REPORT NO. DOT-TSC-OST-76-12.II

SYSTEMS MODELS FOR TRANSPORTATION PROBLEMS
Volume II: An Introduction to Urban Center Modeling

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MARCH 1976

FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
TRANSPORTATION SYSTEMS CENTER
Office of Systems Research and Analysis
Cambridge MA 02142

Technical Report Documentation Page

1. Report No. DOT-TSC-OST-76-12.II	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle SYSTEMS MODELS FOR TRANSPORTATION PROBLEMS Volume II: An Introduction to Urban Center Modeling		5. Report Date March 1976
		6. Performing Organization Code
7. Author(s) A.S. Iberall and S.Z. Cardon		8. Performing Organization Report No. DOT-TSC-OST-76-12.II
9. Performing Organization Name and Address General Technical Services, Inc. 8794 West Chester Pike Upper Darby PA 19082		10. Work Unit No. (TRAIS) OS543/R6503
		11. Contract or Grant No. DOT-TSC-946
12. Sponsoring Agency Name and Address U.S. Department of Transportation Transportation Systems Center Office of Systems Research and Analysis Cambridge MA 02142		13. Type of Report and Period Covered Final Report March - July 1975
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Our thermodynamic theory considers the problem of attempting to formalize in a modeling sense what might be done in an urban economy, wherein transportation planning and other institutionalized requirements of the domain are also to be satisfied, and to build technical notions toward a model that lead towards experimental testing within the real system and by means of the model. To that end we have developed some primitives for an urban system information flow policy model based on a Ziebolz two time scale controller. Policy is open to the existing ideology of the society.

This is Volume II of four volumes.

Volume I, 84 pp.
Volume III, 90 pp.
Volume IV, 132 pp.

17. Key Words Regulation and Control, Modeling, Compartment Analysis, Systems, Systems Science, Systems Models, Social Dynamics, Thermodynamics, Urban Dynamics, Transportation Modeling, Statistical Mechanics, Transportation Systems	18. Distribution Statement DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 46	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Preface

In a first report, a thermodynamic foundation was provided for dealing with complex social systems. Following the suggested leads of our project officer, we now turn toward regulation and control modelling for urban centers. In this report, the basis for a control scheme is offered.

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1. Transition - Two Problems to be Tackled

Having made two self-initiated presentations to TSC-Cambridge personnel, we now would like to approach two specific directions that they suggested we turn our attention to.

1. Attempt to formalize in a modelling sense what might be done in an urban economy, wherein transportation planning and other institutionalized requirements of the domain are to also be satisfied. Try to build toward a model that leads toward experimental testing within the real system and by means of the model.

2. With regard to the possibility of 3 generation forecasts in macro planning, what has to be done in a modelling sense that has strategic significance and that can lead to empirical research?

We will now address ourselves first to the first issue, but in our approach we will try to outline a general strategy for operation of complex systems.

2. Urban Economy Modelling

In general, we know what it takes to run (and build) a thermodynamic engine. Arrange transformation cycles wherein an energy source is periodically tapped; arrange to do this by satisfying momentum constraints; arrange flux paths so that materials sources are tapped and a materials balance achieved. In one sense this formal prescription is empty, but because of a unique process that is characteristic of thermodynamics, not mechanics, the interacting chain comes off. As a result of natural processes, the order of energy can be transformed. Thus chemical energy or thermal energy or nuclear binding energy, etc. can be converted into mechanical energy, but with some degradation of the order of energy into a lower form of heat. This is obviously well known in the scientific and engineering world.

But it is not only men who can arrange such cycles. Nature has been doing this for eons. It is also an interesting extension of 'natural' insensate systems that sentient living systems do it. For them to do it, they must satisfy an additional thermodynamic constraint. Since their ensemble members die (namely the engine processes can only come off for limited times - the lifetime), they must conserve population number by passing on a highly error free replication code from generation to generation. The 'life' of the species thus far far exceeds the 'life' of the individual ensemble member (e.g., 10^8 years as compared say to 10^1-10^2 years).

Now we are up to social ensembles percipitated into the form of urban settlements. Clearly what was involved in every engine system we have thus far named or implied at lower organizational levels (nucleus, atom, cell, organism, human) was a coupling from empowering momentum (or motional) cycles and the escapement (some would use the notion of feedback; we deplore the notion and simply point to a circular coupling between the source-sink and the system) which should be best regarded as a 'catalytic' step, a flow of catalyzing information.[1]

Clearly 10,000 years of urban settlements have operated with communications links among themselves and with their environment. One presumes that deus ex machina,artisans, cognitors all furnished memory (expressed as experience and wisdom) to guide and remain parts of the catalytic steps of the flow of information. We are increasingly certain of the character of the communicational linkages from the urban explosion of Summerian city-state of 6000 - 6500 years ago. One must also presume that by 5500 years ago, the need for a more formal modelling of memory was required and thus record keeping and writing were invented.[2] But we may even go one step farther and point out that formal model codification begins to be found with great clarity about 4000 years ago - interestingly enough beginning with urban codes.

Now the point of these remarks is that we have been running cities for that entire period of time and it is only recently - when they have become fantastic centers of industrial - agricultural activity - that they have begun to appear unmanageable.[3] Those of us from the automatic process control field can begin to tell you what the problem is. We have seen it in many systems.

If you begin to have too many linkages with hysteresis losses, if you are trying to force too great a throughput, if you have inadequate potentials and storage capacitance, if the resistance paths become too choked, stresses are too high and localized, if the noise level is too high, if too great a speed of response is required, the systems show deteriorated performance. This is no analogue. This is a simple statement of engineering analysis and maintenance experience.

Our political system has begun to become geared to a what-you-want-to-hear operation.[4] It is a danger that Aristotle described a long time ago,

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[1]We will define 'information', even though we recognize that it is transmitted by energy packets, albeit small, as those input energy packets that can transform the state of a system. We require that a catalyst be an agent of change which doesn't itself transform in form.

[2]Again we remind the reader that Marshak has already indicated that the competence for record keeping may very well be traced now perhaps to 20,000 years ago. Thus we are not romantically anthropomorphizing. Man's potential symbolizing, abstracting competence has always existed with man.

[3]For those who might want to glimpse the fantastic complexity of a city when they were still manageable they can do well to read Mayhew's London Labour and the London Poor. While only fragmentary and presented poetically, one might compare that picture with the Nat'l. Geog. Society's Everyday Life in Ancient Times.

[4]As a single indication of the current economic malaise and the possible 'bread and circuses' background of those economic difficulties as it involves cities, one might just glance at the New York City financial picture given in the New York Times, Sec. E, p.6, March 30, 1975. Referring to the city's financial crisis "Like the one-hoss shay, it's all falling apart at one time". From whence come the problems? "The bankers blame the city's much-publicized budget problems and its enormous appetite for borrowing, particularly in the past six years when it refused to balance its budget by imposing higher taxes or cutting services." The articles go on to point out that about 25% of the short-term tax exempt paper in circulation in the U.S.A. comes just from New York City.

so we are not inventing the notion for the day. Those little resonant-reinforcing loops, which the selection process for governing elites brings into being, represent lossy time delays, imperfect transmitters. We also have the news media, other resonant reinforcing loops that put up a great noise of high color. All of this prevents an on-time flow of information. It is only in crisis that large gobs of missing information come out, and even at that with extremely high color.

We have absolutely no desire to establish an elite, patrician, Fascist, Communist state system. We are perfectly willing to try to survive in our (should we say primitive post-Neolithic?) rough, frontier, open, over enthusiastic, mixing pot, plebian kind of system. But fellers - girls be reasonable (if you can). Some price must be paid. Some order - of information - must be preserved.

The operational memory (of urban centers) is simply not large enough or long enough to do. As former large city boys, we grow up in an era where a Mayor Hylan, a Jimmie Walker could be tolerated, a La Guardia could actually still do lots of significant reform, but by the time of a Lindsay the city structure was no longer manageable. Oh yes, many cities, not having reached New York's crisis state because of size or other conditions, haven't yet fully gotten there. Just like there are still many countries who don't believe the U.S.A.'s experience with cars and roads. But on the other hand many cities already share the New York City crisis state and know it. And with the greatest respect to the honest hard working mayors and city managers and political scientists writing on urban management, who try their darndest to do their job by a purely political memory, it simply is not enough. That memory is faulty. Its mistakes are quickly buried. Its lessons are not drawn, etc.

So - the standard engineering answer since the 50's has become - bring in a computer. Schedule the networks. But this is one additional fight we have been engaged in since the 40's. You cannot represent a system by the engineer's equivalent network. You need a more significant strategy. And that strategy, we have finally decided, had to be in accord with thermodynamic modelling. That construct was the only one compatable with a dynamic isomorphic description of an autonomous engine system.[1]

Now obviously we are not against network representations and computers, whether digital or analogue, special purpose or general. Our problem is the isomorphic description of complex systems, and only then how to use modelling tools.

So, as a substitute for a hard controlled dictatorial system, we have sought a model for a looser coupled regulator-controller system which perhaps has some viability. It has been tested in engineering applications and we have proposed it as a most meaningful approach toward artificial intelligence systems. The basic scheme is what is known as the Ziebolz two time scale controller.[2]

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[1] A system could be run by a deus ex machina from outside who possessed sufficient resources. Then any fantasy chain could be supported.

[2] See Kelley, Manual and Automatic Control, Wiley, 1968; and A. Iberall, S. Cardon, "Autonomous Systems to Perform Simple Military Tasks", Parts I, II, March, Sept. 1974, reports to MERDC, Fort Belvoir, U.S.Army.

Basically what we are asking for is that real high speed models of systems should be built by analogue (e.g., network or computer programs) which (a) are as isomorphic as we know how to make a real system; (b) which receive input sample data from the real system in real time; (c) which compute out the future predictivity in high speed model time; (d) which intermittently propose outputs to controllers (let us call this policy) which change their settings on regulators and controllers in the real system; (e) which indicate the errors in policy in long real time; (f) which has a corrective cognitive command-control system which 'historically' modifies the high speed analogue model so as to reduce policy errors first by parametric optimization and then by discrete quantum jumps and keeps the changing history of those modifications and the resulting error performance.

In this system, the character of its political system is represented by the policy strategy.

1. If there is no policy strategy, this is ordinary 'open loop' operation of living-social systems (Present systems respond to noise, attempting to filter signal out of the noise by 'intuitions'.)

2. If there is a 'free', sensible, moral, rational, cooperative follower action, this is a democratic system.

3. If instead there is a 'free', sensible, moral, rational, uncooperative (every man for himself) follower action, this is an anarchic system.

4. If there is a coercive connection to follower actions, this is a dictatorial system.

5. If there is an automatic routine follower action, this is a mechanical system.

The point is that the scheme can be run mindless, with the very loosest and tenuous connection (as it really does now), or it can become a basis for a rational flow of information which elites (democratic or autocratic or dictatorial) will perceive as the basis for regulation. Perhaps it can work democratically. Perhaps it will reveal that we are anarchic.

In offering this scheme, which is not idealistic, we suggest that it only deals with command-control circular leader-follower coupling to an existing system which is perhaps viable or perhaps becoming moribund. It is an evolutionary step in the search for intelligence, now social intelligence.

