

LOOKING AT OURSELVES:
THOUGHTS ON PROCESS AND PRODUCT
IN APPLIED SYSTEMS ANALYSIS

William C. Clark

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Thoughts on Process and Product in Applied Systems Analysis

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This paper raises some issues concerning the practice and utilization of applied systems analysis. In order to provide a common point of departure, I begin with a lengthy quote from Howard Raiffa's excellent "partial answer" to the question "What is applied systems analysis?" He writes:

"Our Institute interprets ASA not as a technique or even a set of techniques but as an embracing rational approach to the resolution of complex problems. ASA is a framework of thought designed to help decision-makers choose the desirable (or in some cases a "best") course of action. The approach may entail such steps as:

- recognizing the existence of a problem or of a constellation of interconnected problems worthy of, and amenable to, analysis;
- defining and bounding the extent of the problems area - to simplify the problems to the point of analytic tractability and at the same time to preserve all vital aspects affected by possible solutions;
- identifying a hierarchy of goals and objectives and examining value tradeoffs;
- generating appropriate decision alternatives for examination.
- modeling the complex, dynamic interrelationships amongst various facets of the problem, taking cognizance of the uncertainties inherent and realizing that decision rules incorporating feedback mechanisms can be employed.
- evaluating potential courses of action and investigating the sensitivity of the results to the assumptions made and to facets of the problems excluded from the formal analysis; and
- implementing the results of the analysis.

Precisely because ASA is a rational approach rather than a technique, this list of steps should be understood in a qualified sense. Not all the steps need be included in every instance of responsible systems analysis. Some steps may be handled in a more formal manner than others. The order of the steps can be varied or iterated in various patterns - thus the importance of excluded factors may be repeatedly reassessed or the relevance of the objective structure periodically examined. The most useful models will mimic reality with sufficient precision to serve a broad spectrum of decisions and decision makers. The decision stage may therefore be diffuse and broad and follow the completion of the formal scientific analysis.

In summary, ASA aspired to promote good decision making. As a process it is intended to focus and to force hard thinking about large, complex problems. Where feasible, ASA makes use of automated techniques for computation and decision resolution.

As we are using the term "applied systems analysis", the discipline is interpreted in a broad inclusive sense. It is an umbrella term incorporating under its span such fields as: operations research and management science; cost-effectiveness and cost-benefit analysis; planning, programming, and budgeting (PPB); decision analysis; many aspects of cybernetics, information theory, artificial intelligence, management information and control systems, computer science, dynamic modeling, behavioral decision theory, and organization theory. That ASA embraces such a wide range of scientific activities reflects the increasingly apparent interconnection and interdependencies among these activities. Not one of the fields realizes its potential in isolation from the others nor can the increasingly complex problems of modern societies be efficiently resolved without the coordinated collaboration of these different disciplines."¹

This is undoubtedly the most thoughtful, comprehensive, and mature view of ASA I have encountered. It sets a rigorous standard for good applied systems analysis which, if taken seriously, can provide individuals and institutions concerned with ASA a difficult and exciting challenge indeed. There are even some signs, after two years of work, that IIASA is making progress towards Raiffa's ideal.

My concern here, however, is not with the progress, but with the standard itself. Our present concept of good ASA necessarily implies two assumptions:

(1) It is socially desirable to make decisions in the most rational manner possible, and

(2) The details of the ASA process, i.e. the sequencing of Raiffa's "steps", do not significantly effect the nature of the ASA product.

In the body of this paper I argue that these assumptions are at very least open to question, and in all likelihood quite unjustifiable. Present practice relies completely on the validity on these assumptions and criticism of the latter necessarily implies some fairly fundamental misgivings as to the appropriate conduct and utilization of ASA.

I do not seek to denigrate the real strengths and advantages of good ASA, and do not have in mind any specific alternatives to the viewpoint expressed by Raiffa above. But ASA and even IIASA are finally beginning to come of age, and both could surely benefit from a bit of serious, if unaccustomed, introspection at this point in their histories.

A Need to Look at Ourselves

During its first two years of existence IIASA has put a good deal of time, money, and talent into analyzing the design and impact of policy decisions in energy, environmental, urban, and other systems. It is curious, given this precedent, that we have never given even passing attention to the design and impact of ASA itself.

