon April 6, 1971)

A full double-spaced, typed report of the research will be submitted. The report will contain:

a. Cover sheet: Title
Authors
University
Department
Course Number
Date

b. Acknowledgements (if any)

c. Table of contents

d. List of illustrations

e. Summary of report

g. Introduction, background, and problem statement

h. "Model" of phenomenon

i. Propositions

j. Methodology

k. Analysis

l. Summary and conclusions

m. Appendices:
1. Instruments
2. All data collected
3. Other

n. Bibliography

o. Each team member's carbon copy of his or her research "notebook".

JFB/rt
15/9/70

GEOGRAPHY 3x6

PART II

LECTURE OUTLINE

1970-71

TOPIC	WEEK OF
1. Development of the Systems Perspective	4/1/71
2. Definitions: Models and Theory, Systems, Systems Methods	11/1/71
3. Structuring Systems	18/1/71
4. Mathematics and Models	25/1/71
5. Modeling Complex Systems	1/2/71
6. Complex Social Systems	8/2/71
7. Urban Ecology	15/2/71
8. Urban Ecology cont'd.	1/3/71
9. Social Area Analysis	8/3/71
10. Factor Analysis	15/3/71
11. Factorial Ecology	22/3/71
12. Factorial Ecology cont'd.	29/3/71
13. Urban Social Systems	5/4/71

JPB/rt

21/12/70

GEOGRAPHY 3H6

PART II

REQUIRED READING

1970-71

SYSTEMS THEORY & METHODOLOGY

Boulding, K.E., "General Systems Theory - The Skeleton of Science", Management Science, 2 (1956), 197-208. Reprinted in W. Buckley, Modern Systems Research for the Behavioral Scientist. Chicago: Aldine Publ. Co., 1968, pp. 3-10.

Bertalanffy, L.V., "General Systems Theory - A Critical Review", General Systems, VII (1962), 1-20. Also in Buckley, op. cit., pp. 11-30.

Buckley, W., "Society as a Complex Adaptive System", in Buckley, op. cit., pp. 490-513.

Forrester, J.W. Principles of Systems. Cambridge, Mass.: Wright-Allen Press, 1969.

Hall, A.D. A Methodology for Systems Engineering. Princeton, N.J.: D. Van Nostrand Co., Inc., 1962, Chapter 3, pp. 59-84.

Hall, A.D. & R.E. Fagen, "Definition of System", General Systems, I (1956), 18-28. Also in Buckley, op. cit., pp. 81-92.

HUMAN ECOLOGY

Barrows, H.H., "Geography as Human Ecology", Annals A.A.G., XIII (March 1923), 1-14.

Murdie, R.A. The Factorial Ecology of Metropolitan Toronto, 1951-61. University of Chicago, Dept. of Geography, Research Paper 116, 1968.

THEODORSON, G. A. (ED.) STUDIES IN HUMAN ECOLOGY. EVANSTON: ROW, PETERSON & CO., 1961.

FACTOR ANALYSIS

Armstrong, J.S., "Derivation of Theory by Means of Factor Analysis or Tom Swift and His Electric Factor Analysis Machine", Amer. Statistician, (Dec. 1967), 17-21.

Cattell, R.B., "Factor Analysis: An Introduction to Essentials", Biometrics, 21, No. 1 (March 1965), 190-215, and 21, No. 2 (June 1965), 405-435.

Rummel, R., "Understanding Factor Analysis", J. Conflict Resolution XI (Dec. 1967), 440-480.

JFB/st
21/11/70

GEOGRAPHY 3x6

PART II

READING SCHEDULE

1970-71

	AUTHOR:	ASSIGNMENT:	WEEK OF:
1.	Forrester, J.W. (J.W.F.)	Chs. 1, w1, 2 & w2	4/1/71
2.	J.W.F.	Chs. 3, w3	11/1/71
	Hall, A.D. & Fagen, R.E. (A.D.H. & R.E.F.)	Complete Article	
	Boulding, K.E. (K.E.B.)	Complete Article	
	Bertalanffy, L.V. (L.V.B.)	Complete Article	
3.	J.W.F.	Chs. r, wr	18/1/71
	A.D.H.	Ch. 3	
4.	J.W.F.	Chs. 5, w5, 6, & w6	25/1/71
5.	J.W.F.	Chs. 7, w7, 8, w8, 9, & w9	1/2/71
6.	J.W.F.	Chs. 10, w10	8/2/71
	Buckley, W. (W.B.)	Complete Article	
7.	Theodorson, G.A. (G.A.T.)	Part I	15/2/71
	Barrows, H.H. (H.H.A.)	Complete Article	
8.	G.A.T.	Part II, pp. 129-165, 204-221, Part V, pp. 524-538, & 548-572.	1/3/71
9.	G.A.T.	Part II, pp. 226-252	8/3/71
10.	Armstrong, J.S. (J.S.A.)	Complete Article	15/3/71
	Cattell, R.B. (R.B.C.)	Complete Article	
	Rummel, R. (R.R.)	Complete Article	
11.	Murdie, R.A. (R.A.M.)	Whole Book	22/3/71
12.	R.A.M.	Whole Book	29/3/71
13.	W.B.	Complete Article	5/4/71
	G.A.T.	Part II, pp. 253-279	