If any will follow carefully our proposed thermodynamic - statistical mechanical construct, one would realize it is based on active atomisms that undergo mean free path - relaxation time excursions. We do not wish to discuss command-control 'information' processing in nuclear and atomic moieties. But in our prior bacterial example, we already brought out the most primitive example of a 'central nervous system', a 'brain', a command-control system. Intermittently coupled back and forth to its environment, the bacterium swims a longer mean free path in a favorable environment and a shorter mean free path in an unfavorable environment. That time processing, building up from there to the cerebellum of the human, illustrates the strategy. It is an anisotropic diffusion, an isotropic random walk with an engine bias.

That same circular coupling has finally occurred in our system's dialogues with our biological colleagues. The complex biological system is a circular system in which the brain runs the muscles. Add the triad of a stomach and you have it. The brain executes the muscle actions. The muscles talk back to the brain and tell it what it must do next. An anerobic-aerobic oxidative complex runs in parallel and supportively maintains the process dual.

Now, we are proposing that a circular command-control system must be writ down. The management of the society ensemble has gotten to be too complicated to do otherwise.

We haven't asked that the system must be changed. We believe we know (as our 70 year forecast suggests) what has to be done for the system to continue to run. But suppose the system doesn't move that way? We would be wrong. But the control system we proposed would still be operative.

It is only perhaps when we know or have demonstrated that we have a working control system in the sense outlined, and have some confidence that its future predictions are in fact close and that the policy closures do in fact show the corrective action, that we can then ask the what-if questions that would represent either long range prediction or modification. Thus perhaps this present step of evolutionary ideas is quite necessary.

So with this very general prologue, we can go on to a specification of the urban system information flow policy model. The required tightness of control of a command loop has come about because the notion of value-in-trade is in the mind. It is an idealistic notion, and it has become necessary that as a thermodynamic variable it have as hard an internal view as it does an external view. In anthropological terms, to reduce noise the emics and etics have to be drawn together.

Note that the model system proposed is complex. It is hierarchical. Thus it cannot be prescribed by a single logic, a single algorithm. It is a step toward 'intelligence', of augmented human intelligence, acting as social intelligence. It is not a denial of any social, economic, or political system. Thus before proceeding to discussing the model system as a system, it may be useful to discuss some potential alternate notions of social systems' constructs.

3. An Examination of Some Alternate Kinds of Modelling

If, as we have discribed, history only begins to be a deterministic game at perhaps the fluctuational scale of three generations (70 years);[1] and we are interested in finding out what science may have to say at a shorter time (i.e., at the time at which the individual's 'mind making' scale is involved). Is there any possible content?

[1] See for example, A. Iberall, "On the Thermodynamics of History", Gen. Systems, 19, 201, 1974.

1. Note that the process cannot be at near equilibrium. The individual atomisms - humans - are each in process of learning. Over that time scale of 1 generation (20-25 years), they have no full experience of what to expect.

2. Does physics have <u>any</u> capability for dealing with such processes? Yes. The segment of applicable science is known as kinetics. It is <u>not</u> the physics of an isolated event. It is the individual isolatable aperiodic fluctuation of an ensemble of fluctuations which, in the end, resemble each other.

3. We know that each youth 'discovers sex', a metaphor which means that individuals discover the various phases of life. They are not that far removed from Shakespeare's description[1]. All perceptions are not the same, but clearly there are only a limited number compatible with the human condition.

4. The important thing to note, that just as the human has not 'made up its mind' in a generation fluctuation, neither has an atom. Atoms do not have 'minds', but they have an 'awareness' of their surrounding fields. This is not an anthropomorphization, but the process in reverse. Humans do not really do different from physical force systems. They sense, internally transduce and motor act in fluctuating, whirling modes.

The essence of the matter in descriptive terms, is the issue of equipartitioning of energy. After a number of kinetic fluctuations either energetic particle - atom or human - is 'aware' of its surround and has equipartitioned its energy with all of its neighbors. No man or woman walks mile high or forever. The bounds are severe on each species' behavior, largely because it is highly coded by its internal structures.

5. Kinetics operates by assigning a reasonable model to the atomism. It does not look to make an exact picture of each individual. That would be the physics of completely isolated particles. Instead, it smears over many details to present a significantly arranged character for the individual. The important goal that kinetics strives for is first to be able to roughly identify the individual and second to guarantee that the summation of descriptive states of the individual properly approach the limit of processes required for the ensemble. In the main, the Einstein derivation of the law of diffusion stands as a brilliant prototype for the process (e.g., simplistically examined in the Langevin derivation of the Stokes-Einstein law of diffusion).

6. Having the benefit of Einstein's marvellous path, the problem we face is how to bring the process description to the social ensemble.[2]

The important point we want to make, which we have begun to cast within our Ziebolz modelling, is that if the individual atomism is not fully equi-

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[1] Eric Erikson has a more sophisticated individual and social psychiatrist's view of such phases.

[2] A large amount of network analysis, as practised by electrical engineers and as they have later attempted to offer it as a methodology for all systems, is based on Nyquist's application of Einstein's theory of Brownian motion to electrical networks.

partitioned in one fluctuation, we have to replace that determinism by some indeterministic theme. And it is that indeterministic theme that we call 'policy'. In the end (3 generations), one approaches similar end points, so that determinism emerges.

7. What would the content of a one generation kinetic model look like? We have recently (AAAS, February 1975) clarified three methodologies useful for thermodynamic modelling.

(a) 'Back of the envelop' network modelling. If it suits the modeller to hold a temporary fix, to guide his 'policy' outlook, he can use kinetics to guide his perceptions. This is useful, if he doesn't take it as an absolute guide, but in some important ways a 'caricature' of the system.

(b) Topological - morphological modelling. Given an existing network field, the problem is to fit a full thermodynamic construct to that given geometry and topology and derive its characteristics. Generally this is achieved as a boundary value problem, or - by doing simpler geometric boundary value problems - idealized boundary value problems furnish engineering 'one dimensional solutions' that can be used to piece out or approximate a more complex field.

(c) Modelling for evolutionary fields. This is a more complex application of thermodynamics. This subject is in its infancy. As we have described in a recent publication[1], the subject is a diffusive process. 'Chance', the same process involved in Einstein's theory of Brownian movement, namely a band of underlying atomistic fluctuations - commonly of a thermalized nature - create a band level of noisy fluctuations. The 'necessity' [2] of the existing milieu, precipitates new functional forms that fit the excitation energy and the internal structure of the exposed system.

But it is not one solitary unique path that emerges. Essentially all paths compatible with the energies available become filled. That is deterministic. How long it takes to fill all the paths depends on the time scales. Thus in three generations, you do not see the emanative genetic changes. That process scale looks more deterministic. At a very much longer time scale, the evolutionary process may be found.

So our problem now is with some inkling of the third process, some notion of the second process time scale, to approach the first time scale.

8. For this, we are willing to characterize a network model. Imagine as lumped modes in the network all of those unit forms that a thermodynamic formulation requires and which can be characterized by state vectors. The degree of aggregation is to be guided by a physical notion. A group can be aggregated spatially if its dimensions are appreciably less than a wave length. The problem is to define wave propagation and periodicity. It can be aggregated temporarily if its interacting time scale is rapid compared to a w-ve

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[1] A. Iberall, "The Thermodynamics of History", Gen. Syst. 19, 201, 1975.

[2] We are using the language of J. Monod, Chance and Necessity, Knopf, 1971, as the very apt metaphor.

period and the diffusional time is not too fast as compared to a wave period.

That very definition indicates that there are many possible time scales for network descriptions. This is well known in electrical engineering, where equivalent networks are often cast for systems to resemble their high, intermediate, or low frequency characteristics.

But if the 'back of the envelop' model is to be isomorphic and sharply guided scientifically for the system, it is necessary that it be the low frequency description that fares into the near thermodynamic equilibrium description, namely 1 generation.

For national moieties, one senses a large degree of quantization at the national level. In important ways, that entity tends to be a wave length size, except in times of extreme crisis.

Comparably one can say that a nation changes its face three times a century. So again we find we should be able to aggregate within the nation and within the generation.

The social system operates over seven levels as we have used the concept in Toward a General Science of Viable Systems. Namely we are concerned with science and engineering management at the following atomistic and continuum levels.

	Level	Science aspects	Engineering aspects
A_7	Ecology	The science by which all interacting living and nonliving species on earth conduct and maintain their formal existence	Farming, fishing, animal husbandry, applied meteorology, applied hydrology (e.g., flood control and irrigation), mining, social governance
C_6	Canvas of civilization	Social science of interacting national moieties	International relations
A_5	National moiety	Social science of making, maintaining and governing a large spatial scale national organization	
C_4	Social canvas	Social science of the structural and functional binding of people into operating societies and cultures	
A_3	Material structures - buildings, machines, individual groups	Chemistry and physics of making and maintaining structures - support structures, machines, vehicles, weapons. Also the sociophysics of living groups including human	

	Level	Science aspects	Engineering aspects
C_2	Molecular materials - inorganic, organic materials in bulk form	Chemistry and physics of transforming molecular entities into a form useful for structures.	
A_1	Molecular moieties - geophysical, geo-chemical, biophys-ical, biochemical	Chemistry and physics of abstraction, isolation, combination, character-ization.	

The network description must take cognizance of all seven levels. It need not model them. Thus the lowest level is aggregated. There are atomistic people and engineers, and companies who deal with the problem of obtaining and transforming molecules (literally) and transforming them into bulk materials. These are primary materials producers. But the point is they furnish a list of necessary molecular species that a society must maintain, or the materials which can be interchanged.

Similarly there are secondary materials suppliers who deal with the problem of providing such materials in usable form to make structures.

The easiest way that these materials have been aggregated, at least in economics, has been by input-output tables (i.e., modern forms of economic tables).[1] Our only objection is that better forms of such aggregation have to be arrived at by engineers and scientists guiding economists, because, as the future will show, a considerable greater flexibility of interchangeability will be needed.

Thus in the main a network description begins at the level of aggregated material structures. But this also includes the aggregated human groups, and animal and plant husbandry groupings needed to run the social structure. Thus the aggregation is a matrix of atomistic material structures (e.g., steel making plants, or plumbers, or wheat farms).

But these atomistic structures are caught up in thermodynamic chains. Thus the variables that characterize their state vectors undergo changes in time. As a result of all of their changes, at this atomistic level, a near thermodynamic equilibrium is achieved within the social canvas. While this would appear to be the 3 generation scale, it is in fact the field that the newly arriving fluctuating atomism must face.

The social canvas, broken up into national moieties and organized into a larger canvas of civilization, has in fact been cast in its existing form over a prior period of the order of 25 generations. We are not interested, for the one generation network model, in the dynamics of 25 generations. But we must know - as we each do learn - the past dynamic history that cast the existing form of the cultural milieu. We are immersed as a matter of

[1] See for example W. Leontiev, Input-Output Economics, Oxford, 1966.

fact in a slowly relaxing grainy liquid-plastic mixing pot.[1]

Thus that process has faced us at the one generation time scale not only with the atomistic material structures we have suggested in our matrix, but also with institutional forms and characteristic modes of operation of these material structures and institutional forms.

The first aspect of the network model that must ring true is its equilibrium aspect, that which defines the basic distribution function. Namely there is a cost accounting balance among essential thermodynamic variables (conservations of the essential mass species, the conservation of population, the conservation of energetics, the conservations of basic action modalities, the conservation of value-in-trade) by which the operational state of the matrix is defined.

But by the very nature of the fact that these are dynamic state variables, they possess an additional freedom, which doubles the degrees-of-freedom. They each possess a rate of change which can be independently specified. In physics, it turns out that instead of the velocity of the state vector, the mass weighted velocity referred to as the momentum becomes a canonical variable. The specific issue of the weighting will not concern us at the moment. Hence the time rate of change, whatever may be the most appropriate weighting, will be referred to. Thus state and rate are independent specifications. And in a similar fashion both state and rate must be subject to near equilibrium aspects.

