A Systems Approach To The Analysis of Transportation Law

RALPH K. JONES*
KENT B. JOSCELYN**

INTRODUCTION

The systems approach to solving large-scale problems has enjoyed considerable success in complex technological undertakings but has not lived up to its expectations for solving society's problems. It is hypothesized that there are two principle reasons why the systems approach has not been widely employed for legal systems: (1) lack of personnel capable of understanding the techniques of both law and science and (2) lack of suitably processed data. The authors' experiences in applying systems methodologies to the area of transportation law (*i.e.*, legal systems dealing with highway safety) indicate that these problems can be overcome and that operationally useful results will follow. In particular, the systems approach has been found to be a practical means for clarifying legal system objectives and for coordinating legal system functions.

* Staff consultant to the Public Factor Division, Highway Safety Research Institute, University of Michigan; President of Mid-America Research Institute; B.S., Drury College, 1950.
** Director, Public Factors Division, Highway Safety and Research Institute, University of Michigan; B.S., Union College, 1957; J.D., Albany Law School, 1960.

I. THE SYSTEMS APPROACH TO SOCIETAL PROBLEMS

A. *NATURE AND ORIGIN OF THE SYSTEMS APPROACH*

In 1941, Sir Julian Huxley prophesied:

> As the barber-surgeon of the Middle Ages has given way to the medical man of today, with his elaborate scientific training, so the essentially amateur politician and administrator of today will have been replaced by a new type of professional man, with specialized training. Life will go on against a background of social science. Society will have begun to develop a brain.[1]

Huxley likened the evolution of society's new "brain" to the biological process that led to the human brain, the first step in that process being the addition of two centers of correlation in different parts of the brain (one for sensory functions and the other for action functions) and the second step involving the enlargement of the so-called association areas of the brain which are essential to self-consciousness and conceptual thought. He observed that the highest stage of evolution yet reached by any society was, by biological standards, extremely primitive, "higher than that of a fish, but certainly not beyond that of a reptile." To rise to a level comparable to the human brain, society's brain would have to greatly increase its capability for obtaining information and for planning, correlating, and flexibly controlling execution. He perceived that:

> some large single central organization must be superposed on the more primitive system of separate government departments and other single-function organizations; and that this, like the cerebral cortex, must be at one and the same time unified and functionally specialized. It will thus contain units concerned with particular social and economic functions, but the bulk of its personnel will be occupied in studying and effecting the interrelations between these various functions.[2]

In today's jargon, it might be said that Huxley was proposing a *systems approach* to planning and controlling the functioning of the social organism. The term appears to have originated in the early 1950's to describe techniques being developed for managing large and complex aerospace projects. In essence, the approach taken to such projects was characterized by a concentration on the whole problem rather than on its component parts. As described by one of its most successful practitioners, Simon Ramo,

> It is an approach that insists upon looking at a problem in its entirety, taking into account all the facets, all the intertwined parameters. It is a process for understanding how they interact with one another and how these factors can be brought into proper relationship for the optimum solution of the problem. The systems approach relates the technology to the need, the

1. S. HUXLEY, MAN STANDS ALONE 239-40 (1941).
2. *Id.* at 250.

> social to the technological aspects; indeed, it starts by insisting on a clear understanding of exactly what the problem is and of the goals that should dominate the solution and lead to the criteria for evaluating alternative avenues. As the end result, the approach seeks to work out a detailed description of a specified combination of men and machines—with such concomitant assignment of function, designated use of material, and pattern of information flow that the whole system represents a compatible, optimum, interconnected ensemble for achieving the performance desired.[3]

Representative F. Bradford Morse of Massachusetts has described the systems approach as

> a way of thinking about the job of management. It provides a means for arriving at the best solution to the complex problem or combination of problems by means of a logical process of identification and control of all their interrelated segments. The genius of the systems approach is its ability to bring order out of tremendous numbers of diverse and interacting elements and factors—order that not only stabilizes but creates the conditions for progress as well.
>
> The approach has two main features. First, the problem or problems to be solved are rigorously defined, in terms of performance objectives rather than in terms of product specifications or particular technologies. . . .
>
> The second feature of the systems approach is its emphasis on the interrelations within a system. Rather than dividing a problem into manageable sub-problems and solving each independently, the systems approach enables the managers to develop and implement a plan capable of achieving the entire objective. It provides for comprehensive planning, traces out the effect of any set of choices and decisions upon all other relevant decisions, and then arrives at the solution to the total problem.[4]

It would appear that, reduced to its essentials, the systems approach is nothing more than common sense applied to large-scale problem solving, and is therefore not very new. One imagines that there were pre-historic project directors planning and organizing axe-head production, that someone was devising a pre-Christian project plan for construction of the Parthenon, and that engineers were evaluating the merits of alternative routes for the American transcontinental railroad long before any of the catchy new phraseology became popular. Yet there is a difference between the old and the new systems approach, and the difference lies mainly in the scale and complexity of the projects and in the sophistication of the tools and techniques used to accomplish them. The technological and organizational problems of placing a man on the moon in less than a decade are several orders of magnitude greater than building a Great Wall of China in 1000 years. and the management tools required to solve these larger problems are correspondingly more sophisticated.

