

Complete Value Analysis: Highway Beautification And Environmental Quality

GEORGE L. PETERSON, Assistant Professor, Department of Civil Engineering, The Technological Institute, Northwestern University

•MODERN man is increasingly surrounded by man-made environments. This is an effect of the technological explosion and is producing good and bad consequences, including artificial environments. The intended freedom may be consuming itself in the form of unforeseen and sometimes subtle repercussions of incomplete strategy. The more obvious problems are seen as threats to physical safety and are being tackled, although piecemeal, by scientists and engineers. Unfortunately, the absence of communicable diseases and direct physical hazards is not adequate to fulfillment of human existence. We may in fact be failing in very serious ways to create environments that cooperate with our fundamental goals.

What are these goals? There is no goodness except by preference.¹ Life itself can only be justified by the fact that the majority of those who have it prefer it over its absence. Likewise, there are other fundamental justifications which neither have nor require justification. They are justified by the fact that they are preferred and desired. What are they? Unfortunately, most discussions of engineering and economics laugh at such a question and proceed in their activities by way of tautological networks of justification that appear to make sense only because the circuitous complexity of the process makes it impossible to locate beginnings and ends. Obviously, before anyone can discuss the quality of anything, criteria of preference must be defined or there is no quality. The environment is no exception.

One can start with the Nicomachean Ethics and say with Aristotle that the highest of all practical goods is happiness. But we must further agree with him that there is little agreement on what constitutes happiness. To define such a goal is tautological without associating it with specific conditions of existence.

One of the most concise discussions of values is found in the writings of Santayana.² He says quite simply that the good is that which is preferred and that there are two kinds or classes of goods.³ The first class contains things aesthetic⁴ that are good for their own sake. They require no justification. They are good because they are preferred. In a more profane sense they are things that man consumes or seeks or keeps

¹Although this statement is self-evident to the author, it needs extensive clarification if arguments over semantics are to be avoided. For further discussion see: Randall, J. H., and Buchler, J., *Philosophy, An Introduction*, Barnes and Noble, New York, 1942, Chapter 12, and references; Bronstein, D. J. et al, *Basic Problems of Philosophy*, Prentice Hall, N. J., 1947, Chapters 2 and 6; Santayana, George, *The Sense of Beauty*, Dover, New York, 1955, Part I; and Sidgwick, Henry, *Outlines of the History of Ethics*, Macmillan, London, 1954.

²Santayana, George, *The Sense of Beauty*, Dover, New York, 1955.

³This is obviously an oversimplification with which Santayana might not agree. Unfortunately he is not available to defend himself.

⁴The word "aesthetic" has a more general meaning in this sense than its modern, more limited usage. Here "aesthetic" pertains to pure feelings of value of any kind that are justifiable for their own sake, not because the object of value is useful, moral, etc.

because this gives him pleasure, which is an end in itself. It is of course most meaningful to restrict these ultimately to the set of things that would be preferred if all possibilities and consequences were known.

The second class contains things moral that are good because they serve a preferred purpose. They are not valued for their own sake but because they are keys to other desirable things. This frequently involves an opportunity cost or sacrifice, which means that an opportunity for pleasure is foregone in order to obtain a more preferred opportunity.

These two classes are not mutually exclusive. There is a region of overlap in which things that are desired for their own sake also have moral implications. That is, they enter functionally into the removal or provision of opportunities to achieve good things.

SEARCHING FOR A MODEL

The problem of values is similar in concept to the economists input-output model.⁵ This is a gross oversimplification and the analogy is not completely correct, but it is discussed here in order to develop an idea. In the input-output model in its simplest form a vector of final demands for product j is given by Y_j , $j = 1, 2, \dots, n$. The total production of product j is given by the vector X_j , $j = 1, 2, \dots, n$. The input-output structure of the economy is given by the matrix $A = \| a_{jk} \|$, called the matrix of technical coefficients. The element a_{jk} is the quantity of product j required to produce a unit of product k . The model is then given by:

$$X_j = Y_j + \sum_{k=1}^n a_{jk} X_k, \quad J = 1, 2, \dots, n, \quad \text{or, in matrix notation, } X = Y + AX$$