At this point, except perhaps for the broadening that some economists are beginning to suspect,[2] there is no science except an equilibrium concept which economists view basically as tautologies.

It is not that economists deny dynamic action at the level of the lower scale of atomisms. Humans are recognized as energy exchanging entities that are busy doing a variety of things. But at the level at which societal decisions are made, economists aggregate all these processes into the equivalent of some principle like "Economic man acts to maximize his utility." Economic man is an otherwise defined physiological-psychological atomistic creature who is busily engaged in life tasks. Societal economics then emerges from a

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[1]We would ask all who might wonder about the existing state of national planning within the international milieu to read G. Kennan, American Diplomacy 1900-1950, Mentor, N.Y., 1952, for an extensive discussion of the strategist intellectuals; for our reactions, see A. Iberall, S. Cardon, "Application of Systems Science to Man Systems", report to U.S. Army Res. Inst., Arlington, Va., Dec. 1973, pp. 137-148.

[2]As we heard L. Klein of the Wharton School declare at the Inaugural Convention of the Eastern Economics Association on the future of their modelling, in addition to the balance of three accounts - the input-output table, the flow of funds account, and the national income accounts - he considers that the future of economic modelling will have to consider the kinds of factors that engineers like Forrester (and now Mesovaric) have proposed in limits to growth.

single optimization principle that, in various balances, describes the equilibrium state of his economic decision making. Combining this with the primacy of the economic thread of historical materialism, one is left with little other basis for a science for historical change in society.

Without dwelling too much on the issue, this is much of the current impulse in the social sciences[1], except for the impact of the new breed of control engineer into this field. So now we would like to proceed further to our network characterization.

9. Before reaching it, we would like to dismiss four other proposals which deal with the kind of data that we have thus far characterized.

(a) No science - the past is prologue.

The first method of dealing with the data set we imagine, is simply to extrapolate the existing state into the future. The past is prologue. Thus given the state vectors and the rate of change of the state vectors, we obtain linear 'trends'. The notion behind it is the sound mathematical notion of continuous functions. At any point on a curve, its future is related for some small time only to its existing magnitude and rate of change. In its most sophisticated form, the near equilibrium status is caught up by linear programming constraints.

But with no perjorative intent, we characterize the basic notion as non-science. It has no notion of natural law within it, except possibly to state that nature acts with continuity.

(b) Philosophic argument - ethics.

Since philosophy deals with theories of knowledge, and in fact theories about knowledge in a primitive way, namely philosophy furnishes a start of science before science takes over, philosophy has always been the starting point for discussion of societal system's processes.[2] But in particular, philosophy has always intruded ethics, a discussion of the 'oughts' of society, rather than confining itself to the 'is' of society, a narrower scientific question.

A detailed examination of this question would take us very far afield. Suffice it to simply allude to one reference at hand to characterize the philosophic outlook. There is a recent review by P. Singer "The Right to Be Rich or Poor", of a book by R. Nozick, Anarchy, State and Utopia, Basic Books, in the N.Y. Review of Books, 22, 19, March 6, 1975. The book is described as a major event in contemporary political philosophy. The reviewer also

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[1] See for example Leontiev's remarks on the state of economic theory in a review of Heilbroner's, Beyond Socialism and Capitalism, in N.Y. Review of Books, July 20, 1972.

[2] There is no a priori reason that science could not have remained a subdiscipline of philosophy. But after Bacon and Descartes, a different spirit of inquiry began to distinguish philosopher and scientist, just as later another spirit distinguished scientist and engineer. Thus the fields parted historically.

points out that while the argument is rigorous and needle-sharp in its analyses, there is no chance of President Ford reasoning his way through the book as a guide to his policies. The book could only raise the level of philosophic discussion rather than affect practical politics is the reviewer's comment.

But, most simply put, moral 'force' does not run the dynamics of societies.

(c) Operations research, the theory of games.

In a sense, the most sophisticated 'non-scientific' approach to the future outcome of the state of a system is to regard the future state of the system as being decided by two or more intelligent players - dei ex machina - that are engaged in game play. Moves into the future are made by making use of the knowledge of all previous plays and attempting to operate with a strategy which optimizes some function for one's side as compared to one's opponent's side.[1] It was designed to deal with systems that didn't seem to have a definable scientific 'causal' connection and where somehow one's actions seemed capable of effecting change, e.g., could be gamed for different alternatives where one was free to change the state.

Obviously the method is basically mathematically and not scientific, except for the assumption that natural events are regular, and that an individual (person, group, nation) was capable of independent motor activity.[2]

(d) Dialectic materialism

Since dialectic materialism really represents the most significant philosophic challenge to 'idealistic' physical thought - it in fact having the status of state religions in two of the three world superpowers, it really is worthy of the most serious consideration. We will base our discussion on the use of a single reference (besides our own):

G. Wetter "Dialectic Materialism",Praeger, N.Y., 1963 The book is broadly encompassing enough to carry the full weight of the argument.

We shall attempt to show that dialectic materialism is a scholastic prescientific metaphysics that cannot carry the weight of science, although in a philosophic sense will always permit its believers to enter into the discussion of every new field to which men may want to apply reasoning preparatory to developing its science.

As prologue, we offer the last section of our book, A. Iberall, Toward a General Science of Viable Systems, McGraw-Hill, 1972; R. McKeon (ed.), The Basic Works of Aristotle, Random House, 1966, and an article in review,

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[1] Our previous reference to the strategist intellectuals is quite appropriate.

[2] But beyond strategist intellectuals, say from Machiavelli on, a much more fundamental 'psychological' theme is struck by Ralph Siu in an as yet unpublished document, The Craft of Power.

A. Iberall, "On Fashion in Science". In Chapter 23, we laid down 13 principles that we believed made up the foundation for a usable metaphysics for modern post-Baconian science. We do not believe it is absolutely unique - other statements would likely be equivalent or would do equivalently. But we do not believe that these statements are so remarkably different from what one might draw from Aristotle's writing on metaphysics.

Our 13 principles deal with:

(1) The parsimony of assumption
(2) The assumption of reality
(3) The assumption of existence
(4) The assumption of identifiability
(5) The assumption of mass-space-time
(6) The assumption of uniqueness of perceptions
(7) The assumption of connection
(8) The assumption of self-actuation
(9) The assumption of causality
(10) The assumption of attribute
(11) The assumption of continuity in space-time
(12) The assumption of continuity beyond us
(13) The assumption of an operational test of reality.

One or two of these, e.g., the last one (The Bridgman test), perhaps represents what additionally we have learned in two millenia past Aristotle about a working metaphysics.

To these we now wish to add two more. They strike us as being basically metaphysical. These are:

(14) The assumption of order. We will take David Bohm's statement as being most representative of its spirit. There is a vast totality of topological orders in the mind. (And, further, the notion of order is more fundamental than other notions.)

(15) The assumption of force. We take Newton's statement. Force is that which changes the state of motion of a system. (Newton's Fourth Definition, first having defined mass,momentum, and inertia.)

We believe it fundamental to move the last concept over to metaphysics. It seems to us, in a modern scientific sense, to be the last metaphysical notion before science begins. One reads Aristotle's physics for his threads. Three keynotes stand out therein:

"Nature has been defined as a 'principle of motion and change', and it is the subject of our inquiry."

"The science of nature is concerned with spatial magnitudes and motion and time."

"Everything that is in motion must be moved by something"

Whatever Aristotle says about physics, and it obviously falls short of the physics that was opened by Newton, nevertheless deals with attributes of matter and motion. Thus, tidily, in a modern context, if we move both the concept and definition of force over its metaphysics, science then must begin with the identification of forces and their effects on the state of 'motion'.

The pre-Newtonian scholastic arguments all tended to be long arguments on the metaphysical character of motion and change.

With this introduction we can turn toward dialectic materialism. Webber opens the chapter on The Materialist Dialectic (d.m.) with the following:

"...we have been engaged in examining the dialectical materialist conception of matter. ...it has appeared that dialectic materialism considers matter to be essentially mobile. Motion represents an essential attribute of matter, the term 'motion' being understood in its widest sense as change of any kind whatever."

Clearly this lies within the construct that Aristotle has offered as a science. Further, d.m. is "opposed to the vulgar materialistic and mechanistic point of view in its insistance that the cause of motion in matter gives rise to qualitative changes therein."

But also clearly, d.m. does not get beyond this characterization. For example, Webber asks "Where, then, are we to discern the essence of the materialistic dialectic?...The views of Soviet philosophy...governed by Engel's mode of treatment, which summed up the essence of the materialistic dialectic in three basic laws: The law of the transformation of quantity into quality and vice versa; the law of the mutual interpenetration of opposites; and the law of the negation of the negation." This has not proceeded in any significant way to define force and the effect of force, it returns back to scholastic metaphysical discussion.

As one turns the pages, in detail, from the point on, one clearly sees a continued avoidance to deal with vulgar mechanistic force, and instead to argue in metaphysical detail. To illustrate:

"...this first law...is held to account for the origin of motion in thing and in the world at large" (p. 311)

"...'dialectic' has no very precise connotation in Soviet usage. ... in keeping with the account of the concept...which is broad in the extreme, including as it does 'the general laws of motion and development of Nature, human society and thought' . Hence...'dialectic' often has precisely the same meaning as the concept of a 'dynamic' or even a 'historical' approach to reality, in contrast to a static view thereof, which is designated as 'metaphysical' in character. 'Metaphysics'...becomes a collective term for all systems opposed to dialectical materialism...". (p. 310).

So finally, as one gets to the very learned psychology discussions of Soviet physics, biology, chemistry, genetics, anthropology, etc. in Webber,[1]

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[1] It is learned. One gets the impression that the author is a very highly competent philosopher of science. By no means is the book restricted to social or political science. It covers science and also the history of Marxian and Russian thought very well. Sharper critiques have to be made by experts.

by that point a conclusion seems inevitable. The very fact that d.m. is not a science but a metaphysical extension, is born out in how each new subject becomes treated in the USSR. There is an extensive 'political', basically metaphysical debate on whether observations or theory on some observations seems in accord with d.m. Not once is the matter settled on the basis of proximal cause - change in motion and the identification of forces that change the state of motion. It is always a subject for debate. This is not to imply that there are no Russian scientists, or no great Russian physicists. It is just that - regardless of the advances in understanding - the metaphysical selection process has to be gone through.

As telling in this regard, is the very detailed d.m. arguments offered by Lenin and Stalin on scientific matters. Like all other human arts, we all learn how much effort has to be spent in learning our intellectual trades - making of shoes, building of automobiles, designing of space suits, running of societies, production of motion. It is very rare (example, one president in Israel) that any political leader has spent the time to master the paths of hard science. Lenin and Stalin have never indicated their apprenticeships. So the only inference we can draw is that they use the tool - of d.m. - in a metaphysical, or at most, a layman's sense.

It is the composite, of persons of all walks and ilks, using this philosophic tool of d.m. at all sorts of levels of sophistication that leaves the basic conviction of a pre-Baconian scholasticism.

How is one to characterize d.m.? Instead of the Greek notion of a perfect geometric motion by circles and spheres, one senses the turmoil of a wave motion - back and forth - constantly transferring the fields within which they ebb and flow. As a metaphor, in metaphysical terms, for cosmology, for particle production, for river systems, for weather systems, for rises and falls in social affairs, it may be descriptive, but it doesn't get at the work of developing the economical construct that represents science. Note that by including Bridgman's operational tests for nature and Newton's concept of force within metaphysics, we are ready and must be ready to begin science at the next stroke. Define force. And that, three centuries later, has turned out not to require more than a few force fields, not more than four, perhaps even two.