JFB/rt
21/12/70

GEOGRAPHY 3x6

PART II

EXERCISE & EXAM SCHEDULE

1970-71

	ASSIGNMENT:	DATE:
1.	First-order, negative-feedback system	19/1/71
2.	Coupled-nonlinear-feedback system	9/2/71
3.	Mid-term exam	12/2/71
4.	Ecological analysis	30/3/71
5.	Final exam	As per exam schedule

JFB/rt
21/12/70

GEOGRAPHY 3a6

PART II

MARKING SCHEDULE

1970-71

COMPONENT	WEIGHT
Exercises	30%
Mid-term Exam	30%
Final Exam	40%
	100%

JFB/rt
21/12/70

GEOGRAPHY 3x6

PART II

EXERCISE 1

1970-71

FIRST-ORDER NEGATIVE FEEDBACK SYSTEM

Consider the simple populationggrowth situation of a new town in northern Canada. The optimum total population for this new town has been determined to be 200,000 people. The population growth of the new town is represented by the expression:

$$PR = \frac{1}{200,000} (PL) (200,000 - PL)$$

where PL = the new town population level at time T_0, T_1, T_2, ..., T_n

PL_0 = 2550 people in T_0 = 1970

Let the time interval = 10 years, i.e., T_0 = 1970, T_1 = 1980, T_2 = 1990, ...

1. Sketch and label, the flow diagram of this population growth system using the symbols given in Forrester's Figure 2.2a.

.... cont'd.

2. Prepare a worksheet, similar to Forrester's Table 2.2, showing time, change in population level, population level, flow rate. Use a ten year interval for your time column. Do the computations, based on the expression given above. (Round-off your figures to give us whole people.)

.... cont'd.

3. Draw a graph illustrating the growth rate and population level for the data in your worksheet. (Be sure to label your graph.)

4. What is the goal this system is seeking?

5. When is the goal reached?

.... cont'd.

6. What kind of relationship is illustrated by your graph?

7. What are the initial values of the system?

8. If the initial values were different, would the graph have the same shape? Why?

9. What happens to FR as FL changes?

10. How is this effect indicated in your flow diagram?

/rt
11/1/71

END

GEOGRAPHY 3x6

PART II

EXERCISE 1

1970-71

FIRST-ORDER NEGATIVE FEEDBACK SYSTEM

Consider the simple populationggrowth situation of a new town in northern Canada. The optimum total population for this new town has been determined to be 200,000 people. The population growth of the new town is represented by the expression:

$$FR = \frac{1}{200,000} (PL)(200,000 - PL)$$

where PL = the new town population level at time T_0, T_1, T_2, ..., T_n

PL_0 = 2550 people in T_0 = 1970

Let the time interval = 10 years, i.e., T_0 = 1970, T_1 = 1980, T_2 = 1990, ...

1. Sketch and label, the flow diagram of this population growth system using the symbols given in Forrester's Figure 2.2a.

.... cont'd.

2. Prepare a worksheet, similar to Forrester's Table 2.2, showing time, change in population level, population level, flow rate. Use a ten year interval for your time column. Do the computations, based on the expression given above. (Round-off your figures to give us whole people.)

.... cont'd.

3. Draw a graph illustrating the growth rate and population level for the data in your worksheet. (Be sure to label your graph.)

4. What is the goal this system is seeking?

5. When is the goal reached?

.... cont'd.

6. What kind of relationship is illustrated by your graph?

7. What are the initial values of the system?

8. If the initial values were different, would the graph have the same shape? Why?

9. What happens to FR as FL changes?

10. How is this effect indicated in your flow diagram?

/rt
11/1/71

END

GEOGRAPHY 3x6

PART II

EXERCISE 2

1970-71

COUPLED-NONLINEAR-FEEDBACK SYSTEM

On the following pages the premium-housing sector of J. W. Forrester's model of urban interactions is presented. This material is drawn from Urban Dynamics, pp. 170-179. The following questions are based on this material. Your answers can all be derived from the material.

The premium-housing sector is a feedback system exhibiting both positive and negative feedback loops.

1. Is it a coupled-nonlinear-feedback system? Why?

2. Which loops are positive?

3. Indicate which loops change from positive to negative, or vice versa, if any.

4. What order is this feedback system?

5. What are the initial values of the system?

6. What are the parameters of the system?

.... cont'd.

7. What variables from other diagrams enter in this system? Specify what kind of equation they have (level, rate, etc.).

8. Which variables from other diagrams receive information from this system? Specify what kind of equation they have.

9. Calculate equation 76 for PHGR.k.

10. Given that NE = 200, MB = 1,000, DI = 100, UH = 1,100 and WH = 21,000:

Calculate equation 59 for LFO.k.

Figure A-30 shows the structure of relationships causing the construction and obsolescence of premium housing.