The analysis of ASA is not a trivial or academic matter. Knowledge has always been among the most powerful and contagious products of mankind, and the impacts of such technological innovations as the automobile, DDT, and even controlled fission pale in comparison to those of such information organizers as the printing press, television, and computer. Good ASA is an information organizer par excellence, and it would be surprising indeed were its successful promotion not to result in a variety of substantial, complex, and far reaching impacts. What these impacts are likely to be, whether they are unambiguously desirable in the broader social context, and how they might be constructively altered, are questions we cannot answer because they are questions we have not yet bothered to ask.

Similarly free from any explicit analysis is the design of the ASA process itself. Raiffa describes seven inter-related steps which may be included in an analysis, these ranging from "recognizing the existence of a problem", through "identifying a hierarchy of goals" and "modeling.... the problem", to "implementing the results of the analysis." Surely the particular fashion in which these steps are

intercalated into the overall process is not likely to be irrelevant to the nature of a given ASA result. And yet, once more, we have failed to pose the issue and are consequently incapable of contemplating either its importance or its resolution.

IIASA is explicitly in the business of developing and promoting ASA as a vehicle for increasing the impact of knowledge - more precisely, the impact of rationality - on the decision making process. Were ASA a traditional technological innovation rather than a subtle conceptual one, we already would have noted its potential social impact with no little alarm, and subjected its internal workings to no mean scrutiny. In fact, however, we have been kept from undertaking such a serious analysis of our own affairs by an aversion to self-examination which is as understandable as it is unjustifiable. This regrettable history notwithstanding, there can remain little question that ASA - or, if preferred, "knowledge systems" - presently constitute a proper and even urgent subject for study at IIASA and elsewhere.

In the remainder of this paper I advance some tentative thoughts on what issues such a study might address, and what factors seem likely to prevent IIASA in particular and systems analysts in general from undertaking the study at all.

Our Aversion to Mirrors

A serious study of ASA effects is in fact the last thing we are likely to attempt at IIASA. It is not even clear that we could successfully carry one out with all the good intentions in the world.

First, for the metaphysicians, there is the epistemological problem of whether a thing can know itself. Pose this question in any of its historical forms - can god know god, can a brain build a model of itself, can psychiatrists be expected to lead better adjusted lives than others - and the answer comes out equally ambiguous. But it would seem overly self-serving to abandon our inquest on such amorphous grounds before it is begun.

The second likely barrier is related to the first but strikes much closer to home. We all have our pet little disciplinary preferences and perspectives, more or less central to our more or less dis-integrated views of the world. Of course the fact that we are applied systems analysts should mean that we are interested in applications, and the fact that we are interested in applications should mean that we pay some sort of attention to other disciplines. But few of us are sufficiently saintly or naive to seriously believe that there isn't a lot of "I want to see my technique (or perspective) applied" in even our most sincere efforts to bring about effective applications of systems analysis. Perhaps this sort of narrow self-interest is necessary to provide the requisite driving force for the enterprise, though I would hope we could teach ourselves to do better.

But to teach ourselves we would have to consider seriously the impact and ramifications of our narrowness of view, and that is just what we seem unwilling to do, both as persons and as an institution. Such a self-examination would hurt, to be sure, and all the more so because of our rather self-righteous and uncritical acceptance of our present endeavours as a priori virtuous ones. This strong aversion to mirrors is sadly and clearly evidenced, in case there should be any doubt, by the essential failure of IIASA directorate, projects, and scientists to recognize the difference between making better decisions and making better use of a set of techniques or, at most, a particular "framework of thought." How many of us have seriously faced the issue posed so neatly by some forgotten cogitator:

"Are you doing the right thing?

Or just doing the thing right?"

Finally, there is a political factor mitigating against a critical examination of ASA impacts on society. Without imparting any motives to anyone, we can surely agree with Bacon - and heaven knows who else - that (organized) knowledge is power. Just as much of ASA's high impact potential derives from its ready translation into control, so its attractiveness to many potential users derives from the ready translation of that control into power. Without stretching the imagination - or, for that matter, historical precedent in the NMO's - one can conjure up images of ASA providing the knowledge/control/power for all manner of admirable and not so admirable uses. It would be naive to think that the power potential of ASA is not recognized in the NMOs, or that there are not proponents of our work

specifically interested in its (political) power implications. It is not the nature of such individuals or interests - whatever their nationalities - to sponsor studies such as the recommended ASA self-examination, when those studies are bound to make explicit and perhaps undermine their goals. Lest this last paragraph be interpreted in the wrong perspective, however, let me close by noting without further explanation that it seems likely that the really worrisome impacts of ASA are not those to be inflicted on society by some systems-conscious Big Brother, but rather those which will come along relatively passively, riding on the backs of us good but simple ASA missionaries.