The issue, valid a century ago, was whether the same forces that described natural processes held for social organization. It was a great advance of d.m., a fantastically great advance, to suggest that a common foundation should exist for nature, human society, and thought, and it was even fair to try to cast it so as to transcend 'vulgar' materialism. But the same revolution, that took place in thought, in 'dialectics' as a method to view dynamic process, also produced a closer connection between physics and chemistry, and life, and the restless earth, and the 'unchanging' stars. And as the greatest shock, that in fact a slow hundred year revolution in which the reductionism to perhaps not so vulgar mechanical, thermodynamic, quantum mechanical constructs is well on its way.

Thus minimally, the science of motion begins at the level of notions introduced by Newton and Einstein. And significantly enough, their arguments both crossed the line from metaphysics to physics - science - by essentially mystical notions rather than solely 'hard' notions at every level. (They couldn't continue to be 'hard' at every level. One runs into observational difficulty, and second - more telling - one has to finally face an indefinite regression with a notion, and that is what both Newton and Einstein did.)

10. Network theory

So now we can finally approach the first back-of-the-envelope approximation to a science. The common notion that both Newton and Einstein expanded was the even order symmetry required minimally for motions in this universe.

If the zeroth rate of change, the state vector, and the first rate of change, the velocity vector, was freely prescribable, change in the state of motion begins by a prescription of 'force', that which will cause a second rate of change, the acceleration vector.

Now actually the physics of fields, because of the couplings, looks more complex than the description furnished by a simple second order equation per lumped loop, but when the field is lumped, by the rules stated, a first order scientific theory provides a foundation for computing the rate of change of the 'trend', the existing rate of change.

What is characteristic for well formulated scientific descriptions is that they very easily and very clearly give the second derivative theory. This is clear in mechanics, in gravitational fields, in electromagnetic fields, in thermal fields.[1] That is what has given the engineer the competence to analyze simple coupled processes (e.g., electromechanical) and the confidence to propose equivalent network descriptions for a broader class of phenomena. But - except in these fields where the science was given him by the physicist - the engineer has offered no theoretical base for his optimism. This is what we are trying to offer now.

A scientific theory, of a network type, proposes to offer a basis for computing the changes in trend. If the field has certain stationary characteristics, such computable extensions, time segment by time segment, permit replacement of difference equations by differential equations, and make a formal second order theory feasible. If not, they can only make computations epoch by epoch.

11. But such a network theory must begin at the low frequency end of the ensemble involved. And for living societies, this is the new genera-

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[1]It was fascinating, after writing this section, to have found a very related question raised by M. Eigen, "Molecules, Information, and Memory: From Molecules to Neural Networks", as the A. Katchalsky Memorial Lecture, 1973. It starts with Eigen's question to Katchalsky, "Quote any chemical property that would resemble an electrical inductance?" and explores that issue as a prologue toward a network thermodynamics. We have been concerned with such questions since the 1960's. See A. Iberall "Physiological Control - A Physical View: Life and the Biochemical Oscillator", Chem. Eng. Sympos. Series 67, 190, 1971.

tion level. At any more rapid period of time, the individual atomism - because of large bulk viscosity - ties up too much internal energy with regard to release in societal processes.

But the fluctuating time scale of the individual atomism may not yet appear so compelling to the theorist. He may expect the oscillations to be quite highly washed out in averaging, although he obviously must consider the scale in any kinetic calculation. There is a more compelling reason.

12. In our piece, "The Neurophysiological Basis of War"[1] we put forth the theses that the same evolution that developed a coordination center in man and the ability to transform signal among all sensory modalities at neural rates and thus the ability to develop abstract notions and therefore speech at neural rates 40,000 years ago, made all abstractions tolerable including the abstraction of war, of mass killing of one's own kind. But the first 30,000 years of modern man's existence was associated with the cold weather driven life of a hunter-gatherer.[2] And that it wasn't until the warming climatic change of the past 10,000-12,000 years, whereupon man mastered a fixed style of life, and turned to his own kind in trading constellations, using his abstractional ability to form the abstract notion of value-in-trade, that the abstraction of war, of killing one's own kind for various abstract ends arose.

But from that time on - turn maps in any historical era, in any trading constellation - one finds the rhythms of war. It would serve little purpose to cite hundresds of source books that bracket all regions of the earth. Instead one source, still primitive in its characterization, will be offered. It is M. Melko, Fifty-two Peaceful Societies, Canadian Peace Research Institute, Oakville, Ontario, 1973. It provides some very approximate notion on the distribution function for war in a state. We plot a result taken from that source.

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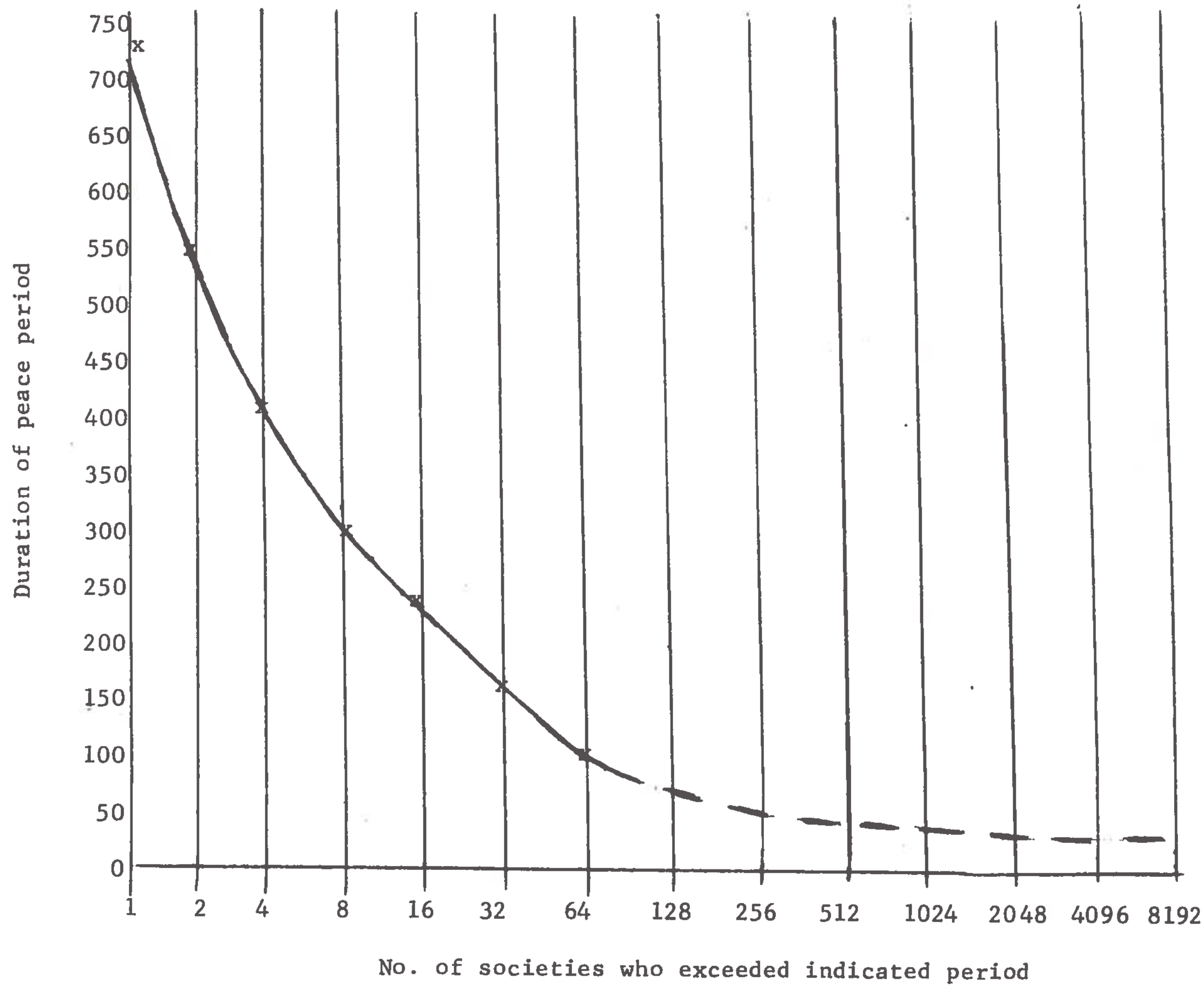
[1]In Gen. Syst. 23, 161, 1973.

[2]It was the periodic ebb and flow of many ice ages in the last two million years of the Pleistocene that weathered man's ancestors, and finally led to man in the bottom plateau of the last 100,000 year weather cycle.



First note how very limited are the number of societies that have remained at peace for any extended period, and how rapidly the curve converges toward the 1-2 generation time scale. For the convergence tail, one can examine E. Dewey, "The 17.7 Year Cycle in War 600 B.C. - A.D. 1957",Res. Bull. 1964-2 Foundation for Study of Cycles, Pittsburgh, Pa., August 1964. As its title suggests, large scale quarrels in any civilization constellation seems to have an 18 year scale. This does not make the time-scale per society one generation, but the two pieces of evidence together tend to squeeze the asymptote very severely toward the 1-2 generation time scale.

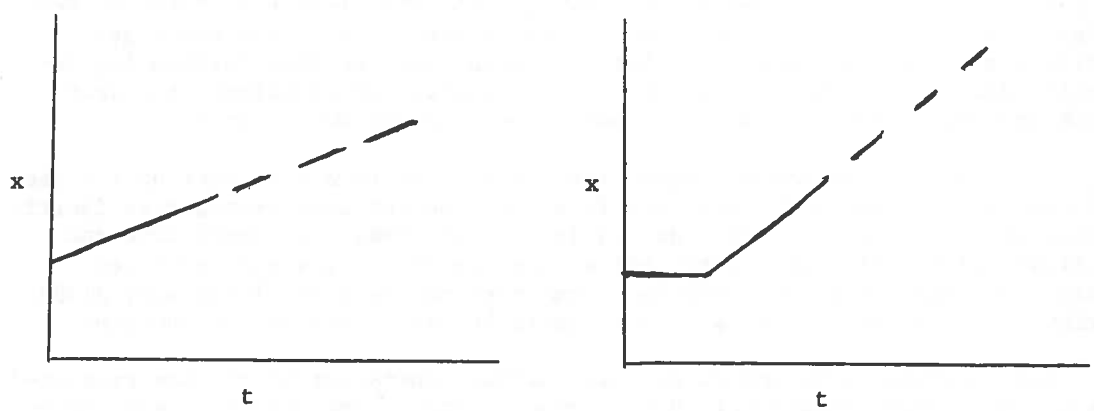
The most cynical explanation for 1-2 generation war rhythms is that it takes a generation to wipe out the emotional and physical effects of one war, before providing a new generation of young players to undertake the next.

But just as anger is an individual human model action, so is war a societal modal action. Mismatches in the process of social thermodynamics simply take that characteristic human social mode.

It is the rhythm of war that dominates the fluctuating kinetic process. And as a result, it is the dominant low frequency fluctuation on which to base a network model.

13. Namely while technology can be viewed as a linear evolutionary chain and furnishes the basis for the precipitation of elites and one of the independent empowering potentials for a social thermodynamics (ecology being another), in the shorter time of one 'war generation' time scale, societies are dominated by that issue of war and peace, and so largely make policy - as an independent perception of war and peace. Technological selection, the policy of the usually small number of governing elites between wars, building, and most other social currents are stirred by the ebb and flow of wars.