Equation 64 defines the rate of premium-housing construction PHC in terms of premium-housing construction desired PHCD multiplied by the factor LCR

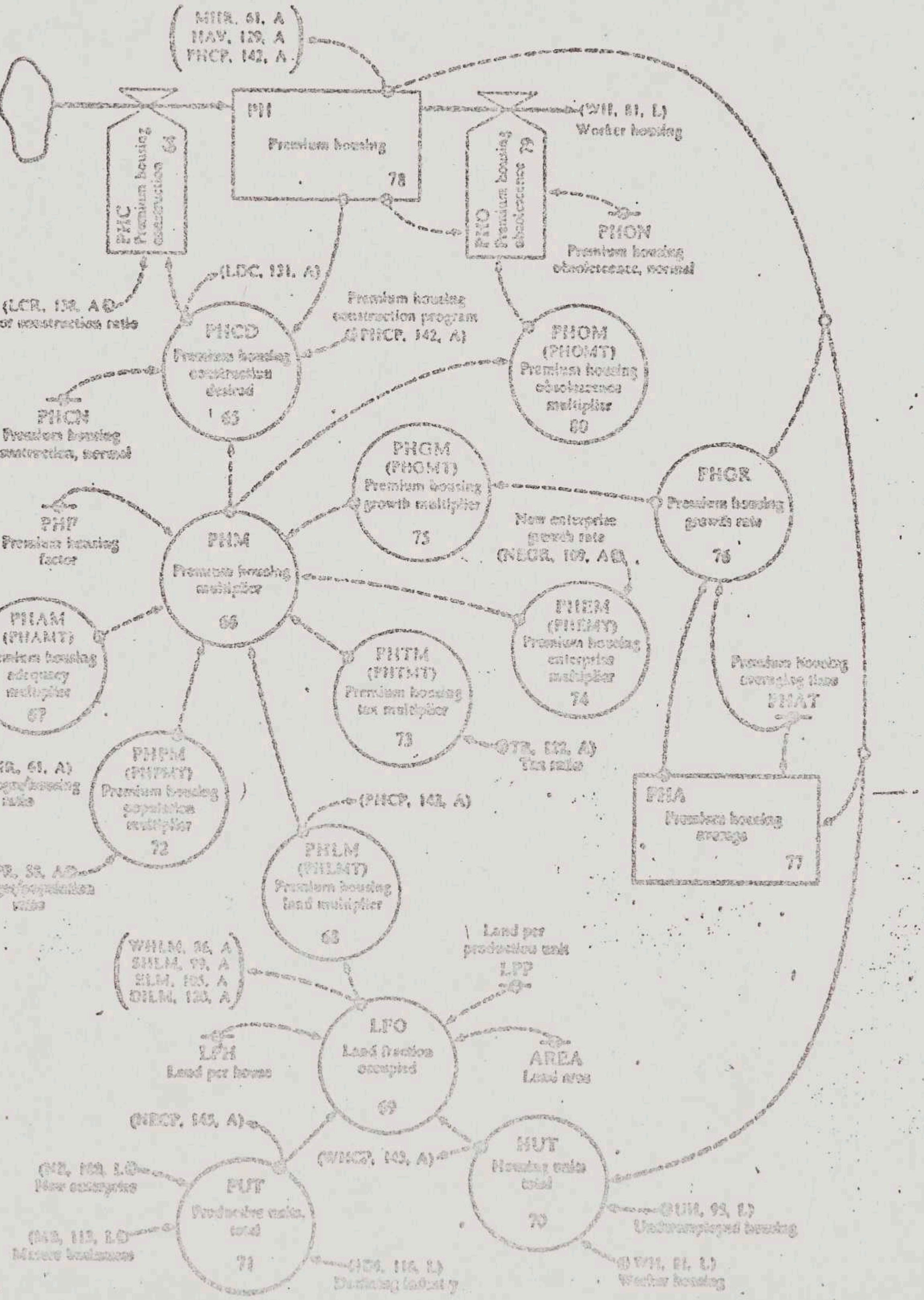


Figure A-30 Premium-housing sector.

coming from the job sector and causing limitation in the actual construction rate below that desired if the labor shortage in the city does not permit full construction activity.

```
PHC.KL=(PHCD.K)(LCR.K)                                   64,R

     PHC    - PREMIUM-HOUSING CONSTRUCTION (HOUSING
                UNITS/YEAR)
     PHCD   - PREMIUM-HOUSING CONSTRUCTION DESIRED
                (HOUSING UNITS/YEAR)
     LCR    - LABOR CONSTRUCTION RATIO (DIMENSIONLESS)
```

The premium-housing construction desired in Equation 65 contains the structure seen earlier for flow rates. It describes the desired construction rate as 3% per year of existing premium housing. This normal rate is influenced by the premium-housing multiplier PHM. An externally imposed premium-housing-construction program can be added through the last term. Desired construction is first generated in this manner so that it can be influenced in Equation 64 by the availability of construction labor.

```
PHCD.K=(PHCN)(PH.K)(PHM.K)+PHCP.K                        65,A

PHCN=.03                                                 65.1,C

     PHCD   - PREMIUM-HOUSING CONSTRUCTION DESIRED
                (HOUSING UNITS/YEAR)
     PHCN   - PREMIUM-HOUSING CONSTRUCTION NORMAL
                (HOUSING UNITS/YEAR)
     PH     - PREMIUM HOUSING (HOUSING UNITS)
     PHM    - PREMIUM-HOUSING MULTIPLIER (DIMENSIONLESS)
     PHCP   - PREMIUM-HOUSING-CONSTRUCTION PROGRAM
                (HOUSING UNITS/YEAR)
```