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3. S. Ramo, Cure for Chaos 11 (1971).
4. 112 Cong. Rec. 20715 (1966) (remarks of Rep. Morse).

Thus, there has appeared in recent years a new approach to planning, organizing, and accomplishing complex technological undertakings, an approach whose basic concepts are deeply rooted in the past but which is, at the same time, unique to today's technological society. The question is: can this systems approach be usefully applied to society's problems, problems which are, in many cases, more concerned with the activities and interrelationships of human beings than with the primarily technological? Is the systems approach really the beginning of a social brain? Many analysts believe that it is, and have written glowingly of its potential benefits. Ramo, a pioneer in the development of the new systems approach, calls it flatly "a cure for chaos." He speculated in 1969 that

> In ten years, the battle might well have been joined, the contest being between the growing need, on the one hand, and the application of the scientific systems approach to the areas of social engineering, on the other. After that, it may take another couple of decades of strong utilization of the systems approach to get on top of these problems.[5]

At this point Ramo sees the dawning of a "golden age" when the "full application of logic, objectivity, and all the facets of science and technology [are used to] get solutions to society's problems. . . ."[6]

B. *Early Attempts to Apply the Systems Approach to Societal Problems*

Government agencies have also become interested in applying the systems approach to social problems, and the U.S. Senate has introduced bills to study and implement systems techniques for this purpose. In 1965, Senate Bill 2662 was introduced "to mobilize and utilize the scientific and engineering manpower of the Nation, to employ systems analysis and systems engineering to help fully employ the Nation's manpower resources to solve national problems."[7] Several other similar bills were subsequently introduced in both the Senate and the House, culminating (in 1967) in Senate hearings before the Special Subcommittee on the Utilization of Scientific Manpower[8] on two bills[9] to study, mobilize, and utilize the systems approach in solving "national problems." Interestingly, none of these bills was ever passed.

Since the mid-1960's fragmented efforts have been conducted to apply the systems approach to non-defense problems. In November of 1964, the State of California announced a plan to apply systems engineer-

5. S. Ramo, *supra* note 2, at 115.
6. *Id.* at 116.
7. S. 2662, 88th Cong., 1st Sess. (1965).
8. *Hearings on Scientific Manpower Utilization Before the Special Subcomm. on the Utilization of Scientific Manpower of the Senate Comm. on Labor and Public Welfare*, 90th Cong., 1st Sess. (1967).
9. S. 430, 90th Cong., 1st Sess. (1967); S. 437, 90th Cong., 1st Sess. (1967).

ing techniques to four public problems which were of major concern: transportation, waste management, crime, and information control. More recently systems techniques have been applied to many other social problems ranging from health care delivery to environmental control. In 1967, interest in such application to legal systems was stimulated by the President's Commission on Law Enforcement and the Administration of Justice, both of which offered numerous examples of the systems approach to analyzing and improving the operations of the criminal justice system. A commission task force report noted that:

> There are distinct limits at looking only at the parts [of the criminal justice system]. What is also needed is a means of relating the parts to each other. The Criminal Justice System must be viewed as an integrated whole . . . .[10]

Subsequent passage of the Law Enforcement Assistance Act in 1968,[11] and its requirement that participating agencies engage in comprehensive planning of their criminal justice system (CJS) activities served to further encourage the application of systems techniques. Since then, a broad spectrum of related activities have been reported in the literature. One of the earliest and best-known attempts at a systems analysis of CJS activities was a comprehensive analysis of offender cohort proceedings through various enforcement, court, and corrections agencies. This study was conducted by Blumstein and Larson (both of whom had participated in the above-mentioned task force study) in 1968. It developed and applied a quantitative model for the CJS in one state, depicting the flow of arrested persons through the system as a function of type of crime.[12]

Activity has also been evidenced in the area of systems theory as applied to legal and other social processes. Many interesting and sometimes original systems-oriented methodologies and conceptual approaches have been described,[13] but there have been few attempts at applying directly to legal systems the specific tools and techniques that have been used with so much success in the world of technology. Further, there is evidence of confusion on the part of some writers on systems analysis methodology as to the exact nature and uses of these tools and techniques.

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10. INSTITUTE FOR DEFENSE ANALYSIS, A REPORT TO THE PRESIDENT'S COMMISSION ON LAW ENFORCEMENT AND THE ADMINISTRATION OF JUSTICE 53 (1967).

11. Pub. L. No. 90-351, 82 Stat. 197 (1968), codified at 42 U.S.C. § 3701 (1970).

12. Blumstein & Larson, *Models of a Total Criminal Justice System*, 17 OPERATIONS RESEARCH 199 (1969).

13. Bertlanffy, *General Systems Theory—A Critical Review*, 7 GENERAL SYSTEMS (1962) (Yearbook of the Society for General Systems Research); Goldman & Jahnige, *Eastonian Systems Analysis and Legal Research*, 2 RUTGERS CAM. L. REV. 285 (1970); Howlett & Hurst, *A Systems Approach to Comprehensive Criminal Justice Planning*, 17 CRIME & DELINQUENCY 345 (1971); Navarro & Taylor, *An Application of Systems Analysis to Aid in the Efficient Administration of Justice*, 51 JUDICATURE 47 (1967).