And so, as they say in the trade, the priors seem very much against our undertaking a critical examination of ourselves and our Gospel. But what if we did? Without pretending to have carried out the comprehensive and systematic analysis of this problem which a good ASA study would require, I'd like to turn now to some of the more obvious points which would almost certainly emerge from the inquiry.

Through the Looking Glass: Evaluating the effect of systems
analysis on systems. I. ASA as product

Raiffa's comments quoted earlier make it explicitly clear that the desired product of the ASA process is rational decision-making. And Häfele, in a thoughtful review of experience in the energy field, concludes that the ultimate role of ASA is in establishing "a rationale for the formalization of the debate."²

For the moment, let me assume the ASA process to be given, and to be successful in attaining its goal. (I will return later to a discussion of the process in its own right). Granting that assumption, an inquiry into the broader implications of ASA becomes an attempt to assess the social effects of generally increasing the rationality content of decisions and decision-making.

It is essential to perceive, in contradiction to conventional dogma, that even this "pure form" of a rationality-increasing ASA is manifestly value laden. Furthermore, the underlying value presumption can be simply and precisely identified: ASA contains a dominant preference for the rational as opposed to irrational, a-rational, post-rational, or any other form of process and product in decision-making. We cannot make this preference any less of a value judgement by repeating over and over again (as ASA practitioners are wont to do) "Well, of course you want to be rational; its just a question of what you want to be rational about..." On the contrary, there are some real alternatives to the rationalist presumption. The works of the early existentialists, of Bergson, of Levi-Strauss,

and others explicitly refute the goal itself.³ Simon and the incrementalists attack the rationalist presumption on pragmatic grounds and endorse at least non-rational methods of practical decision making.⁴ Similarly, Meyerson, Banfield, Hirshman, Wildavsky, and others have produced quite enlightening social science research by consciously rejecting the rationalist assumption as an underlying model.⁵ This roster could be extended at some length, even without calling on the psycho-analytical or non-western literature for support.

The point here is that our proposed self-examination cannot concern itself only with questions of technical efficacy, viewing ASA as one of several possible processes which might be adopted to attain a generally agreed upon goal. Rather, we must recognize that the adoption of ASA constitutes, above all else, a value statement about goals. A statement which explicitly holds that maximum attainable rationality is a desirable characteristic of decisions independent of, and perhaps in contradiction to, other similarly value-laden goals. It follows that our evaluation of ASA must be preceded by an explicit value statement as to the desired nature of decision-making in a given society. If rationality of decision is chosen as our predominant goal, then good ASA (in the Raiffa sense) should certainly be considered one of the primary tools of our goal seeking repertoire. But if some other goal is judged to have a dominant or even shared position in our social value structure, then we must recognize that ASA alone is inherently incapable of attaining that goal. Further, we must understand that the use of ASA -

inexorably if implicitly invoking the rationalist presumption - may be fundamentally antithetical to the realization of our non-rationalist goals.

A pointed example of the effects of ASA's rationalist presumption has been raised by Karl Popper. He argues, in effect, that ASA's comprehensive and compelling search for positive values is plausibly conducive to the development of totalitarian societies. Societies in which utopian goals are systematically pursued in ways which, precisely because they are essentially rational and nothing else, "may easily lead to an intolerable increase of human suffering."⁶ The argument - which I will not develop here - is largely based on the observed implicit substitution of aggregate material welfare and efficiency considerations for those of individual liberty and justice in the social goal structure. Popper's case is a compelling one with respect to actual behaviour of known political systems, though he does not pretend to offer a rigorous proof that comprehensive adoption of the rationalist view must necessarily lead to nondemocratic government. Arrow's so-called "impossibility theorem" comes much closer to such a proof, and may reasonably be interpreted in the present context as demonstrating the ultimate incompatibility of democratic and rationalist values.⁷ In the end, one of these values must be explicitly judged to have priority over the other. The central point of the present essay is that ASA philosophy and practice are intrinsically incapable of recognizing either the necessity or the implications of such a value judgement.

A particularly chilling example of this insensitivity on the part of applied systems analysts was provided recently by Dennis Meadows. Asked by Business Week to explain his recommendation of a "subtle decentralized process" of social planning, Meadows replied:

"In our study of corporations, we found that the really outstanding companies - Polaroid and IBM for example - tend to have a small leadership, maybe one guy, able to diffuse throughout the organization a concept of goals and values. He pushes these down, not decisions. It guides people in a fashion much more coordinated than you'd have with central planning. We have the capability to achieve that. It takes an image." (8)

Exactly.