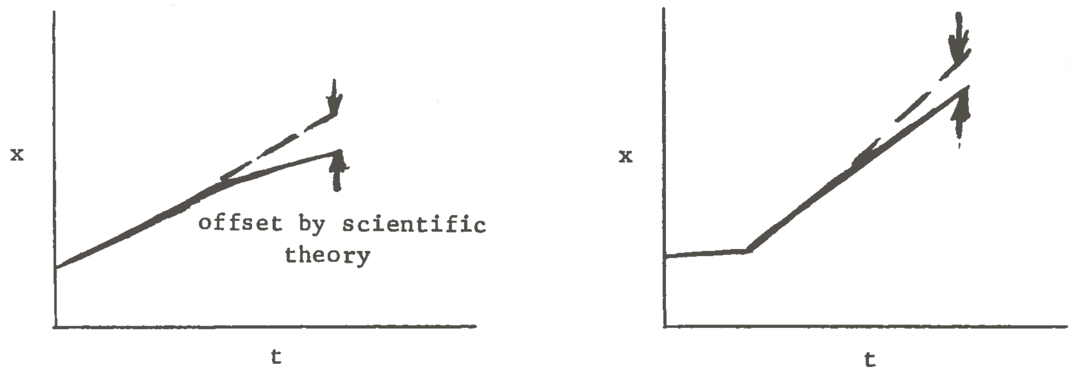
14. So in summary, what a 'scientific network' theory or description can do is the following: One can generally surmise a linear extension from the present, in one of two forms



The example used is one degree of freedom x, and two types of response are shown, a linear change (displacement x, velocity $\dot{x}$) or a time delay and then linear change.[1] We consider estimates of both of these responses to be achievable by causally free linear programming.

[1] It is more than a conjecture that the dynamic response of any distributed R-C system is a time delay plus a first order response.

Now what we expect the scientific network theory to be able to do is estimate the curvature, as shown



Namely what a 'science' should be able to do is to estimate the total reaction - inertial and relaxational - for some future segment. Namely it should be able to predict and estimate the future offset.

One should note that the future offset is not a description for ever; second that it is not a large magnitude which is being estimated, only, as a curvature estimate, an estimate of a quadratic deviation; third that it is a 'back-of-the-envelop' description in that it does not deal fully in the field with overall stability, only within a very limited time domain with what sort of rate will a nonlinear deviation show up. For that reason a 'network' description cannot deal fully with the issues of stability in the whole geometric-dynamic phase space field but only with some possible forthcoming instabilities. Of course one may then try successive continuations, but each epoch may contaminate the previous parameters and the noise state.

15. And, if one wonders where the 'causal' factors that make up the second derivative come from, they come from the coherent wave propagative inertial character of the local field. Namely it is their reactive common coherent 'solidarity' by which they start off a response to a newly applied force field. In some lower, more subtle, form there may be (and likely are) hidden variables. They communicate at hidden variable levels and become coherent.[1]

But in gross form, one finds this inertial character if one has expressed the thermodynamic equations in valid format - namely the rate of change of summational invariants (the left hand side) is related to various gradient fields that involve transport coefficients appropriate to the summational invariants. This structure must remain in some primitive form even when the equation set is lumped over fields to obtain engineering approximations.

And when applied to human society, we must recognize that the right hand side has to be decomposed to present form and functional variables that are cultural, sociological, economic, political, ecological, climatic, geological-geographic.

[1]Mystical? At current levels of knowledge about primitive physical processes it still is. See R. Lewin in "Genes and developmental biology", New Scientist 66, 381, May 15, 1975 for a similar statement. Or see M. Eigen.

16. What this likely means is that the rate of linear evolution of new technology and the repetitive rhythm of war are likely tied together. Namely repeated wars put some kind of kindling of new ideas into each generation's head. We don't insist on this as an absolute, but since warfare is an experience that crosses through human consciousness during almost every lifetime in human history, it furnishes some of the heated processing of ideation.[1] As an internal process, new ideas - both technical and perceptual - emerge as a facilitated linear diffusive chain at the near equilibrium 3 generation level. Thus a network model at the one generation level partakes partially of an atomistic fluctuational ensemble and partially of a near equilibrium ensemble. Roughly, in a kinetic sense, we place it at the kinetic level of a Stokes-Einstein diffusion process level. Namely one can use near equilibrium thermodynamic results, but the noise level is quite high.

So the likely best strategy to view this via a 'back-of-the-envelope' network model is as follows: One uses equilibrium thermodynamic results; one estimates - via 'atomistic' entities 'thermometrically' embedded in their milieu (namely one asks a random group of competently trained and functioning scientists and engineers) - along the linear chain of emergent technology (of scientific ideas and engineering ideas); but one adds one new systems' variable - a measure of the <u>defense risk margin</u> or the <u>perceived threat metric</u>. This measure, included in elite command-control planning, becomes a productive measure of how the national moiety must comport itself (e.g., in distribution of manpower, materials, energies, structures, value-in-trade) to optimize the perceived threat. Operational strategy emerges from how that metric is optimized (e.g., minimized).[2]

> The national experience at the time of writing presents an excellent opportunity to illustrate the modelling problem. At the time of writing the Viet Nam war has finally wound down. Contrary to our past experience we have not emerged as a victor. Had we emerged as a victor, we would likely have one notion of a perceived threat. As it is, we likely have a different notion of a somewhat high perceived threat, although, by expert objective accounts the real measure might not be that much different.

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[1]We refer to the network of 'national' moieties that are involved in constellation. Among both these nations and others who may not be directly involved, the technological process spreads by diffusion.

[2]Some note is required for this measure. First, look at the problem from the point of view of the individual human. Human conduct is operated roughly by a metric 'outlook' associated with two switch states of anxiety and euphoria. The normal vicissitudes of the milieu, with a certain long term (e.g., 30-60 day) scale provide a basis for alternating between these state outlooks. The state outlook then 'colors' decision making, between extremes of responding to rate parameters and responding to difference in state parameters from a world mental image ideal. No less is this true in national command-control, except for a change in time scale. The individual retains the same 'atomistic' time scale, but caught up in a command-control net. The driving frequency tends to be summed over epochs of 5-10 years. Thus in a generation there are perhaps a handfull of choice optimizations- path corrections.

Nevertheless, can it be doubted that national planning has a large scale fluctuating shape between this point in time and the next point at which we will have perceived the end (or beginning) of another serious war?

But look at the national system. While 'clearly' (to physicists) the entire society is locally near thermodynamic equilibrium (life goes on day by day), certainly the whole national field system is not at thermodynamic equilibrium. In the field there are too many unbalances - 8-10% unemployment, ongoing inflation, prospects for recovery, uncertain food futures elsewhere, an uncertain fuel energy future. Thus, if anything, the system is subject to the laws of irreversible thermodynamics. Processes must move toward a nearer thermostatic equilibrium (creeping motion) that its gradients will support. (They may not get there, new time dependent disturbances may throw them off again.)

But how can such a field be described? Clearly, as a minimum, even without putting on the dynamic constraints of irreversible thermodynamics (e.g., summational invariants will change in accordance with maintained gradients and transports), a specification of the 'state', in phase space, requires a statement of states and rates (i.e., state variables and their velocities or momenta). The yearly rate of change of employment, of prices, etc. cannot be regarded as equilibrium states.

Thus, common to the 'kinematics' of any coherent description, we must start from such phase space specifications. Then the game of 'science' may begin. What is past is prologue? Fine, extrapolate. Some quasistatic notions, say of economics, such as if A then B? Fine, then steer by that strategy. But it is only a network theory based on thermodynamics that can select the minimal variables and the minimum transports that form a complete set. Be that as it may. Note that it is a difficult question 'today' for a young couple within child bearing age to decide when and how many children to have. Yet this is a basic portion of a theoretical description.

So, in any case, national leadership from this point on out could both use a science (it will certainly use a game plan and a strategy) for affecting the nation, e.g., as an economy, and an objective strategy for dealing with perceived threats. Drop threats of war now, build the economy? Consider the external threat high and still invest heavily in defensive or offensive capability?

But we are concerned with urban areas. We ask the question, in no rhetorical way, does not urban leadership have to respond to the perceptions of external threat in similar ways? With Viet Nam off our back, does it not behoove every city to have a post-war strategy for its development or redevelopment in between wars? (At least that was our concern in 1942-1944, in developing a post-war program for the agency we were in, the National Bureau of Standards in the Department of Commerce. We are pleased to say, whether it has turned out to be as fully valuable as we imaged or not, efforts such as ours each played a small role in developing the Full Employment Act of the U.S.A.). Clearly, the fluxes and rates of change are different in wartime and in peacetime. (We don't want to debate the Viet Nam issues over again, but clearly that war was fought remotely with money costs and costs largely in lower class youth life as its major interaction. Thus it took a long cumulative time before its effects made themselves evident. But this is no scientific excuse to avoid the study of how such large scale fluxes - near or remote - affect any particular urban area). The urban area perhaps can simplify its planning to peace (post one war, pre a next war), remote war, and contingency planning for proximal war. At least it would seem that this is much as any urban area can do in any particular epoch.

So with this introduction, we can return to our shorter term social modelling, to indicate how this perception is and can be used more effectively for policy making.

4. An Information Policy System for an Urban Center

The last interjected section was in the nature of a mathematical - physical lemma, albeit extended, to indicate what might be expected of a network model system,[1] which was validly based on physical law. So now we can continue the discussion from where we left off.

We had made the point that the system is hierarchical. Now we can indicate how the system (namely the social system, say of a large autonomous functioning entity, such as the U. S. A.) can be modelled in a valid network sense.

Level 1 (if desired) - the community of nations.

Level 2 - the national model. At this level, we indicated that it could be modelled for the 1-2 generation period between wars. Assuming that a nation operated with such a model, and it is clear that more and more nations are tending toward some form of national modelling,(e.g., France, Sweden; clearly there are many primitive starts toward U.S.A. modelling), then the utility of modelling national interactions (level 1) is immediately obvious to guide internal policy. As war gaming models at the Kahn operational research level (largely balances among state variable), at the Forrester-Meadows-Mesarovic engineering network level (largely state and rate variables - no 'forces' yet), world modelling has begun.

Level 3 - the local regional level. Often but not always, identical to a political subdivision. From a modelling view these differences - geographic-ecological and political have to be reconciled.

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[1] It is interesting to note that soon after writing this section, the article of M. Eigen's was discovered, which calls for a development of a network thermodynamics to deal with life processes. The biochemically trained biological Nobelist, Eigen, asks Katchalsky a critical question. "What is the meaning of inductance in chemical reactions?" The physicist will recognize it as the same question of how is the second derivative determined. Capacitances and resistances are easy to see by many analogues, but the 'inertia' character of mechanics is what is so difficult to discover.

Level 4 - the urban level. This generally includes the greater area which acts as an immediate center for urban action. This also often poses distinctions with the political subdivision.

Level 5 - the intermix of cultural moieties that make up the urban mixing pot. It is only the wealthiest of these moieties that can and have afforded to do any extensive modelling, e.g., programming for the economic affairs of medical doctors or some earlier guides or the elaborate support of a family like the Medici's[1] or the Rothschild's.

Level 6 - The nuclear family. This unit is the smallest social unit. It commonly plans, less commonly models, other than by mental image planning.