Thus, despite a growing awareness on the part of researchers and practitioners of the need for a more comprehensive and methodical approach to the analysis and engineering of the legal system, the promise offered by the systems approach has not yet been fulfilled. No social brain has materialized, and no golden age has dawned.

On the surface, this lag in the application of the systems approach to the legal realm might appear incongruous, since the legal system has long been considered an example of man's finest effort to bring objectivity, order, logic, and reason to the management of social conflict.

C. Reasons for Lack of Widespread Application of the Systems Approach to Legal Systems

We hypothesize that there are two principal reasons why the systems approach has not been transferred to analysis of legal systems.

First, the application of any methodology requires manpower. The individuals who possess the requisite skills to utilize system analysis techniques effectively are for the most part unfamiliar with legal system concepts. Conversely, the individuals who man our legal systems are in general unfamiliar with system analysis concepts. The separation is perhaps even deeper. Typically, the systems analyst is a product of a so-called "hard science" background with minimal exposure to the social sciences, including law. In the same sense the legally trained individual has often scrupulously avoided intensive exposure to the sciences. Each disciplinary area has developed its own semantic structure and mystique that tends to preclude effective interdisciplinary communication. Thus, those who are confronted daily with the issues of the legal system do not realize that an effective methodology is available to them for problem solving, and instinctively avoid "scientific" applications. In contrast, many systems analysts approaching a socio-legal problem fail to recognize the subtle complexity of the issues and the flow of history that dominates legal systems. Effective application of the systems approach to socio-legal systems will be dependent upon the development of personnel capable of understanding the techniques of both law and science. Men capable of bridging the two cultures must be trained.

Second, data that is essential for meaningful analysis of system operations is stored in a manner that defies retrieval. Legal records, like most record systems, are stored or indexed in response to principal users. The present use makes individual case indexing most suitable. However, this precludes simple examination of classes of cases or other activity groupings. Thus, any system analysis effort must include a significant level of funding for the reduction or collection of data. Such a constraint is a partial explanation of why the literature is not replete with small "system studies" focused on the legal system.

The state of the data in reality is a symptom or indicator rather than a cause. The basic operational philosophy of the legal system revolves around concern for the individual case as opposed to the system. While distinguished scholars have expressed appropriate concern for "law systems," their impact has been minimized by the daily effort of the multitudes involved in legal system activity whose concern focuses on individual cases.

Once system personnel grasp the need for analysis of system operations one may expect that data will be stored in different modes to facilitate such analysis. Once the data is arrayed more efficiently it is reasonable to expect a significant increase in "systems studies."

II. Analyzing and Engineering Traffic Law Systems: A Case Study of an Application of the Systems Approach to Legal Systems

A. *Introduction*

For the past several years, the authors have been examining the application of the systems approach to the analysis and design of legal systems. Our initial investigations have focused on the role of the criminal justice system in the management of risk in society.

While we have been concerned with the general theory of socio-legal systems as control or risk management systems in society, our efforts have focused on the application of system analysis tools and techniques to specific examples and case studies. Emphasis has been placed on the application of existing aerospace methodologies rather than general system theories from the social sciences. This section describes our general approach to legal systems analysis and its specific application in a recent study of a socio-legal subsystem: the Traffic Law System.[14]

B. *The Traffic Law System as a Social Control System*

The first step in applying the systems approach is the development of a conceptual framework within which the tools and techniques of systems analysis can be employed. In the Traffic Law System (TLS) study, our conceptual framework was based on utility theory and the idea of socio-legal systems as social control systems. We hypothesized that social systems grow because of some utility or perceived utility to those involved. However, associated with every social system there is some disutility. Some of this disutility may be said to arise from activity that is labeled dysfunctional. Events that may produce dysfunctions and create disutility are often called "risks." While society will tolerate some level of disutility, a point will be reached when the disutility is so great that it cannot be tolerated. At that point society will take action through control systems to manage the events that create risk and produce dysfunctions in order to reduce the disutility to a tolerable level.

14. This study was performed for the National Highway Traffic Safety Administration, U.S. Department of Transportation, under Contract No. FH-11-7270. The study does not necessarily reflect the official views or policies of the Department of Transportation.

Frequently, the control systems generated to manage risk will in themselves produce some disutility. Society will then constrain the control systems to ensure that the disutility of the control process does not exceed its utility. The utility of the control process would be measured by its success in managing the disutility within the basic social system. In essence, if the cure is worse than the illness, it will not be tolerated.