The premium-housing multiplier in Equation 66 is composed of six terms and the factor PHF, which is again included for experimental purposes to allow introducing test changes into the equation.

```
PHM.K=(PHAM.K)(PHLM.K)(PHPM.K)(PHTM.K)(PHEM.K)(PHGM.K)   66,A
  (PHF)

PHF=1                                                    66.1,C

     PHM    - PREMIUM-HOUSING MULTIPLIER (DIMENSIONLESS)
     PHAM   - PREMIUM-HOUSING-ADEQUACY MULTIPLIER
                (DIMENSIONLESS)
     PHLM   - PREMIUM-HOUSING LAND MULTIPLIER
                (DIMENSIONLESS)
     PHPM   - PREMIUM-HOUSING POPULATION MULTIPLIER
                (DIMENSIONLESS)
     PHTM   - PREMIUM-HOUSING TAX MULTIPLIER
                (DIMENSIONLESS)
     PHEM   - PREMIUM-HOUSING ENTERPRISE MULTIPLIER
                (DIMENSIONLESS)
```

```
PHGM   = PREMIUM-HOUSING-GROWTH MULTIPLIER
           (DIMENSIONLESS)
PHF    = PREMIUM-HOUSING FACTOR (DIMENSIONLESS)
```

The premium-housing-adequacy multiplier as defined in Equation 67 and shown in Figure A-31 is one of two strong influences on the construction rate. The adequacy multiplier has a value of 1 when the manager/housing ratio is

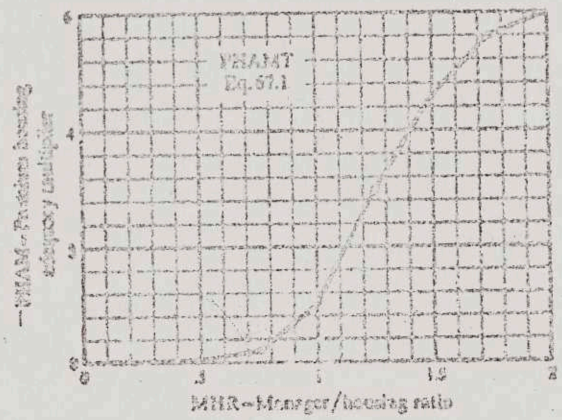


Figure A-31

at its normal value of 1. As MHR falls, indicating fewer managers than housing, the construction rate falls rapidly because of lack of need. On the other hand, as the managerial population exceeds available housing, there is pressure to increase the rate of construction.

```
PHAM.K=TABLE(PHAMT,MHR.K,0,2,.25)                     67, A

PHAMT=0/.001/.01/.2/1/3/4.6/5.6/6                     67.1, T

    PHAM   = PREMIUM-HOUSING-ADEQUACY MULTIPLIER
               (DIMENSIONLESS)
    PHAMT  = PREMIUM-HOUSING-ADEQUACY-MULTIPLIER TABLE
    MHR    = MANAGER/HOUSING RATIO (DIMENSIONLESS)
```

The land multiplier in Equation 68 and Figure A-32 illustrates the influence of land availability on the construction flows within the model. At very low levels of land occupancy, the area has not yet shown economic importance and the nearly empty land tends to discourage aggressive construction. As land occupancy increases toward the middle region, the rising multiplier indicates economic excitement and potential. Also, all of the common urban activities and services are now present to support further expansion. But as the area approaches the fully occupied condition, the more favorable construction sites have already been used. The less and less attractive locations begin to depress the tendency to build

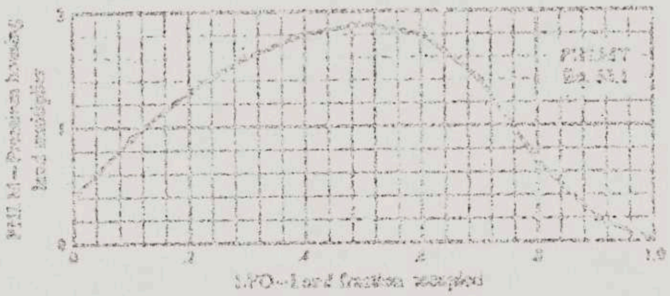


Figure A-33

until the absolute unavailability of land drives the construction rate to 0 at full land occupancy.

```
PHLM.K=TABLE(PHLMT,LFO.K,0,1,.1)                      68,A

PHLMT=.4/.9/1.3/1.6/1.8/1.9/1.8/1.4/.7/.2/0            68.1,T

     PHLM   - PREMIUM-HOUSING LAND MULTIPLIER
              (DIMENSIONLESS)
     PHLMT  - PREMIUM-HOUSING-LAND-MULTIPLIER TABLE
     LFO    - LAND FRACTION OCCUPIED (DIMENSIONLESS)
```

As the land fills, the changing values of the land multipliers begin to suppress the growth of industrial and housing structures in the original land area and to set the stage for the other variables to interact into the stagnation phase.