Level 7 - the elite structural entity. And then there is an entity that runs across the board of levels, and, by whose ever emergent existence, has made the societal levels come into being. Commonly emerging at the level of the nuclear family, it captures and entrains a large amount of space - time - matter - people energetics. The institutional form it takes to capture that energetics varies with the times and places. It represents a level which is none of the other six levels. At various times it is coequal in potential to any of the other levels, or it is immersed in various of those levels.

> [This issue of coequality is a very serious one, particularly for physical science. It could leave many with the impression that the whole vaunted structure of a physical thermodynamics was slightly a fake, unless the physical foundation could be set out. The issue expressed by example of two different levels, is how can a nuclear particle be equipollent with a whole organized system of molecular structure; or how can there be a great man theory of history equipollent with a high degree of determinism?
>
> Translated into physical terms, the question translates into how can there be a large degree of long range order? It is fortunate that in superconductivity, the character of long range order, e.g., of two electrons at the enormous distance of millions of electron diameters retaining order in their superconductive march through what would otherwise be considered to be an ordinary resistance path, is becoming comprehensible. The fact is that each electron, being in one domain and another, avoid the dissipative loss associated with passage near the dislocations that identify each domain by their pairing. It is like watching two expert basketball players dribbling and passing between them down the field to a goal, regardless of what resistive pitfall each player encounters in turn.[2]

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[1] See for example, C. Hibbert, The House of Medici, Its Rise and Fall, Morrow, 1975, for nearly 500 years (1296-1743) of influence of the Medici's in a particular historical period in a particular 'sub-national' moiety.

[2] It is interesting to note that this issue has begun to surface on the agenda of science. Soon after writing this section, there appeared a still primitive article, H. Haken, "Cooperative Phenomena in Systems Far From Thermal Equilibrium and in Nonphysical Systems", Rev. Mod. Phys. 47, 67, 1975, which touches on this theme. Or see an earlier article, C. Enz, "Two Fluid Hydrodynamic Description", Rev. Mod. Phys. 46, 705, 1974.

Actually in order that an elite can manage to 'blitz' through a society and establish a reinforcing resonance around his organizing notions requires some property among the various ensemble members. They may not all be at low 'stable' energy levels. They must be in fairly high, not so stable, energized states. The 'kT' energies[1] involved in transition from energized level to energized level is low. Thus it doesn't take too much of an excitation to trigger states.

In other words, we are talking about nonlinear triggers or switches very near their switching thresholds.

As we have indicated[2], society is formed on the basis of a sixfold ordering of electrical forces, which involve now very weak switching forces. That weakness of force makes for very colorful social organization. About 20 modes of action, for example, emerges in the human - eating, sexing, sleeping, angering, interpersonally attending, etc. These are easily triggered.

With adequate potential energy sources, human behavior rings through its modes with easily triggered states. Also when the gradients of potential sources are large, the triggering takes place easily. Thus, like in all such highly excited state systems (e.g., cloud or bubble chambers, or all the other fancy devices in which the motion of nuclear particles becomes observable), whenever there are elites who can figure how to mobilize a resonant reinforcing field growth, without getting bombed out energetically, their notions go. It is not that their notions are so unique. It is that of the many elite particles who may try, only a few percent manage to organize blitz paths.

Without going much further, one should be able to sense the computable process by which elites become equipollent with other social levels, and in fact one ought to be able to construct a computable schedule that feels the triggering 'temperature' (namely there exists some such measure of the existing society.[3]) This possibly is the most important portion of a policy construct for modern societies. It is a scale and guide for when certain things can be accomplished in society. Every age can't be stirred, but there are space and time domains that they can be.

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[1] The notion of 'kT' implies different scales of energy at which organization is ordered. For chemical and phase changes, molecules are literally ordered at the electron volt range of kT. For stronger orders, one may be at the millions or billions of electron volts, etc.

[2] "On a Method of Modelling Complex Systems", 1975 Alza Distinguished Lecture Biomedical Engineering Society, in press for Ann. Biomed. Eng.

[3] By the 50's, the electrical engineer had a new instability technique for 'modelling' or designing oscillators. Imagine an ensemble of all frequencies going around the designed network. The object of the design was to achieve a network whose desired frequency would go around the loop without being attenuated, in which gains made up for the losses. This took such design out of the black magic, or do-it-this-way approach. See for example, H. Reich, Theory and Application of Electron Tubes, McGraw-Hill, 1944; and Functional Circuits and Oscillators, von Nostrand, 1961.

As such it is value free. It can be used by democratic society or dictator alike. It can be used for good or for evil. But for intellectual completeness, it is a missing piece in social systems modelling. A well ordered society would understand the merit of performing this computation in the same sense that it would perform computations on the first level of the dynamics of the community of nations. Note that it is one problem for an individual or group that feels competent to take on an elite role to do such a computation on its own structured action and reaction in an existing society. It is another matter for a society with a great deal of concern with the general mix of society to begin to spot what elite tendencies the mixing pot will 'suddenly' precipitate out.[1]

Almost as a parenthetical remark, we believe we can add one more small piece on the dynamics of the elite.

A basic question, in post-Neolithic times with value-in-trade, is why does the elite unstabilize the thermodynamic cycle process so much? Obviously the answer cannot be a raw application of some Freudian theme. The dominance of the male boss monkey has run through all primate existence, and the pre-Neolithic human had such leadership for 30,000 years of human history.

We would like to suggest that the fundamental change that took place in human society was the change in the mortality experience.[2]

The basic requirement in living species is that reproduction takes place. Thus the 'adolescent' age and the mating age has to be 'nurtured'. Beyond mating and sufficient procreation to protect the young, the older members of the species are not of too great significance. As seems clear in primates, a few 'older' than mating age animals are useful. They seem to have learned various tricks for survival and seem to have more of the 'big picture' required for the troop to survive. 'Epigenetically', within their lifetime (even when it is not transmittable from generation to generation), they seemed to have learned from experience. In these basic respects, pre-Neolithic humans seemed not largely different from other animals - even if they have added speech and artifacts of both utilitarian and not-so-utilitarian nature.

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[1]An interesting 'Rashamon'-type analysis of an international crisis, from three different point of view and its analysis within each framework, is provided by G. Allison, Essence of Decision, Brown, Little Co., 1971. There are a goodly number of perceptive studies that are all relevant small pieces on the road to a social physics. We will continue to try to ferret them out as fast as we are able to find them.

[2]See for example, A. Comfort, The Process of Aging, Signet Library, 1964. He shows average life spans of about 15 years (estimated) for Neolithic times, 30-35 years for 1700; and 70 years post 1960. Average life spans of 30 years are already indicated in 400 B.C.

But in post-Neolithic times, the survivorship of those post-first matings became more and more ensured. They remained in place. Their aggressivness became a more dominant theme. Elites form and linger on in the 30-70 year age slot. Their interests and visions have begun to skew the social priorities, away from procreation, toward the conservational retentional (in a Freudian sense) themes of value, property, duty, honor, virtue, nation. Thus the abstractions become more dominant than the simpler 'real' items involved as a minimal requirement for living.

As 'older' persons, we appreciate the concern. But we also know how much society is turned around toward our interests and views. It is a basic question which requires a great deal of thought in the physics of a viable society and in its policies.]

The dominant network time scales for all these levels tend to be the 1-2 generation time scale, operationally down to 1 day, and for the urban level operationally down to the minutes and hours range.

Because of our contractual limitation, we shall confine our modelling to level 4, modelling for the urban level. We will assume (contrary to current experimental fact) that working models exist for the other levels. At least we know that they are foreshadowed in many minds.[1] And unfortunately, some of the operating contradictions will be found in there being no common model, except in the metalanguage of mind, to reconcile modelling differences. Certainly, today, there is no rational way of reconciling differences, although there are operating rationales.

Obviously the urban system is not autonomous within its political boundaries. It is unfortunate for simplicity of description, but in the historical battles between centralized authorities and localized authorities, the urban organism spilled outside of its confining walls.

This should not be viewed as too surprising. The viability of the living cell was importantly nurtured by its surrounding membrane. As a controlled admission (i.e., conductance, or its reciprocal resistance) characteristic, it provided a calming shield for internal processes and forms, including more 'lately' formed organelles. On the other hand, with the formation of a colonial multi-cellular organization, leading up to the higher forms of tight organ subassemblies in complex organism, the individual cell loses much of its autonomy. Instead regional issues, a larger ordered 'functional' unit in organs emerge.

But now if one still wants to take the 'back water' view of a cell, as an autonomous element, one can. However, its boundary is now quite a leaky

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[1] But to indicate its primitive nature, we can only ask any thinking person of this era to start, say, from G. Keenan's American Diplomacy 1900-1950, U. of Chicago Press, 1951. Can anyone doubt the relevance of its concerns up to 1975, thereafter certainly for the next 25 years and with high probability for the next 50 years. In our view, it won't appear highly dated for the next 75 years.

sieve. It still controls admission in some basic sense, but now there are outside forces, dei ex machina, which far overshadow its ability to control its own destiny.

This picture is no metaphor. Nor is it limited to living cells. It is a specific exemplar of the problem of nested organization when it changes from the near ideal gas form (very dilute solutions) to condensed phases. The large newly emerging organized phase must come to accord with its underlying molecularities, and conversely. And when one is an atom, one always finds oneself in a very active local hubris. The 'big picture', the long range ordering issues almost never arise. But generally there are some key elite elements, e.g., dislocations in solids, a few command-control elements in a one celled creature, who dimly sense the larger currents. That 'dim sensing' in an evolutionary sense, is sufficient direction for command-control to emerge in complex systems. As a generalization of a biological theme of our dear late colleague, Warren McCulloch, pointed out, a little information flow carries with it the potential for seizing command-control.

So now we have to move from less murky physical fields on up and out into the human social field.

The political city is a nearly autonomous element with its own command-control center. Like a living cell in an osmotic field, by virtue of some here unspecified processes, there is a movement of ions in and out of the cell so as to maintain near thermodynamic equilibrium. In some long time scale that maintains the gross morphological character of the cell.

In the same way, there is a gross movement of population in and out of an urban (henceforth this will denote the political unit) settlement.

Just as we have shown in liquid kinetics, there are more than one 'near-equilibrium' time scale. A network model somehow must be able to represent the intrinsic processes of all of the relevant time scales.

Thus the first intrinsic thermodynamic time scale is of the order of four hours. It is the equilibrium physical thermodynamic time scale of the human atomism. Thus work periods, and eating domains, and sleep units, etc. are scaled here. Transportation rush hours at morning, midday, end of workday has been scaled with regard to this process. It is the level at which Stokes-Einstein diffusional steps, albeit with inhomogeneous diffusions can be discerned.

The first near-equilibrium for momentum, wherein the action modalities have practically all shown their spectrum, is the day. The individual atomism and the social molecularities have tended to exhibit their coherence. Averaged over the day, one knows why there are social molecularities. They have done their thing.

The social week still has a well defined physiological basis, but it is far removed from our scope to expand on it. Suffice it to say that societies that have attempted to move from a seven day week have found that period to be strangely persistent. Thus rest-work cycles, of whatever nature are appropriately tied to the week period.

Similarly, the month, the season and the year provide very strong physiological-ecological cues. Thus we are accepting these six major time scales as quite basic to urban operation for very basic reasons, and we are not suggesting any significant tampering with these process scales for any forseeable future.

On the other hand, the faster time scales, e.g., which in fact have to go down to the 0.1-0.2 second reaction time scale of the human vehicle driver, we exclude from our network modelling. These faster time scales become part of 'engineering design' of the subelements - human, and mechanical - that may be involved in an urban settlement. They are represented as operating routines.