C. A Conceptual Framework for Analyzing the Traffic Law System

The TLS study applied these general principles to the development of a more formal and specific conceptual framework. Here, we were concerned with society's primary formal mechanism which operates to influence or control activity within the nation's Highway Transportation System (HTS). It was therefore necessary to define in general terms the composition of these two systems and their relationship to each other and to other affected segments of society. This stage of the work was based almost entirely on four substudies:

- A literature review to identify pertinent research,
- A field survey in two jurisdictions to define the functioning of related real-world processes,
- Conferences involving scholars from various academic disciplines and professionals in the area of highway safety and traffic law,
- An analysis of the law affecting the relationships between the HTS and the TLS.

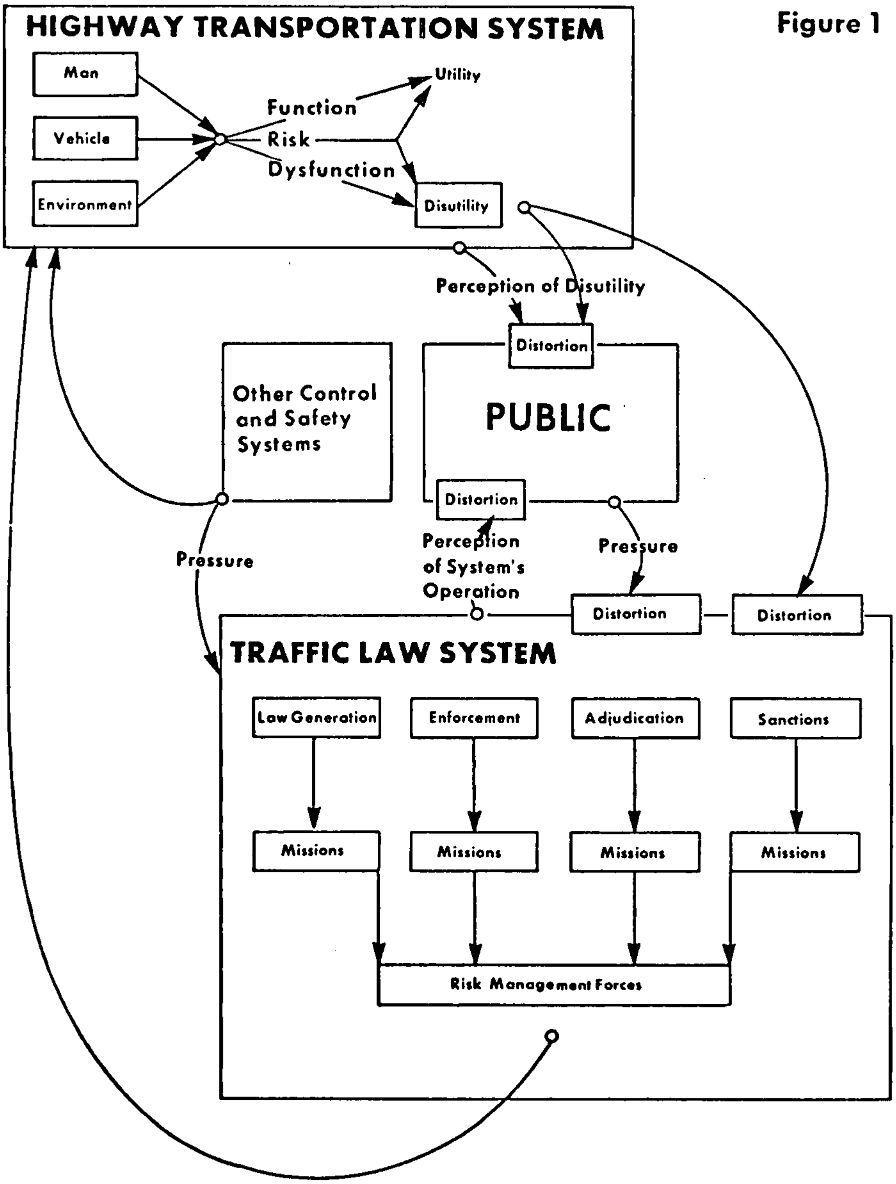
We found that the major elements of our TLS conceptual framework were as follows:

- *The Highway Transportation System (HTS)*, consisting of highways, vehicles, and drivers, plus their supporting elements.
- The general *objective of the HTS*: the provision of *fast* and *safe* road transportation.
- The economic and psychological *utility* of a perfectly functioning HTS to the general public.
- The existence of *dysfunctions* in the HTS, *i.e.*, HTS failures to function perfectly.
- The *disutility* to society caused by dysfunctions in the HTS, representing a counterforce to the utility of the HTS.
- The *public perception of the utility and disutility* in the HTS, which in general differs from actual utility and disutility.
- The *social control processes* which function to manage risks that create dysfunctions and produce disutility.
- The *Traffic Law System* as one of these social control processes.
- The concept of *risk management* as the process by which control systems function.
- The existence of specific TLS *missions* or particular sets of TLS actions taken against a particular element of the HTS which is presumed to be a primary cause of a given dysfunction.