The pattern of total production that satisfies the final demands is given by:

$$X = (I - A)^{-1} Y$$

A Goals Programming Model

Assume that a public planning agency has received a specification of goals from the power structure. These goals constitute a vector Y of n elements which are not necessarily independent. Let this interaction among goals be described by the coefficient C_{jg} . This coefficient says that each unit of satisfaction received by goal g simultaneously contributes C_{jg} units of satisfaction to goal j . This goals interaction can be written as a system of simultaneous linear equations:

$$\hat{Y}_j = \sum_{g=1}^n C_{jg} Y_g, \quad J = 1, 2, \dots, n,$$

where \hat{Y}_j is the portion of Y_j contributed by the satisfaction of other goals. Suppose that there is a vector X of m public investment opportunities, and that these opportunities are not necessarily independent. Investment of one dollar in opportunity p induces an effective investment of b_{kp} dollars in opportunity k . The total effective investment in opportunity k is thus given by the sum of the direct investment and the induced investment:

$$X_k + \sum_{p=1}^m b_{kp} X_p$$

⁵ For a discussion of input-output analysis with references see *Methods of Regional Analysis* by Walter Isard, MIT Press, Cambridge, Mass., 1960, Chapter 8.

Further assume that each dollar of effective investment in opportunity k produces a_{jk} units of direct satisfaction to goal j . This is a linear marginal utility coefficient. The total effectiveness of a given allocation of investments in terms of satisfying goal j is thus given by:

$$Y_j = \sum_{k=1}^m a_{jk} \left(X_k + \sum_{p=1}^m b_{kp} X_p \right) + \sum_{g=1}^n C_{jg} Y_g$$

In matrix algebra notation, this can be written

$$Y = A(X + BX) + CY$$

Solving for Y :

$$Y = (I - C)^{-1} A(X + BX)$$

This model is obviously an oversimplification of a multiple-objective public investment problem.⁶ Nevertheless, it is a good place to start thinking about the problem. It is a working hypothesis for a complex decision model that puts concepts into neat packages in ordered places.

One of the most difficult problems in public planning is to obtain an exhaustive operationalized specification of goals. The operational procedure most commonly used is probably the other way around. The planning staff guesses what the power structure prefers, proposes alternatives and converges to a compromise through iterative interaction.

In concept at least, the ultimate public goals cannot be determined by deductive means. They are axioms produced by a social resolution of the value structure imposed by man on existence. Inductive methods (such as a public election) must be used to obtain a statement of what man prefers. A set of rules for the process of social resolution can then be defined (or derived inductively). When the stated preferences of individuals and institutions are transformed through the social resolution rules, the vector Y of ultimate public goals is produced. The process must begin with axiomatic definition or empirical measurement followed by induction, because value is the ultimate justification and cannot be justified. For example, the elements of the vector Y might include the following: (a) preserve life, (b) preserve health, (c) provide opportunities for pleasure, (d) educate people, (e) increase economic freedom and stability, etc., (f) protect property, and (g) reduce tension.

In our society in the short run these goals might be obtainable empirically by induction from analysis of the actions and attitudes of the power structure. In the long run the goals should be inferred through social resolution of the popular will (unless one happens to be God, or happens to have discussed the matter with Him recently).

Description of the system of interactions among goals is itself a challenging research problem. The interactions are dependent on the real world and also on how the goals are stated in the first place.

The matrices A , B , and C probably cannot be operationalized, except by inference based on surveys of attitudes and opinions of people who are experienced with the processes in question. Nevertheless, intuitive judgments about small parts of a system may be more accurate than intuitive judgments about the entire system, depending on levels of perception and complexity.

⁶The purpose of this paper is not to develop a model. Rather, the purpose of the model is only to provide a way of stating as simply as possible (perhaps too simply) a rather complicated concept. Work is being done on multiple objective investment problems, and the author apologizes for not taking the time to study what has been published, so that the concept could be stated in the language of current research.

Let it be assumed that the elements of the vector Y have been defined and operationalized so that levels of satisfaction can be numerically measured. Assume also that a finite set of investment opportunities have been empirically inferred or intuitively estimated. Then the allocation decision reduces to a linear programming problem. If the goals have been expressed in commensurate units so that elements in Y can be summed, and if the goals are all equally important, then the problem is

$$\text{Max } \sum_{j=1}^n [(I - C)^{-1} A(X + BX)]$$

$$\text{S.T. } \sum_{k=1}^m X_k \leq \text{budget constraint,}$$

$$Y_j \geq \text{minimum level of satisfaction, } j = 1, 2, \dots, n,^7$$

$$X_k \geq 0, k = 1, 2, \dots, m.$$

If the elements in Y are non-commensurate, they cannot be summed and a different approach must be used. If desired levels of satisfaction can be specified for these elements, the problem can be stated

$$\text{Min } \sum_{k=1}^m X_k$$

$$\text{S.T. } (I - C)^{-1} A(X + BX) \geq Y$$

$$X_k \geq 0, K = 1, 2, \dots, m$$

Investigation of the duals to these problems might reveal very interesting things about the system. Applications of parametric programming and other kinds of sensitivity analysis might also be productive.