But beyond these geophysical-physiological dominated time scales, there then is the brief 'political' period - generally of the order of 5-10 years[1] - and finally the war generation period. For policy control purposes the latter war generation period is quite basic for urban settlements. It tends to mark the changing face of the urban settlement. The marks tend to depend on how the successive war waves in fact affected the settlement. Thus even if urban settlements do not have to do the large scale national moiety defense planning[2] (which at one time they had to do, but - as is our contention - with serious accuracy in long range artillery, the believable defensive posture of the city disappeared, except in last ditch efforts), they are still seriously affected by the waves of war.

So all-in-all, we have an 8 scale system to deal with - from 4 hours to 30 years, 5 decades in time. How can we model this system?

By the choice of scale we don't have to model the atomisms. They are ongoing in a statistical mechanical sense. They furnish lumped transports at higher more nearly continuum systems levels.

The system starts with there being a typical performance day for the city. There is a characteristic series of modes by which the daily performance cycle of the city is discharged and all of its thermodynamic chains are completed.

Let us examine the chains of two different levels of organization. For the individual, the following chain is common (in a family - working father, home keeping mother, school going children):

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[1] Humorously enough, the 'knee-jerk' reaction time of societies is 2 days. We exclude this from network modelling.

[2] Which at the time they had to do, but - as is our contention - with the capability and accuracy of modern long range artillery, the believable defensive posture of the city disappeared, except in last ditch efforts. But in the very writing of this, what reader can avoid conjuring up visions of Leningrad, Rostov, Warsaw, Paris, Berlin from World War II, or the more recent wars in the Far East?

Father

7:00 - 7:30 a.m.	wake, void, wash, dress, eat and drink (interpersonally attends)
7:30 - 8:00 a.m.	transport to work (attends)
8:00 - 12:00 a.m.	work (rests, motor practices, angers, escapes, aggresses)
12:00 - 1:00 p.m.	eat, and drink (escapes, interpersonally attends)
1:00 - 5:00 p.m.	work
5:00 - 5:30 p.m.	transport to home
5:30 - 6:00 p.m.	(escape, interpersonally attend, talk, anger, euphoria, anxiety)
6:00 - 7:00 p.m.	eat and drink (greed)
7:00 - 11:00 p.m.	(rest, talk, attend, motor practice, work, escape, euphoria, laughs, interpersonally attends, envies)
11:00 - 7:00 a.m.	sleep, (anxiety, euphoria, escape, aggress).

(Obviously 1/2 hour shifts are quite possible. The data, as indicated above, are stereotypical, rather than centered on a large amount of actual data. We have added the emotional modes, but only parathetically and suggestively. We have underlined those modes that have external extensional or institutional implications for society.)

Mother

7:00 - 7:30 a.m.	wake, void, dress, work
7:30 - 8:00 a.m.	eat, drink, (escape)
8:00 - 1:00 p.m.	work (interpersonally attends, clean, wash, shop)
1:00 - 1:30 p.m.	eat, drink (escape)
1:30 - 6:00 p.m.	work (clean, errands, interpersonally attends, personal attends, shop, prepare food)
6:00 - 7:00 p.m.	work, eat and drink
7:00 - 9:00 p.m.	work (interpersonal attends), (rest, escape)
9:00 - 11:00 p.m.	(rest, talk, attend, envies, interpersonally attends)
11:00 - 7:00 a.m.	sleep (anxiety, euphoria, escape, aggress)

(Yes, the homekeeping mother has a much more extensive work schedule than the working father. And it is part of the current feminine social perception in industrialized nations to have begun to take note of it.)

Child

7:00 - 7:30 a.m.	wake, void, wash, dress, eat and drink
7:30 - 8:00 a.m.	transport to school
8:00 - 12:00 a.m.	(attend, motor practice, angers, escapes, etc.)
12:00 - 1:00 p.m.	eat and drink, void (escapes, etc.)
1:00 - 3:00 p.m.	(attend, motor practice, etc.)
3:00 - 3:30 p.m.	transport to home
3:30 - 6:00 p.m.	play (escape, attend, motor practise, etc.), study (attend, etc.)
6:00 - 7:00 p.m.	eat and drink
7:00 - 9:00 p.m.	play, study (escape)
9:00 - 7:00 a.m.	(escape) sleep

Clearly this scheduling, quite characteristic for American industrial - urban living[1] already implies a large amount of social organization. There is no point in saying "But everybody knows this. Of what significance is it to call it to our conscious attention?" The problem is that an idiot computer, a program or analogue for this operative thermodynamic chain, does not know it; is not aware of the connections implied.

Suppose the reader were a deus ex machina of any sort (benign ruler, mayor, pastoralist, plant or industry operator[2]), would he not recognize the need to have a good working understanding of scheduling such a complex social organization so as not to violate the ecological-cultural-economic-sociological-political-thermodynamic constraints?

Clearly, the human atomisms are autonomous self-actuating systems. Thus the deus ex machina does not have to guide every step of the interacting atomisms. Nor, as in those simpler thermodynamic engines that he makes - steam engines, internal combustion engines, hydroelectric generators, atomic energy plants, and the like - does he have to provide very perfect kinematic raceways (bearings, tracks, etc.). Even those, once started, keep running in their tracks, and can be stopped, and self-started by stability criteria, and simply programmed.

But there is a point to be made that only became evident technically with the Wright brothers' success in producing flight.[3] The Wright brothers were not the first to comprehend the technical aerodynamic and power requirements for flight. But they added a new ingredient in their solution. Whereas all earlier efforts had tried to produce an aerodynamic system that possessed complete stability in flight, the Wright brothers left the stability inter-determinate as an open loop system and permitted it to be determined by the pilot - the 'steersman' - only through a closed loop connection.

Against the vicissitudinal contingencies of the milieu, the system (social or otherwise) cannot be designed for complete operating stability.

So from where should stability come? Obviously, one answer is from outside. Thus it seems always to take place by some leadership element. (But this is only true in the macroscopic domain. In the microscopic domain there are internal hidden variables, dei ex machina from below that assure coherence.)

And for complex systems (beyond the almost structureless near-ideal gas), there is a large degree of circular interaction between the atomistic ensemble

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[1] It would have been a little different 70 years ago, because the national moiety was more an agricultural than an industrial nation, so that its rhythms were slightly different.

[2] Perhaps slightly overdrawn, nevertheless an article by N. Macre, "The Japanese Century Begins" from the Jan. 4, 1975 London Economist, in Atlas World Press Review, 22, 11, March 1975 outlines such a deus ex machina outlook for a modern competitive nation.

[3] We are obliged for the notion to C. Draper who made the point in his Wright Brothers Lecture for the Institute of Aeronautical Sciences in the 1950's.

and its leadership pack.[1] But the connection is not hard. Through guideways, along railways, it takes place through modes of action, distributed as parts and mechanisms throughout the system. It is with such understanding that we must approach any modelling program.

For that, the molecular associations begin to structure the social mixing pot. But it is not our intent to provide a complete list of all American occupations.[2] Given that such lists exist, the problem is what sort of organization structure comes out in the urban area?

Clearly it is a class structure.[3] Its major parametric determinants are ethnic, income, and occupational function. Earlier cultural determinants outline the ethnic matrix. The occupational matrix is outlined by the operative technoeconomic structure. Income level is determined by a complex of economic and cultural factors.

An existing urban settlement operates as a near equilibrium thermodynamic system. Let us characterize its properties. We are given its land extent, its ecological resources, its climate, and its geological-geographic character.

Population. One can draw a boundary around an urban area in which 'practically no one' (e.g., 1% of the enclosed population who live within 'permanently' without crossing the boundary) moves out of that area on a daily basis. Namely the interior population is domiciled within the area, and on a daily average never move out of the area. That may be considered the boundary of the 'greater metropolitan area'. It is then possible to draw interior nested contours each of which is crossed daily by an increasing fraction of the population. (Although the regious may no longer be singly connected. Such complex contours, singly or multiply connected - nucleated - domains, roughly can serve as the spatial characterization of an urban area.

For that population to survive, certain requirements have to be met.

Foodstuffs. Foodstuffs must either be grown in the land area (by photosynthetic conversion) or they must be brought in and perhaps converted or used, as is, by the consumer. There is a lumped scale for such foodstuffs - e.g., carbohydrate, fat, protein, minerals, vitamins, water. Modern society will not quite accept food on such a lumped scale. Thus the breakdown that its cultural and income determinants will permit has to be noted. Also its

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[1] See part one for its presentation of the evolution of intelligence.

[2] The latest such list has recently been issued.

[3] It was most appropriate, at this point, to have come across a review by G. Suttles of F. Chapin, Human Activity Patterns in the City, Wiley, 1974, entitled "Urban Time Allocation", Science, 87, 1072, Mar. 21, 1975. The reviewer states, "Judging from the rather small differences [the] study finds in the temporal distribution of activities within subgroups, one is led to the conclusion that the fragmentation of urban life results primarily from the spatial segregation of ethnic groups, income groups, and economic functions. The counter weight to this fragmentation is that members of various subgroups are involved in a common set of activities that incorporate them into a mass society."

seasonal nature has to be noted.[1]

Organic wastes. The correlation of organic wastes with active systems in the urban domain is obvious.

Modal activity. People within the settlement are occupied in time averaged daily activities. While these activities are fairly well known in any cultural-ecological-technological milieu, the problem is their grouping for regulatory purposes. First enough space, time, and extensional material systems and institutions have to be provided that the individual atomistic modal needs are satisfied. Second, the balance must exist that guarantees that the materials and processes necessary for persistent survival take place. Namely whatever is not prepared or produced within the region must be brought in, and there must be potential drives that bring them in. Third, sufficient surplus must exist to provide support for matching the community to its outside boundary fluxes. Such match involves the community not being an endless sink to its neighbors, or an ever persistent threat to its neighbors. Namely sufficient quid pro quo has to exist that satisfies human constraints.

We are not Medici advisors, etc. So we are not concerned with Machiavellian strategies or tactics for how to become the ruling city of the world, or how to milk the populace so as to achieve maximum benefit to 'outside' investors. At this point, we are trying to point out to policy operators, including their systems' modelling capability, what kind of systems' aspects they must model.[2]

Institutional forms. Heretofore such provisions in institutional form, e.g., markets, shopping districts, parks, entertainment facilities, transportation systems, etc. have generally been selected and designed for by individual expertise or as an art or intuitional form. We are asking now for a more deep seated cultural-behavioral-ecological-physiological-sociological-technological balance.

Because man is a biological species, who lives symbiotically with the earth and its ecology, his life style modes put marks on the earth. But beyond that, man is the external and internal extension-forming animal, and so he creates mechanistic forms and institutional forms within which he channels his modes, not by hard constraints, but by soft constraints. The building of these forms, to match the aforementioned restraint categories is very much a matter for the command-control regulation of an urban center.

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[1] This is serious information that such groups as Department of Markets have to program. A more adventuristic program than heretofore - just barely beginning in some areas - is to provide the consumer a notion of what current and near future markets may produce - in quality, plentifulness, price.

[2] At the present time, we do not believe that urban area managers - mayors and the like - have yet begun to operate with complete systems' balances. Oh yes they may have institutionalized efforts to attract industry, etc. to their area, but we doubt that complete economic-ecological-cultural balances have been struck and adjusted. It is not yet within the American political way of life. As for outside organizations, one might say that preliminaries to such planning may have begun in some corporations.