Figure 1 shows the basic interrelationships between these elements as they were developed in the study. The figure shows that the TLS as a whole acts to exercise control over the HTS and, as such, functions as a *control system* for the HTS. The TLS itself is divided into four distinct parts, each with its own specific control function. Further, each part has different agencies and methods for exercising control over the elements of the HTS.

Traffic Law System Operation

Figure 1



The control cycle starts with the generation of dysfunction by the HTS. Dysfunctions in the HTS (crashes, traffic congestion, environmental degradation, etc.) occur in what must at the present time be considered an imperfectly defined manner. Each dysfunction generates a certain amount of real disutility (or "cost") to society, or in other words reduces the utility (or "value") of the HTS to society.

This actual disutility is observed and measured by the public, but inaccurately. Various forces intervene to make the disutility perceived by the public different from the actual disutility. The public, for instance, may not be informed of the actual cost of a certain kind of dysfunction, or of the probability of their being affected directly by this kind of dysfunction. Their knowledge, in other words, will be inaccurate or incomplete.

Despite this distortion, however, if the disfunction is sufficiently strong and persistent, public opinion about it will mount to the point where something must be done. This suggests the hypothesis that there exists a *maximum tolerable perceived disutility* which, if exceeded, results in a public demand for control forces to eliminate or reduce the unallowable component of disutility—which is now perceived as having become intolerable. This demand goes to the various social systems which have the task of exerting control over the HTS to restore it to equilibrium. One of these social control systems is the TLS.

D. Operational Modes of the Traffic Law System

In our formulation, the TLS works in three operational modes, that is, it applies its forces on three elements of the HTS:

1. Humans (drivers, pedestrians, passengers)
2. Vehicles
3. Highway environment

The TLS tries to control the disutility due to any given dysfunction by applying control forces against a selected characteristic(s) of the element(s) of the HTS thought to be a primary cause(s) of the dysfunction. Control actions are grouped together to form a TLS mission: *i.e.*, a particular set of TLS actions taken against a particular HTS characteristic(s) presumed to be a primary cause of a given dysfunction. The mission may operate in any or all of the three operational modes—driver-control, vehicle-control, or highway-control. An example of a TLS mission is the control of drinking drivers. Here, a specific set of TLS actions (*i.e.*, laws against drinking-driving, enforcement techniques, adjudication procedures, and sanctions) has been devised to reduce the disutility of crashes caused by drinking drivers. This mission is driver-oriented (that is, its operational mode is driver-control), because the driver is the element of the HTS thought to be a primary cause of the highway crash disutility.

E. Traffic Law System Functions and Risk Management

The final essential element of our TLS conceptual framework is the existence of four top-level functions performed by the TLS in all operational modes and missions:

- The generation of laws prohibiting the activities presumed to be causing the unallowable component of disutility due to HTS dysfunctions.
- The enforcement of these laws.
- The official determination of guilt for those accused of not complying with the laws.
- The imposition of legal sanctions against those found guilty of disobeying the laws.

In performing these functions, the TLS allocates its resources among numerous missions in order to achieve a level of HTS disutility that will both be tolerable to the public and satisfactory in terms of its own rankings of the various disutilities. Because of the probabilistic nature of both disutility and the effects of the forces designed to control it, the concept of *risk management* was introduced in the study as being descriptive of the TLS *resource allocation process.*

We defined *risk management* as the whole process by which a social system responds to dysfunctions. It consists of three distinct stages. At the first stage, the social system must identify the risk. This means both determining accurately the cause of the disfunction and also measuring the degree of risk caused by the dysfunction. Risk can be said to have been identified only when both steps have been taken. At the second stage, the social system must determine whether to attempt to manage the risk. Some risks are too small to be worth the effort, others are not amenable to solution no matter how great the effort. This second stage, therefore, requires two judgments. First, can the social system do anything to reduce the risk? It may be better merely to accept it as inevitable or to assign the responsibility to some other social system. Second, assuming the risk can be reduced, is the attempt worthwhile? This is a matter of resource allocation. Since resources are limited, they must be allocated for maximum effectiveness. In essence, the social system must set priorities among risks, allocating resources to deal with those risks whose reduction would produce the most cost-effective reduction in the total disutility within the system. The second phase of risk management, therefore, is complete only when the priority of risks has been examined in terms of the optimal allocation of resources. Finally, the third stage may begin: the choice of methods or measures for reducing risk.

It can be seen, therefore, that any social system must accurately perceive risk, precisely measure risk, and carefully determine priorities among risks. Assuming that the overriding objective of a social system is to achieve the highest possible level of utility and the lowest possibile level of disutility, then to achieve that objective the system must perceive risks accurately and respond to them rationally.