If the several goals are of unequal importance, a vector W of n elements must be defined. Each element, w_j , defines the relative importance of satisfying goal j . Its dimensionality might be in units of total satisfaction per unit of type j satisfaction. The model must then be redefined to include these differences in goal importance:

$$\text{Max } \sum_{j=1}^n W (I - C)^{-1} A(X + BX),$$

$$\text{S.T. } \sum_{k=1}^m X_k \leq \text{budget constraint,}$$

$$Y_j \geq \text{minimum level of type } j \text{ satisfaction, } j = 1, 2, \dots, n,$$

$$X_k \geq 0, k = 1, 2, \dots, m.$$

This model is either normative or predictive, depending on how it is defined. If it is operationalized so that its structure is isomorphic with real-world relationship

⁷Penalty functions in the criterion function, rather than minimum standards in the form of constraints might be a more interesting approach to the problem.

among goals, satisfactions and investments, then optimization recommends what decisions ought to be made, and the model is normative. If the variables and parameters are subjectively operationalized so that they describe perceptions and expectations held by a decision-maker, then optimization is predictive under the assumption that goal oriented behavior is subjectively optimum-seeking.

This general model establishes a conceptual framework, and it is now possible to talk specifically about highway beautification and environmental quality.

HIGHWAY BEAUTIFICATION, ENGINEERING, ECONOMICS, AND ART

One fundamental public goal is (or ought to be) to provide for man a pleasant and comfortable public environment. This is justifiable for its own sake. It is safe to say that a universal human characteristic is the desire to feel at home. If it is desired, then it is good, as long as acquisition of it does not preclude acquisition of other goods that are more desirable.

This question of an environment in which man feels comfortably at home is also important because of functional interaction with other goals. The matter is far more subtle than simply providing familiar and friendly surroundings or a pretty view. Suppose that we have evolved or have been designed to exist in relative equilibrium with a particular range of environmental attributes.⁸ If our nervous and physiological systems have been fitted to certain kinds of surroundings, then radically violating those conditions will produce discord. We all recognize the difference between music and noise. Noise creates tension and irritation, while music relaxes and gives pleasure. If man is unconsciously in discord with his surroundings, the consequences on his behavior, efficiency, and even sanity could be profound. Studies are beginning to point out that there may be something to this argument.⁹

In terms of practical engineering we need to give serious thought to environmental beautification for three reasons:

1. A certain amount of environmental comfort is justifiable as consumption of pleasure for its own sake. How much is justifiable is a policy question.

2. Some environmental comfort is probably justifiable because of functional impact, consciously or unconsciously, on the mental, physical, and social health of man. The more subtle questions of goodness-of-fit between man and environment are largely unexplored.

3. Pleasantness of the environment certainly has an effect on behavior. People try to obtain pleasant things and avoid unpleasant things. Beautification of highways, particularly in urban areas, may well have significant effects on local land values and land-use patterns. From another point of view, the visual sensations experienced while driving may affect highway safety and driver behavior. The variety of billboards with which free enterprise wants to line the highways may in fact help to keep drivers awake and alert.

The engineering mandate is "efficient function." There is a difference between building a structure to support a given weight and building a structure to support a given weight efficiently. It is also well recognized by engineers that a function is not efficient if it is not complete, at least within the boundaries of significance. Not to be forgotten is the principle that a perfect answer is not necessarily efficient or desired either, because the cost of obtaining it may be more than it is worth.

With these principles of engineering solidly in mind, the problem of highway beautification reduces to a few basic questions, some of which can only be answered by extensive research if, as a matter of public policy, it is decided that the answers are worth the cost.

⁸This is not a new idea. The author was most thoughtfully made aware of it by Paul D. Spreiregen in a paper he presented at the 1966 meeting of the American Association of Planning Officials. See "Making The Scene" by Paul D. Spreiregen, *Planning* 1966, p. 194.

⁹Hall, Edward T., *The Hidden Dimension*, Doubleday, Garden City, N.Y., 1966. This book has an excellent bibliography relating the problem of goodness-of-fit between man and environment.

1. How much pleasure in the form of beauty in the public environment do we want for its own sake? What portion of this pleasure should be provided (or prevented) by our highway system? This question can only be answered as a decision of public policy after social resolution of the many interacting, cooperating, and competing points of view. The question itself interacts strongly with the next question.