For example, there have have been historically two patterns of control of an urban center. To use a shorthand description, civilizationist social-ogists have referred to this as an eastern and a western model. In the eastern model, governance comes from a centralized authority outside.[1] In a western model, self-governance exists (of course, in western history there then ensues a considerable tug-of-war of central versus local rule). But then within the construct of local self-government, the issue arises as to who is the governing self-moving (i.e., autonomous) elite. Our current nat-ional view is a mixed one. There are those functions which are governmental and those that are in the private sector (i.e., capitalistic). But it hardly requires any fantastic acuity to see the changes that have taken place in the U.S.A., say in various waves since 1870.

Now clearly in each age (not quite each generation, because building or rebuilding is more a near 50 year 'Kondratiev' cycle, namely loosely not every war epoch, but every two war epochs), urban centers are rebuilt. Thus the rebuilding takes place through the visions of the existing power elite. We can see no way - for current biological man - of breaking that process chain, only of providing it a more rational basis. Namely the act of storing programs as an epigenetic heritage by something more serious than newspaper articles, textbooks, memoirs, historical archives, not-quite-Aristotelian teachers can provide a harder transmission of past historical experience. Note it brings the question up immediately about the human characteristic of the receiving command-control elite. A human is not a 'rational' machine. As a result he may or may not be willing to accept rational mechanistic-like instruction and notice of past performance, unless - ? Unless, it has become traditional, or subject to other similar urging or coercing social 'forces'. One cannot have recourse to the Cartesian notion of reason.

But willy-nilly, regardless of how policy is selected (i.e., regardless of how the past heritage is transmitted), the elites and technician governing and managing command-controllers they tolerate have to get on with the affairs of the community. Thus food, materials, manufacture, tools, vehicles, build-ings, shelters, recreation facilities, governing facilities, police, fire pro-tection, water, public works, power, health care, etc. have to be provided for. The regulation of each of these takes place under the Aristotelian topological rule - they may be regulated and governed by the one, the few, or the many.[2]

And whether by our overall perception of policy or by the policy of any 'competent' ruler of an urban settlement, these compartments or departments have to be manned and integrated in their function, with the basic problem on how to integrate their diverse or conflicting demands on limited resources.

Rational programming, within the content of the governed flow processes,

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[1]Marx, for example, was the likely source for the notion that the development of large scale water supply for irrigation was a prime force for the develop-ment of an Eastern central authority with precedence over the local settle-ment.

[2]Or occasionally, the none.

determines various stability boundaries for failure.[1] Conversely there is a topological region in which more favorable operation can take place. One presumes that a desirable policy is to select those conditions that can lead either 'now' or in the 'future' to more favorable sustained operating conditions. Thus one presumes that the manipulation of institutional forms (their planning, their building, their 'selling', their enculturation) is a basic part of the ongoing operation of an urban settlement by its governing elites.[2] The populace by itself will not maintain the organizational forms. Socially, their actions would tend to be thermodynamically degradative.

Materials. The maintenance of selected institutional forms and functions requires a flux of materials.

Nonorganic wastes. Thereby there must be a concomitant flux of waste materials to support the material cycle.

Power. Energetic supplies must be balanced too so as to support the necessary activities.

Maintenance and prevention activities. The maintenance of the health of a population, the 'health' of its extensions, both to treat pathology or to prevent pathology (of persons, buildings, machines, etc.), is a necessary function for survival. How it is conducted depends on what society knows.

Procreative and educational activities. By the very biological structure that man is, the birth, and care of the young, and their socializing education is a function to prepare the newly formed active thermodynamic engine unit for transit to his mature social ensemble.

Non-material, i.e.,'idealistic' modal provisions. While in principle, we have touched on modes and institutions, it is worth while to make the point again - man, as a biological species, has action modes that are first life-form derived (e.g.,'curiosity' to explore the environment); second, mammalian derived (e.g., procreative activity); third, primate derived (e.g., boss 'monkey' dominance); and fourth, human derived (e.g., speech, abstractions, warfare, values). He has no external metrics for his 'values'. They are internal - biochemical. Thus money, and love, and hate, and recreation, etc., the value of all modes can be confused.[3] But conversely all of these internal modes - both hard constrained internal physio-chemical modes and soft constrained internal-external behavioral modes have to be satisfied. How love and recreation and anger and curiosity and escape, etc. are satisfied in an urban center becomes one more concern for elite governance. You cannot raise people like chickens, in little confined cubicles with wire floors so that

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[1] It is like designing a complex electronic system. One border may be a stability border, e.g., conditions under which the oscillators will no longer oscillate. Another border may be mechanical failure, e.g., the most severe mechanical stresses the system can take.

[2] We can only stress over and over again that without the stability process by which elites continue to be precipitated into the social solvent the process would stop and its existing level would presumably degrade backward toward more primitive forms.

[3] How else do some young people throw away their lives by drug addiction, etc.?

they won't infect themselves with their own excrement. Or, in any case, you can't do it for long.

That, sketchily, provides some notion of what must be programmed in an urban center; further one that is sensitive to its cultural constraints.

Clearly, the scheduling and programming has to have the following essentially distinct causal components: These components are part of the ergodic decomposition of any near equilibrium ensemble.

It must have a program for the mean operative state of the system.

It must have a program for the periodic operative components of the system. In the context of what we have been talking about, that means, minimally, it must have a program for the mean daily component of the system; for the weekly component (i.e., the weekend differences, but also what is known to be different characteristics throughout the work week); for the seasonal components of the year. It may be too premature scientifically but it must also begin to sense the driven periodic components. These are dynamic processes that arise from interaction within the total ecological milieu. Examples are the dynamic consequences of atmospheric tidal oscillations, which lead, for example, to the near periodic variations in air mass movements that make the ever changing weather. Meteorologists are working very diligently trying to decode those variations in weather for longer term forecast. Their excuse is the same one we give - namely that look of knowledge of weather change is quite costly to man in society, whereas planning could be so very usefully performed if change could be predicted.

It is is not only such 'natural' cycles[1] that are of concern. Men interacting in society have produced a broad spectrum of economic cycles, perhaps of somewhat dubiously understood causality, but nevertheless belonging to the class of process that the well-known econometrist, H. Wald, has referred to as flexible cycles. We can cite a few, without going far afield, the building cycle and perhaps more recently entrained a cycle for trade union strikes.[2]

And beyond the periodic components of a system there are the impulsive vicissitudes of the total milieu. These too must be programmed. Some of these, of course are less than isolated, e.g., the question of whether strikes are aperiodic or periodic, or war. Thus, what we are asserting, really, is that human experience largely deals with a stationary spectrum even for these 'stochastic' components. It is only their phases which are largely random

[1] Even the highly dramatic one of whether we face a coming mini-ice age - we hasten to add, within very practical time scales of 50 years - which could have profound effects on future societal conduct.

[2] We have tried to face the question that Wald raises in a number of publications. We were confronted by the issue in our experimental biophysical work. The human and animal body exhibit a large number of cyclic phenomena that in toto we have identified as dynamic regulation, homeokinesis. These cycles we believe to be limit cycles. But they are not well correlated in time. We finally had to decide that their phases are random or warbling. We have found the issue first raised by the great statistician, G.U.Yule. But Wald has likely devoted the most mathematical study to the problem of these flexible cycles. Their causality is hard and determined. Their phase is not.

(e.g., getting killed by an auto). Thus many contingency processes can be programmed.

And at the far end of such programming lies the near periodic repetitive character of wars. They represent, roughly, the end scope of urban contingency planning.

With some hard programming for all such process dynamics, then the inventive innovative skill of the artistic human can come in. His efforts can be devoted to overcoming defects, smoothing the road, perceiving and bringing in new factors, using the existing program for feedback purposes, planning the future.

One final commentary is useful before starting more detailed modelling. One may wonder how the large scale long term modelling and the shorter scale more local modelling has to be related. Our general strategic notion would be that large scale processes have to be slow and gentle in their impact on local processes. Conversely local processes must avoid locking themselves in with a hard set so that no change is possible. The following piece, from H. Salisbury, To Peking - and Beyond, N.Y. Times Book Co., 1973, is quite appropriate in its message even if its perception turns out to be imperfect in the long run.

Referring to how a local farming commune in Yenan was organized, Salisbury points out:

"Perhaps, the most striking aspect of Liu Ling was the continuity of leadership and the continuity of growth..."

"The peasants of Lin Ling did not live as well as those in many other communes. ... But no one went hungry..."

"I was impressed by Feng Chang-yeh. [The Brigade Leader]. He showed me as much of his commune as he could in a brief visit. He did not pretend that it was perfect. ...Indeed, I did not think he had any elaborate hopes... But he knew what had been achieved... Most of them were due to hard work...damming a few gulleys and creating small water reservoirs. The possibilities were limited, but only with water could the land's yields be raised..."

"Feng Chang-yeh knew every foot of Liu Ling. He knew precisely which crops could be raised on every mu of land - and so did the other members of the commune. ...not planted in great fields and cultivated mechanically. ... in small strips and subdivisions of fields... They knew by years of experience which crop grew best on which plot. No one came from Peking to tell them they must convert all their fields to corn...to announce that machine-tractor stations would undertake all plowing and seeding and harvesting... No party secretary from the provincial capital suddenly...fired all the leaders...

"And here, of course, was the dramatic difference between the Liu Ling commune and any Soviet collective farm I ever visited. ...I had never visited a Soviet...farm that was directed by a...resident on the farm...or...area for 10 years - let alone 20. ...that was not told... precisely what crops to plant, where...and when...where the men and women living on the spot were permitted to run their own affairs because they were known to understand local conditions better."

"...the hallmark of the Chinese commune...diversity, local autonomy, total adjustment to local conditions, free and easy exchange between team and brigade leaders and the membership, individual houses, ...formed plots... animals and poultry (in addition...to the commune plots), ...diversity from one commune to another, ...remarkable absence of interference from Peking... peasants....free to sell surplus private production on the market.

"What ...had been added by the Communists? ...convenient means for organizing countryside and the peasant work force for more efficient labor, ...simultaneous action to carry out...seeding and harvesting...gift of health through...elimination of epidemic disease, ...elimination of ruinous burdens of taxes and interest, ...gradual introduction of better strains of seed and of improved fertilization, ...provision of technical aid and capital for large-scale irrigation...that often made the difference between life and death in arid areas of China."

One must take note in this area that

"Northern Shenshi is erosion, endless eroded hills, and low, worn mountains, the sides ravaged by centuries of wind and occasional torrential rains, the land as scarred as the crater of the moon, barren, red, lifeless."
And commonly with drought every few years.

"...mechanization? ...hardly a trace...either by U.S. or by Russian standards..."

This is not our future (hopefully). But just as Israel reclaimed its desert, we stand with 1/3 of our nation poor and unused, and 1/2 of the nation still attached to a hard life because of climate. Nevertheless, in every case there is a local life and there is a central government. In the large our future will still lie with how we succeed in taming nature locally to our ends. And that always means coming to grips locally, with understanding of the thermodynamics of living. And, remotely, with comprehending and planning and empathetically helping the local way of life to succeed in near self-support.

Summary

At the suggestion of our project monitors, we turned our thermodynamic theory to the question: Attempt to formalize in a modelling sense what might be done in an urban economy, wherein transportation planning and other institutionalized requirements of the domain are also to be satisfied. Build technical notions toward a model that leads toward experimental testing within the real system and by means of the model. To that end we have developed some primitives for an urban system information flow policy model based on a Ziebolz two time scale controller. Policy is open to the existing ideology of the society.