F. Functional Description of the Traffic Law System

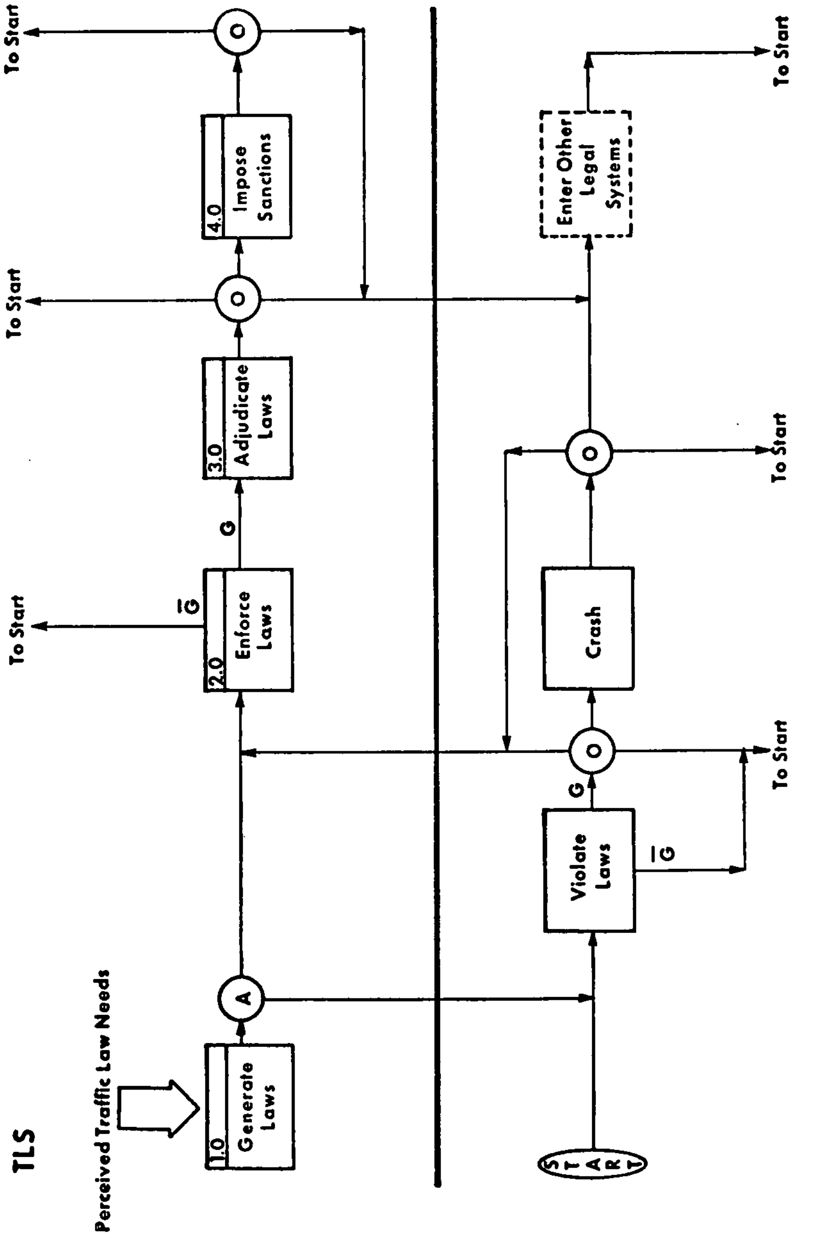
The second major step we have taken in applying the systems approach to legal systems is the construction of a firm foundation for detailed analysis by means of a generalized *functional description* of the existing system. This description identifies both the activities carried out under each of the most significant functions of the system and the agencies and personnel performing the activities. In the case of the TLS analysis, this description incorporated and summarized materials developed in the afore-mentioned substudies.

The methodological tool used in developing the TLS description was lifted almost intact from aerospace technology. Known as a functional analysis, the technique divides a system into its most general (so-called "top-level") functions and describes them through flow charts, which show how the functions are sequenced and interrelated, and by a narrative discussion. Next, the top-level functions are each broken down into their next lower level of detail (first-level functions), and appropriate flow charts and narrative are provided. The process is continued until the lowest significant level of detail has been recorded. As used in this technique, the term "function" is defined as a subunit of activities which share a lesser objective thought to be important in achieving the system objective.

The top-level flow diagram used in describing the TLS operating in a driver behavior control mode is shown in Figure 2. Alternative functions are identified by "or" gates (symbolically: Ⓞ), and functions performed simultaneously are indicated by "and" gates (symbolically: Ⓐ). The symbol "G" over an output arrow indicates the path taken if the preceding function is performed ("go"), and "$\bar{G}$" indicates the path if the preceding function is not performed ("no-go"). For the TLS, the process starts when the citizen violates a traffic law generated by the legislative body and implemented by the various highway and enforcement agencies (function 1.0). If the citizen does not violate a traffic law, the process starts over again. Otherwise, the citizen is defined as a traffic law violator, and all future system interactions are a result of his being in this state.

After reaching the violator state, three alternative paths are presented:

1. No crash and no interaction with TLS (return to "start").
2. No crash and interaction with TLS enforcement.
3. Crash.



Traffic Law System Top-Level Flow Diagram
(Driver Behavior Mode)

If a crash occurs, the citizen may not experience any contact with the TLS (*e.g.*, low level of damage, hit-and-run) and may, as before, return to "start." Otherwise, he will interact with function 2.0, "Enforce Laws." An enforcement action (arrest or summons) may not result, because of lack of detection or other reasons, and the citizen may return to "start."