Equation 69 generates the land fraction occupied as the sum of the land used for housing plus the land used for productive units divided by the land area.

```
LFO.K=(HUT.K*LPH+PUT.K*LPP)/AREA                      69,A

LPH=.1                                                 69.1,C

LPP=.2                                                 69.2,C

AREA=100000                                            69.3,C

     LFO    - LAND FRACTION OCCUPIED (DIMENSIONLESS)
     HUT    - HOUSING UNITS TOTAL (HOUSING UNITS)
     LPH    - LAND PER HOUSE (ACRES/HOUSING UNIT)
     PUT    - PRODUCTIVE UNITS TOTAL (PRODUCTIVE UNITS)
     LPP    - LAND PER PRODUCTION UNIT (ACRES/PRODUCTIVE
              UNIT)
     AREA   - LAND AREA (ACRES)
```

Equation 70 totals the number of housing units in the system. Equation 71 totals the productive units.

```
HUT.K=PH.K+WH.K+UH.K                                   70,A

     HUT    - HOUSING UNITS TOTAL (HOUSING UNITS)
     PH     - PREMIUM HOUSING (HOUSING UNITS)
```

```
WH     - WORKER HOUSING (HOUSING UNITS)
UH     - UNDEREMPLOYED HOUSING (HOUSING UNITS)

PUT.K=NE.K+MB.K+DI.K                                71, A

    PUT   - PRODUCTIVE UNITS TOTAL (PRODUCTIVE UNITS)
    NE    - NEW ENTERPRISE (PRODUCTIVE UNITS)
    MB    - MATURE BUSINESS (PRODUCTIVE UNITS)
    DI    - DECLINING INDUSTRY (PRODUCTIVE UNITS)
```

In Equation 72 the premium-housing population multiplier illustrated in Figure A-33 reflects the social composition of the city. It tends to depress premium-housing construction if the city is heavily oriented toward labor and underemployed groups. Under such circumstances the city becomes a less desirable place for construction of premium housing.

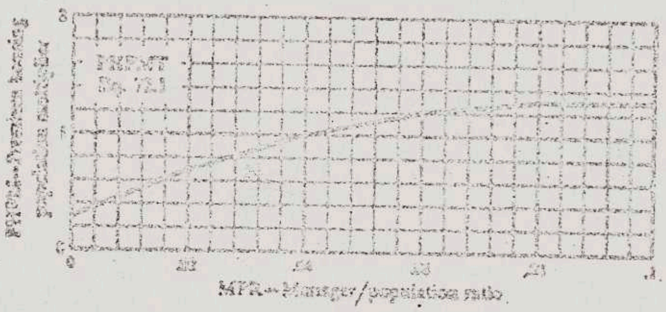


Figure A-33

```
PHPM.K=TABHL(PHPMT,MPR.K,0,.1,.02)                  72, A
PHPMT=.3/.7/1/1.2/1.3/1.3                           72.1, T

    PHPM  - PREMIUM-HOUSING POPULATION MULTIPLIER
              (DIMENSIONLESS)
    PHPMT - PREMIUM-HOUSING-POPULATION-MULTIPLIER TABLE
    MPR   - MANAGER/POPULATION RATIO (DIMENSIONLESS)
```

Equation 73 in Figure A-34 shows the depressing effects of a high tax rate on premium-housing construction.

```
PHTM.K=TABHL(PHTMT,1.44*LOGN(TR.K),-2,4,2)          73, A
PHTMT=1.2/1/.7/.3                                   73.1, T

    PHTM  - PREMIUM-HOUSING TAX MULTIPLIER
              (DIMENSIONLESS)
    PHTMT - PREMIUM-HOUSING-TAX-MULTIPLIER TABLE
    TR    - TAX RATIO (DIMENSIONLESS)
```

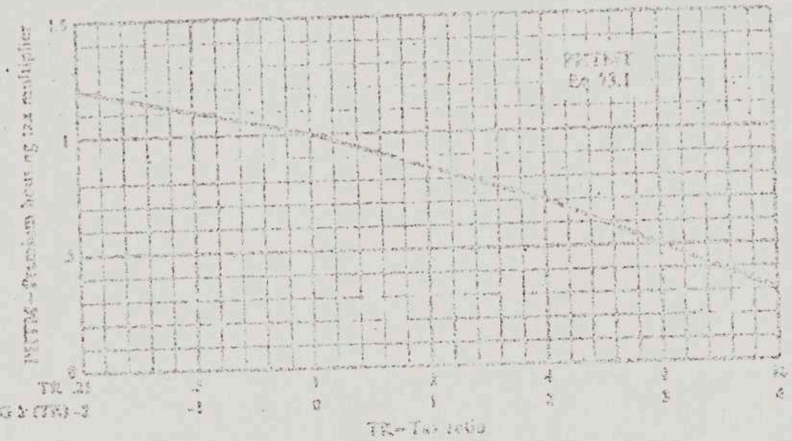


Figure A-34

The premium-housing enterprise multiplier PHEM in Equation 74 and Figure A-35 provides a speculative or momentum factor which increases premium-housing construction if there has been a recent history of above-average growth in