2. What are the other goals with which the consumption of pleasure competes for resources? How do the goals interact? What is the order of priority, and are there in fact any resources left for purchasing environmental beauty for its own sake when the priorities have been satisfied?

3. Assuming that beauty is to be produced, how can it be produced efficiently (if this is possible) so that the result is not just artistic prejudice?

4. What are the functional impacts of public investment in environmental beauty that might justify it or deny it as a contributor to other, perhaps more important goals?

From this discussion it may appear that art is not being granted a part in the process. This is not true. True art is nowhere more present than in an elegant bit of scientific research. Beauty has been defined by Santayana as pleasure objectified or cooperation among sensations. These may be visual sensations, aural sensations, intellectual sensations, or a combination of several or all kinds of feeling. Beauty, no matter what its dimensions, is easy to recognize but difficult, in certain forms, to create. Art is in the creation of it. But even art is greatly enhanced by an understanding of the principles of sensual harmony, just as the art of engineering is enhanced by an understanding of the principles of physical harmony. Things that are physically discordant, relative to their objectives, are neither good art nor good engineering. To the extent that highways are aesthetically and functionally ugly, they are in discord with the objectives they are intended to serve. The cost of these discords should be evaluated if possible and compared with the costs of harmony. Thus, complete value analysis has not been accomplished until performance has been evaluated relative to all significant fundamental goals.

If we do not know how the beauty of a highway affects the overall efficiency with which the highway serves our public goals, then we do not know whether the answers about performance that we are able to calculate are even meaningful. We may suspect on strong intuitive grounds that satisfaction of our goals is not overly sensitive to the so-called "intangibles," but until they have been successfully studied, we will not know.

TOWARD SOME SPECIFIC ANSWERS

Thus far this discussion has done nothing but suggest an ordered way to ask some not very original questions. Attention will now move to the problem of suggesting some answers that may be useful to more effective highway design, particularly in urban areas.

Obviously the final decisions about how much money to spend on beautification of highways are matters of public policy. The main plea of this paper is that this policy should not be dictated by default nor overly swayed by glittering rhetoric or eloquent expressions of artistic prejudice. Highway beautification is as much a problem in engineering as the design of the highway itself and is in fact a part of it.

Many opinions have been expressed about what is beautiful and what is not. There have been discussions of how people feel in cities and how they ought to feel. Unfortunately, some of these opinions conflict. Jane Jacobs, Lewis Mumford, LeCorbusier, Frank Lloyd Wright, Ebenezer Howard, and the President's wife, to name only a few, have all offered more or less studied opinions on what constitutes a good environment. Some people have gone so far as to suggest that money spent on beautification is wasted, because if a thing functions well, that is all the beauty that is needed.¹⁰ Others argue very strongly to justify specific objects of aesthetic beauty in the environment.

Among the more studied ideas are those of Spreiregen,¹¹ an architect, who suggests that man may need some very fundamental satisfactions from his environment in order

¹⁰Unfortunately this attitude seems to be shared by a great many engineers.

¹¹See note 8.

to feel at home. These are satisfactions that are not forthcoming from our modern artificial environments.

Hall, an anthropologist, and others have pointed to spatial needs and perceptions of space as being related not only to individual satisfaction, but also to the development of social and physical pathologies.¹² In discussing visual sensations, Hall decries the visual sterility of many modern structural forms and even alludes to such things as sensory deprivation, which, in extreme cases, has been shown to have serious consequences.

At Northwestern University we have been doing some fundamental research on perceptions of environmental quality. One of our purposes is to develop a statement of goals in terms of environmental objects. Wachs, in his studies of the attitudes of people about the investment of public funds, has shown that environmental beauty in the general context and highway beautification, more specifically, are low on the goals priority list.¹³

For the past three years the author has been studying the visual quality of residential neighborhoods.^{14, 15, 16, 17} These studies have used color photography, psychometric methods of measurement and multivariate statistics to infer visual goals. The basic model hypothesizes that the desirability of a neighborhood's visual appearance is a linear function of simultaneous satisfaction of three independent goals. These goals are:

1. Sound physical quality, as evidenced by an appearance of newness and expensive-ness;
2. Harmony with nature, as evidenced by an appearance of greenery, open space, privacy, and naturalness; and
3. Variety of richness of appearance as opposed to uniformity and monotony.

For the limited population studied, beauty was synonymous with desirability. Satisfaction of these three goals contributes to the desirability of a neighborhood, as visually perceived, according to the following relationship:

$$Y = +0.723 X_1 + 0.587 X_2 + 0.264 X_3$$

where

- Y = visual desirability (beauty),
- X₁ = sound physical quality,
- X₂ = harmony with nature, and
- X₃ = variety.