An enforcement action will lead directly to function 3.0, "Adjudicate

Laws," which is involved with the administration and conduct of the trial or hearing, and the subsequent official determination of guilt. A finding of "not guilty" will result in a return to "start" while a "guilty" finding will lead to the imposition of sanctions (function 4.0) or to other legal systems (appellate courts). Civil and criminal action may also follow.

G. Objectives and Effectiveness of the Traffic Law System

The functional description makes it possible for one to proceed with the next step in the system analysis, the analysis of system and subsystem objectives. The objective of the TLS is, through the application of social control forces, to restrict the disutility due to dysfunctions in the HTS to a level which is societally acceptable. Subsystem major objectives in a driver control mode were subsequently defined as:

Law Generation

- Provide for operation of the TLS.
- Define risk precisely.
- Proscribe risk behavior.
- Prescribe "correct" behavior to create common expectations.

Enforcement

- Manipulate individual behavior to reduce risk.
- Initiate formal control system action (arrest/citation).

Adjudication

- Determine fact and law in a particular event involving an individual charged with an act that "Law Generation" has formally labeled as representing a risk.

Sanctions

- Apply the ultimate system response that is intended to modify behavior to ensure that risk generating events do not recur.

After outlining the present system's objectives, the next stage in our system approach involves the devising of methods to measure the effectiveness of the present system and subsystems, by comparing the present performance with its ostensible objectives. While it is desirable to make the measures of effectiveness quantitative, we have generally found that the data necessary to do so are not readily available. Nevertheless, the precise specification of needed data is in itself an essential part of the early phases of the system analysis process and should not be bypassed.

The meaningful quantitative parameters of a system are best determined through development of a system quantitative model, a rigorous statement of system structure relating system effectiveness and performance to system functions. Rather than presenting the surface of its subject, a quantitative model depicts the skeleton of the underlying relationships between one part of the system and the others in such a way that their workings can be observed, measured, and altered. It must be quantitative rather than qualitative, for its purpose is not merely to describe a system but also to act as a blueprint for the redesign of the system. It is a basic tool of the systems approach, the pattern from which new modifications depart and by means of which the possible effects of new modifications can be anticipated and measured. When sufficient data are available, the quantitative model may be computerized; but whether the data are available or not, the quantitative model serves as the principal method for organizing and disciplining one's ideas about the design and engineering of any new system.

A system manager or designer needs a quantitative model because it gives him a better way of understanding the manner in which the different components of the system influence its effectiveness in achieving its objectives. It enables him to organize his thinking and helps him to be sure that his knowledge of the multiple cause and effect relationships between components is as complete as possible and thereby gives him a reasonable chance of anticipating undesirable effects.

A quantitative model also facilitates the proper exploitation of the manager's expertise. Because it is much easier to understand one part of a system than the whole, the system contains many people at the component level who possess a great deal of knowledge and experience in their own area but lack avenues and methods to forward their expertise to other components of the system, or to adapt their knowledge to information from those other components. The quantitative model provides a basic mechanism for channeling the expert knowledge of system managers into statements useful to the whole system.

Finally, the quantitative model is specific, and by providing a common and quantitative language for identifying the significant factors of the system operation, it enables each component to be evaluated in the same terms and by the standard of its contribution to these clearly stated significant factors. This, in turn, enables each component to know what data it requires and, if necessary, to remedy that lack. Simultaneously, each component can construct submodels of its own operation, which in turn describe in more detail the factors indicated as significant by the quantitative model. Thus, a constant working relationship is set up. More knowledge about component operation extends knowledge about system operation, which then facilitates component operation. The quantitative model is a basic common medium by which the system components can communicate operationally as an integrated system.

The particular kind of quantitative model developed in the TLS analysis is analytic in form. It consists of a set of mathematical expressions which describe precisely how the various TLS subsystems relate to the effectiveness of the TLS as a whole. Such a model differs fundamentally from a simulation or a game in that a unique value of system effectiveness can be determined from any physically realizable set of values of the model's independent variables. This is in sharp contrast to simulations and games where it is necessary to compute many solutions (replications) in order to determine the expected outcome of a decision.

H. Qualitative Analysis of the Traffic Law System

We have taken some care here to point out the value and utility of quantitative tools in the systems approach. However, it should be emphasized that the systems approach does not require the use of quantitative methods. For example, in the TLS study, we found it possible to make a qualitative evaluation of the system's malfunctioning by employing a well-known aerospace systems analysis technique called a *failure analysis*. The technique makes use of the previously described system functional description and makes it possible to identify those areas where the system is failing to perform its functions.