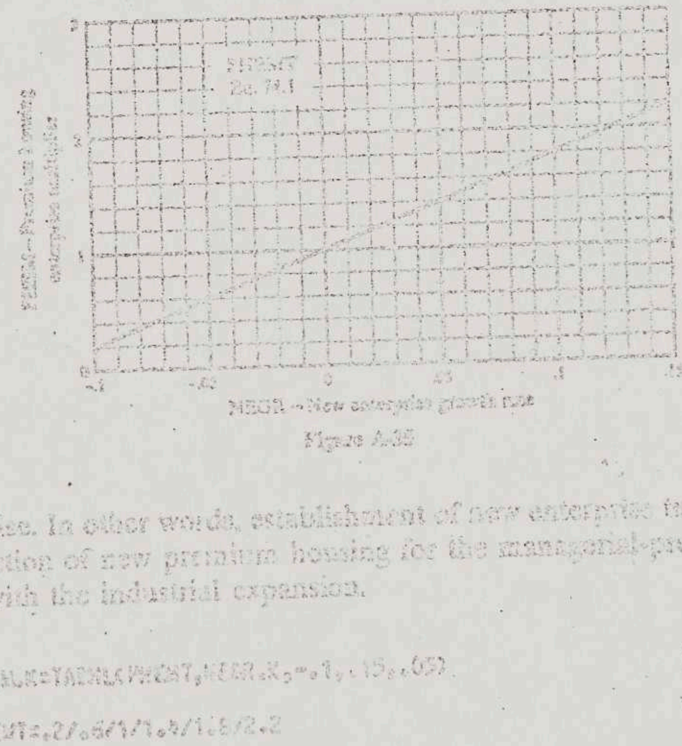


Figure A-35

new enterprise. In other words, establishment of new enterprise tends to encourage construction of new premium housing for the managerial-professional class associated with the industrial expansion.

```
PHEM.K=TABHL(PHEMT,NEGR.K,-.1,.15,.05)                74, A
PHEMT=.2/.6/1/1.4/1.8/2.2                             74.1, T
   PHEM  - PREMIUM-HOUSING ENTERPRISE MULTIPLIER
           (DIMENSIONLESS)
   PHEMT - PREMIUM-HOUSING-ENTERPRISE-MULTIPLIER TABLE
   NEGR  - NEW-ENTERPRISE GROWTH RATE (FRACTION/YEAR)
```

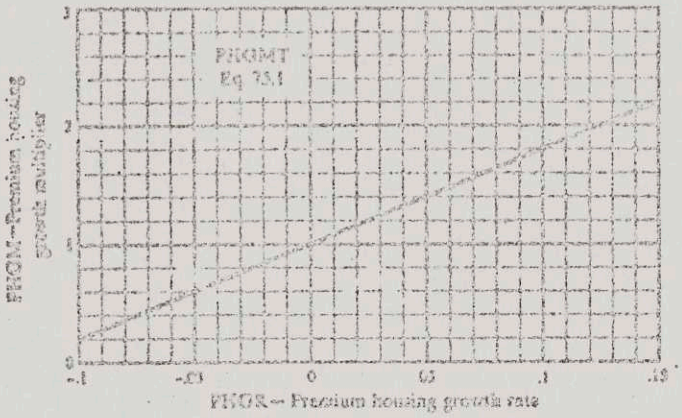


Figure A-36

Also, the momentum of recent construction in premium housing itself tends to carry forward and cause still more premium-housing construction. Equation 75 and Figure A-36 provide a link in what is essentially a positive-feedback loop from premium housing through growth rate and back into premium-housing construction.

```
PHGM.K=TABHL(PHGMT,PHGR.K,-.1,.15,.05)                    75,A
PHGMT=.2/.6/1/1.4/1.8/2.2                                 75.1,T

     PHGM  - PREMIUM-HOUSING-GROWTH MULTIPLIER
              (DIMENSIONLESS)
     PHGMT - PREMIUM-HOUSING-GROWTH-MULTIPLIER TABLE
     PHGR  - PREMIUM-HOUSING GROWTH RATE (FRACTION/YEAR)
```

Equation 76 computes the premium-housing growth rate used in Equation 75. It is generated by taking present premium housing, subtracting an earlier value of premium housing PHA, dividing this by the time delay PHAT to obtain the number of housing units constructed per year, and then dividing by premium housing to convert to a fractional growth rate. The formulation might also have been made by averaging PHC from Equation 64 and dividing by premium housing.

```
PHGR.K=(PH.K-PHA.K)/(PH.K*PHAT)                           76,A

     PHGR  - PREMIUM-HOUSING GROWTH RATE (FRACTION/YEAR)
     PH    - PREMIUM HOUSING (HOUSING UNITS)
     PHA   - PREMIUM-HOUSING AVERAGE (HOUSING UNITS)
     PHAT  - PREMIUM-HOUSING AVERAGING TIME (YEARS)
```

Equation 77 is a first-order exponential smoothing or averaging equation which generates the delayed version of premium housing needed in Equation 76. The initial value of PHA is computed so that it will generate an initial premium-housing growth rate of 3% per year.

```
PHA.K=PHA.J+(DT/PHAT)(PH.J-PHA.J)                         77,L

PHA=PH-(PHGRI)(PHAT)(PH)                                  77.1,N

PHAT=10                                                   77.2,C

PHGRI=.03                                                 77.3,C

     PHA   - PREMIUM-HOUSING AVERAGE (HOUSING UNITS)
     PHAT  - PREMIUM-HOUSING AVERAGING TIME (YEARS)
     PH    - PREMIUM HOUSING (HOUSING UNITS)
     PHGRI - PREMIUM-HOUSING GROWTH RATE INITIAL
               (FRACTION/YEAR)
```

The level Equation 78 accumulates the amount of premium housing by adding construction and subtracting obsolescence.

```
PH.K=PH.J+(DT)(PHC.JK-PHO.JK)                             78,L

PH=5000                                                   78.1,N

     PH    - PREMIUM HOUSING (HOUSING UNITS)
     PHC   - PREMIUM-HOUSING CONSTRUCTION (HOUSING
               UNITS/YEAR)
     PHO   - PREMIUM-HOUSING OBSOLESCENCE (HOUSING
               UNITS/YEAR)
```