These findings have been presented elsewhere.¹⁶ It has also been shown that neighborhoods can be classified into types according to their position in the three-dimensional space formed by the factors.¹⁷

Assuming that these tentative conclusions are meaningful and generalizable, it is now possible to formulate some very specific principles of highway beautification toward the preservation of pleasant environments.

¹²See note 9.

¹³Wachs, Martin, Evaluation of Engineering Projects Using Perceptions of and Preferences for Project Characteristics, Ph.D. dissertation, Northwestern University, 1966.

¹⁴Peterson, George L., Subjective Measures of Housing Quality, Ph.D. dissertation, Northwestern University, 1966.

¹⁵Peterson, George L., "Aesthetic Considerations in City Construction," (Discussion), Journal of the Urban Planning and Development Division, ASCE, Vol. 92, No. UPI, May 1966.

¹⁶Peterson, George L., "A Model of Preference; Quantitative Analysis of the Perception of the Visual Appearance of Residential Neighborhoods," accepted for publication in the Journal of Regional Science, to appear about May 1967.

¹⁷Peterson, George L., "Quantitative Classification of Residential Neighborhoods According to the Perception of Visual Appearance," currently being reviewed for publication.

1. If highways and highway structures are constructed so that their visible portions convey the impression of sound physical quality, particularly in terms of looking new, expensive and well maintained, then half the battle of beautification will have been won. Dirty scaling paint, cracked and chipped concrete, rusty columns and obsolete form are contributors of ugliness and perhaps more serious consequences.

2. Considerable effort should be aimed at designing highways so that they appear to harmonize with nature. They should convey messages of greenery, open space, and naturalness.

3. A variety of visual forms should be incorporated in the structural design and in the landscaping. Effort should be made to avoid the often monotonous appearances of mass production and modular construction.

GENERAL RECOMMENDATIONS

Given the present state of the art with respect to understanding of environmental beauty, both for its own sake and in terms of its functional impacts, perhaps the best strategy to adopt on the question of highway beautification is the following.

1. Include excellent landscape architects, architects and designers in the decision process. Some are obviously better than others, but they are artists and part of their business is environmental beauty. Engineers have made great strides in the direction of understanding and controlling physical systems, but they know far less in the practical sense about environmental beauty than the architects and city planners. Let us give the artists a cautious ear. We might even listen to an anthropologist or two.

2. There is a great deal to be learned from plain old common sense and popular consensus. After all, it is only in very recent times that man has resorted to mathematics, models, and rational analysis in making decisions. Men have survived far longer by doing what they feel is best than they have by doing what a computer tells them is the optimum solution to a linear program that one cannot even think about without getting a headache. Ask people what they want and, where possible, try to give it to them.

3. Engage in a continuing program of well-planned research. The costs, benefits, and substance of environmental quality have been largely untouched by the scientific method. This may be a very fertile field. People may object and say that art and people are things science should not invade, but the assertion that they are something is itself a contradiction of the position. Pleasure objectified is not as great a mystery today as electricity was two-hundred years ago. Electricity is more a mystery than ever, but look what science has done just by observing its behavior.

This program of continuing research should not be allowed to suffer from a preoccupation with the environment alone. The research must study the environment in interaction with man and should thus be a cooperative effort, including not only environmental specialists such as engineers, architects, and planners, but also applied sociologists, psychologists, anthropologists, and others who admit the existence of man.

BILLBOARDS

In certain situations even billboards may be good contributors to highway beauty. The other night while driving from the northern suburbs to my home in Chicago via the Edens Expressway, I suddenly became aware of the fact that the trip is terribly tedious, especially at night. I drive that same route at least ten times a week and I am thoroughly bored by it, almost to the point of dreading the trip to and from work. As we approached our destination in Chicago, my two-year-old son began to squeal with delight as he noticed some frightfully glaring but original and unique signs dominating the scene along the highway. These are favorites of his and he has some amusing little ceremonies that he performs whenever we drive by. As a matter of fact, we all look forward to seeing these architectural monstrosities everytime we drive in or out of Chicago. In their own way, they are beautiful.

I was reminded of my family's two-week automobile trip when, as a child, one of my favorite games was reading signs and billboards along the way. Nowadays a trip across the country via the Interstate is frightfully boring. Maybe it is because I am not a child anymore, but a billboard or two is a welcome sight. There is more to beauty than uninterrupted countryside.