The "failures" are areas where the system is behaving inadequately or poorly. The analysis discusses in general terms the nature and location of such failures in the present system, emphasizing particularly their effects on the various subsystems. In the TLS analysis, for example, we ascertained that a major systems failure was the lack of a suitable mechanism for informing both the public and the members of the control system as to the nature of the HTS risk, for measuring their perception of that risk, and for communicating that information to the other subsystems. Thus, in qualitative terms, the major system failures were found to be administrative failures which could be met through improved management and an appropriate level of funding for the various system agencies.

I. Improving Operations Through the Systems Approach

In applying the systems approach to so-called physical systems, the ultimate intent is nearly always one of design and operation of a new system. In the case of the legal system, the intent will usually be one of modification of subsystems and components in such a way as to achieve economically and politically acceptable improvements in the existing system, or to maintain a present level of system performance at reduced cost. The trick, then, is to devise ways of modifying the system components so that the results of all are in harmony with respect to the desired overall system improvement. Horror stories about the disruptive and counterproductive effects of well-meaning but careless tinkering with legal system components are numerous and often painfully nonfictional.

The systems approach offers several specific techniques for evaluating the expected impact of proposed component modifications. Quantitative models of the type discussed previously are an obvious tool and can often be applied even if exact or complete data are not available, since the purpose will generally be to measure changes in system performance

FIGURE 3 EXAMPLE OF COUNTERMEASURE IMPACT ANALYSIS

COUNTER-MEASURE	SYSTEM FAILURES ADDRESSED	IMPACT ON: LAW GENERATION	ENFORCE-MENT	ADJUDI-CATION	SANCTIONS	TREATMENT	TOTAL SYSTEM	PUBLIC
Provide Breath Testing Devices to Patrol Units in a Sufficient Number to Allow Field Testing	1-Insufficient Detection	1-Must Authorize Use of Instrument	1-Funding Equipment Training Manpower	1-Increased Number of Cases	1-More Evidence for Sanction	1-More Evidence for Treatment Selection	1-Procedures More Accurate Definition and Detection of DWI	1-Might Be Considered as Invasion of Privacy
	2-Insufficient Evidence	2-Must Authorize Use of Results	2-Resource Allocation	2-Shift in Case Handling a) Fewer Trials & More Guilty Pleas (Plea Bargaining) b) More Complex Trials	2-Clarifies Decision	2-Clarifies Decision	2-Makes Decision More Accurate Because of Standard Procedure and Quantitative Measure	
			3-Increase Arrest Rate	3-Clarifies Decision with Better Evidence	3-Increases Range of Sanctions	3-Increases Cases	3-Creates Greater Consistency Between Subsystems and Reduces Ambiguity	
			4-Increase Quality of Evidence	4-Must Establish Operators' Expertise as a Matter of Judicial Notice				
			5-Clarifies Concept of a DWI					
			6-Simplifies Decision-Making Process					

rather than to provide absolute values. Simulations and games offer another approach to evaluating alternative modifications to components; and sometimes it will even be feasible to conduct real-world experiments in selected jurisdictions.

In our work we have found that a purely qualitative evaluation of component change effects, if done carefully, can be highly useful in the early phases of a system analysis. We have used the phrase *impact analysis* to describe the technique which involves the systematic examination of the system failures which the change would cause to be avoided or mitigated and then what impact it might have on the subsystem, the total system, and the public. Figure 3 illustrates a summary presentation of the results of such an analysis when applied to a proposed change in performance of the TLS enforcement function in dealing with the drinking driver. In addition, a more general analysis of the impact of a broad range of suggested techniques for improving the specific enforcement function of drinking driver detection identified issues concerning basic individual rights and the need for careful management of the interaction of such techniques with other social systems. These issues provide an excellent example of the modifications required in the systems approach when applied to social rather than technological processes. Few modifications within a social system can simply be ordered into effect. Few modifications can be tested in a laboratory. Though they can be given an in-depth theoretical investigation, eventually, since the legal system is integrated with other social systems, the ramifications of modifications can be fully explored only in real-world operations. Indeed, the achievement of system objectives under operational conditions is the true test of the systems approach when applied to any problem.

III. Future Applications of the Systems Approach to Legal Systems

Our exploratory attempts at applying the systems approach to legal systems lead us to believe that it offers great potential as a way of structuring, analyzing, and improving the operational effectiveness of legal systems in this country. We find, in particular, that many of the techniques developed for technological systems are directly transferable to legal systems and can be of immediate benefit to those interested in improving the system's efficiency and performance. We believe that by providing a common framework and common objectives, the systems approach offers a powerful force for integrating the management of legal systems.

At the same time, it is clear that the present state of the art of legal systems analysis is extremely primitive and that a considerable effort will be required to move the technique from the research laboratory to the field. Fundamental problems, such as management at the system level and the lack of availability of data describing the effect of system action on human behavior, need better solutions before the full benefits of the systems approach can be realized. Perhaps of even greater immediate importance is the need to train both researchers and system personnel in the philosophy and presently known methods of the systems approach so that there will be a better chance of its full range of tools being applied correctly and more frequently. With luck, needed improvements both in method and substance will follow, and the development of the legal component of Huxley's social brain can accelerate.