Premium-housing obsolescence is defined in Equation 79 as having a normal value of 3% per year. This means that premium housing is taken to have the reciprocal of .03, or 33 years of normal active life in the premium category. But the multiplier PHOM can modify this average age depending on the demand for housing. In periods of high demand, housing will be maintained and will continue to be occupied by the managerial-professional group beyond its normal life. As the managerial group decreases relative to housing and housing becomes excessive, the housing drifts more rapidly into the worker-housing category.

```
PHO.KL=(PHON)(PH.K)(PHOM.K)                               79,R

PHON=.03                                                  79.1,C

     PHO   - PREMIUM-HOUSING OBSOLESCENCE (HOUSING
               UNITS/YEAR)
     PHON  - PREMIUM-HOUSING OBSOLESCENCE NORMAL
               (FRACTION/YEAR)
     PH    - PREMIUM HOUSING (HOUSING UNITS)
     PHOM  - PREMIUM-HOUSING-OBSOLESCENCE MULTIPLIER
               (DIMENSIONLESS)
```

The premium-housing-obsolescence multiplier in Equation 80 and Figure A-37 is derived from the premium-housing multiplier PHM. To the right, as the urgency of new premium-housing construction increases, the obsolescence rate declines and the average life of premium housing increases. At the extreme left the

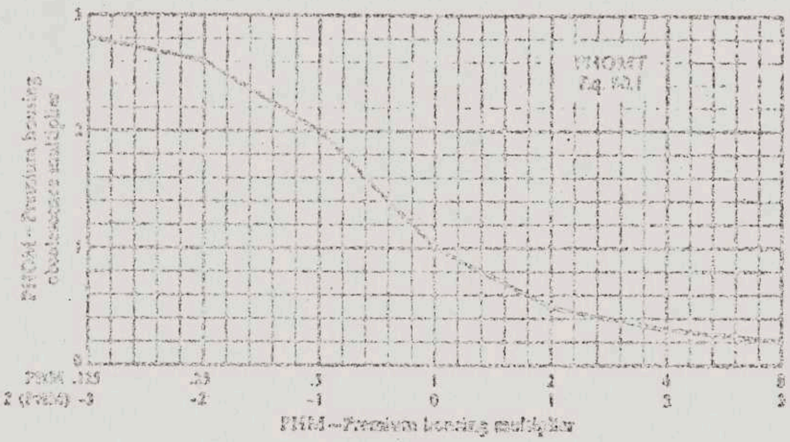


Figure A-37

obsolescence rate can climb to almost three times normal, indicating an average life of about ten years under some imaginary extreme circumstances where there is no managerial-professional population to occupy the dwellings.

```
PHOM.K=TABHL(PHOMT,1.44*LOGN(PHM.K),-3,3,1)          80,A
PHOMT=2.8/2.6/2/1/.5/.3/.2                            80.1,T

    PHOM   - PREMIUM-HOUSING-OBSOLESCENCE MULTIPLIER
               (DIMENSIONLESS)
    PHOMT  - PREMIUM-HOUSING-OBSOLESCENCE-MULTIPLIER
               TABLE
    PHM    - PREMIUM-HOUSING MULTIPLIER (DIMENSIONLESS)
```

A.5 Worker-Housing Sector

Construction of worker housing in Figure A-38 depends on a group of factors equivalent to those explained in relation to premium housing.

The level of worker housing is given by Equation 81, which accumulates housing becoming available from premium-housing obsolescence, worker housing being constructed, and outflow of worker housing through obsolescence.

```
WH.K=WH.J+(DT)(PHO.JK+WHC.JK-WHO.JK)                  81,L
WH=21000                                              81.1,N

    WH     - WORKER HOUSING (HOUSING UNITS)
    PHO    - PREMIUM-HOUSING OBSOLESCENCE (HOUSING
               UNITS/YEAR)
    WHC    - WORKER-HOUSING CONSTRUCTION (HOUSING UNITS/
               YEAR)
    WHO    - WORKER-HOUSING OBSOLESCENCE (HOUSING UNITS/
               YEAR)
```

GEOGRAPHY 3x6

PART II

MID-TERM EXAMINATION

1970-1971

You must answer questions number 1 & 2. A third question is to be answered from questions 3 to 6. Each question has the same weight. You may use an outline style to answer the questions. Diagrams, etc. may be used in developing your answers. You should not spend more than one hour to write the exam. This means you have 20 minutes per question. Illegible papers will not be marked. The exam is due at 10:00 a.m., 12/2/71.

1. Systems engineering and operations research are of theoretical interest because systems analysis is applicable to entities whose components are most heterogeneous - men, machines, buildings, monetary and other values, inflow of raw material, outflow of products and many other items. Support or refute this statement on the basis of the writings of Hall & Fagen, Boulding, Bertalanffy, and Hall.

2. Two social scientists argue about mathematics and models. One argues that if a theory cannot be expressed in sophisticated mathematics (such as a differential equation or a stochastic process with known solutions), then the theory is useless. The other objects. Join the argument.

3. Behavioral scientists can be divided into two groups: (1) those who aspire to the scientific status of physical scientists, and (2) those who are moved to "understand man". What are the positive and negative attributes of both groups? In what way are these attributes positive and negative?

4. How do Forrester's definitions of open and closed systems relate to the definitions of open and closed systems given in the general systems literature?

5. The following equation is an expression of the relationships involved in the attractiveness for migration for under-employeds, as proposed by Forrester. In this equation, the components of attractiveness are combined by multiplication rather than by addition. What are the implications of this?

   AMM.K = (UAMM.K)(UHM.K)(PEM.K)(UJM.K)(UHPM.K)(AMF) 3,A
   AMF = 1 3.1,C

   AMM - Attractiveness-for-migration multiplier (dimensionless)
   UAMM - Underemployed-arrivals-mobility multiplier (dimensionless)
   UHM - Underemployed/housing multiplier (dimensionless)
   PEM - Public-expenditure multiplier (dimensionless)
   UJM - Underemployed/job multiplier (dimensionless)
   UHPM - Underemployed-housing-program multiplier (dimensionless)
   AMF - Attractiveness-for-migration factor (dimensionless)

6. Goals and objectives are not contained anywhere within the systems method. What are the implications of this?

GEOGRAPHY 3x6

PART II

Exercise 3

1970-71

There are two alternatives for exercise 3. Do one or the other, not both. Each is to be a paper of not more than 10 pages in length (typed).

ALTERNATIVES

I. Do a critical evaluation of one theoretical work in human ecology.

II. Do an ecological analysis of one of three types of social systems:

1. Primitive group (anthropological studies such as Tepoztlan Village in Mexico).

2. An American Community: Canada or U.S.A. (classic community studies such as Plainville, U.S.A.).

3. An American Ethnic Group: Canada or U.S.A. (studies such as Ghetto).

SPECIFICS

I. For the critical evaluation of the theoretical work in human ecology the following items must be covered:

A. Frame of Reference (the foundation upon which hypotheses are stated or examined).

1. Assumptions: all statements about variables which are considered as untestable or not needing to be tested within the theory. These are statements considered as true themselves. (This may be implicit or explicit).

2. Domain: the specification of the variables which form the system of analysis. Thus, the domain of demography consists of the variables fertility, mortality, and migration. The domain consists of both independent and dependent variables.

.... cont'd.

3. Theoretical definitions: each concept within the domain has a theoretical definition which specifies the characteristics of the datum investigated. In effect, the theoretical definition delineates that portion or reality considered a recognizable entity (material or non-material). Thus, a theoretical definition of social status might be: a position in the prestige structure of society.

4. Operational definition: an operational definition states the procedure and evidence used as an indicator of the theoretical definition. Thus, the operational definition of social status might be: the number of years of formal education completed by an individual.

B. The Assertions (the link between variables)

1. Descriptive: all x's have characteristic Y, while all $\bar{x}$'s have Y. A descriptive assertion specifies an association between two variables. Thus: social class is related to mental illness.

2. Explanatory: x causes y. An explanatory assertion specifies causality.

C. Evidence (data which evaluate assertions or suggest assertions)

D. General Statements of Methodology (statements about how events should be studied)

E. A Systems Model, à la Forrester, summarizing A through c.

II. For the ecological analysis of a social system, the following items must be covered:

A. What are the conditions (physical and social) for the group's survival?

B. What is the environmental situation in which the group lives vis-à-vis the necessities for the group's survival?

C. What is the technology (that portion of the social system and culture elaborated to deal with the environment) and how adequate is it for meeting the survival prerequisite?

D. How does the technology affect the other aspects of the social system and vice versa?

E. How do technology, social structure, and population relate to each other?

F. A systems model, à la Forrester, summarizing A through E.

.... cont'd.

III. You are to select a reading outside of those assigned in Theodorson.

IV. The paper is to be not more than 10 type-written pages in length. You are to use standard footnote and bibliographic formats.

V. The paper is due at 9:00 a.m., 30 March, 1971.

JFB/rt
23/2/71

GEOGRAPHY 3x6

PART II

TAKE-HOME EXAMINATION

1970-71

D. L. Anderson
J. F. Betak

Answer only ONE question. You may use an outline style to answer the question. Diagrams, etc. may be used in developing your answer. You should not spend more than one hour to write this exam. No more than three (3) pages are to be used in answering your question. Write on one side only of each sheet. Illegible papers will not be marked. The exam is due by 4:00 p.m., 8/4/71.

1. There are two approaches or uses of factor analysis: (1) Q-factor analysis, and (2) R-factor analysis. According to Rummel:

> Factor analysis applied to discern patterns of profile similarity of individuals, groups, nations, or areal units such as census tracts is called Q-factor analysis. Factor analysis applied to delineate patterns of variation in characteristics is called R-factor analysis.*

   Factorial ecology studies, such as Murdie's, are R-factor analyses. Discuss the meaning, advantages, and disadvantages of the application of a Q-factor analysis to the types of data commonly used in factorial ecology studies.

2. Discuss the relationships between Murdie's approach to urban ecology and the principles of systems discussed by Forrester.

3. Discuss some of the relationships between Buckley's "Society as a Complex Adaptive System", the sociocultural approach discussed in Theodorson, and, Forrester's principles of systems.

---

*A paraphrase of Rummel, pp. 445-446.

/rt