Nowhere in Meadows does one find the slightest recognition of the bitter historical lessons which such "one guy" self-appointed "image diffusers" have inflicted on us in the last half century. And Meadows is in no way alone. The much-touted British Blueprint for Survival⁹, for example, reflects an equally cavalier and missionary attitude on the part of well intentioned analysts. Popper's observation that entire societies can - and have - quite unconsciously allowed the rationalist value choice to be made for them, simply through their passive acquiescence to (and even enthusiastic adoption of) a growing body of more "highly rational" control and planning approaches, makes the value issue an even more urgent and critical one.

The sorts of problems contingent on ASA's dominant rationalist presumption can be usefully highlighted by one more set of examples, this time with immediate

practical import.

We can all cite specific cases of applied systems analysis where it was not sufficient just to get the answer "right". Häfele sadly notes such a situation with respect to reactor licensing in his "Hypotheticality" paper.¹⁰ Anyone in the energy field is all too aware of similar difficulties with respect to plant-siting studies. Even when no one disagrees with any stage of the analysis - including its implicit treatment of "multiple conflicting objectives, preferences, and tradeoffs" - the right rational answer ends up being irrationally rejected by the political system necessary for its implementation.

I am not referring to bad analysis here. In particular, I am not referring to analysis which neglects Raiffa's last step of "implementation". There is little enough of value written on this subject, to be sure, and less actually accomplished.¹¹ The small body of implementation work which does identify itself as part of a broader ASA study generally seeks only to identify the difficulties imposed on an otherwise correct policy design procedure by the misallocated resources, power politics, and other (regretably) irrational aspects of the situation, and to steer a pragmatic rational course through these obstacles. Even the best of these implementation-conscious ASA studies, meeting each of Raiffa's previously stated criteria, still completely fail to recognize that correct and comprehensive rational inference alone is and should be an essentially insufficient criteria for the "rightness" of a policy.

In republican society, a government derives the authority to implement proposals from its perceived performance - past,

present, and future - as a representative and legitimate mediator of citizens' rights and interests. What determines the nature of these perceptions is not primarily the "rightness" of the proposals, but rather the responsiveness of the system as a whole to citizens' desires, rational or otherwise. The system relies for the legitimate authority necessary to implement proposals not so much on the nature of the individual proposals themselves, but on the nature of the process employed to design and select those proposals.¹²

This, of course, is nothing astounding, being merely a restatement of the basic principle of (almost) obligatory minority compliance in a representative government. But note the internal contradictions and ultimate instability of the alternatives: A government which secures compliance of citizens only when they feel a given decision is "right" is doomed to an existence of either partial compliance, which is often sufficient to render the decision and the government null and void, or of total thought control designed to make the "rightness" of government-sponsored decisions a tautological matter of definition. Neither extreme is unprecedented in modern society, but it is clear that for concertive government action to be possible in a nontotalitarian context, the political implementation system must be such that it retains its legitimate right to implement even when some of its proposed implementations are (perceived to be) "wrong". This is an impossible contradiction for an essentially rationalist system which has no source of legitimacy other than the presumed (but inevitably disputed) "rightness" of its decisions. On the other hand, such transcendence of individual decisions per se by the process of arriving at those decisions is the explicit strength of

the inefficient, nonrational systems of bargaining, compromise and periodic elections which characterize Popper's archetype "Open Society".

The expected result of replacing the process-based implementation systems of political compromise with product-based ones of rationalist ASA is to force either impotence or totalitarianism on the implementing government. Häfele's comments emphasize the former fate, Popper's the latter. In either event, the adoption of ASA and its rationalist goals as a foundation for social decision-making does not seem to be an altogether innocuous or desirable social undertaking.

Through the Looking Glass: Evaluating the Effect of Systems
Analysis on Systems. II. ASA as Process

Raiffa's description of ASA lists seven "steps" or disciplinary components which might be included in the analysis process. These are portrayed in a highly schematic and arbitrary manner in Figure 1, the caption to which should be consulted by those presently in need of a footnote.

The issue to be addressed here is whether the particular process through which these components are integrated can effect the analysis' final product. By ASA process, I simply mean the way in which we guide the analysis through the "steps" of Figure 1. This includes our choice of starting point, our sequence of iterating through the steps, and the emphasis we give to each step.

Raiffa's description and most ASA applications imply that detailed process considerations are properly matters of expediency and minimally significant in determining the nature of the ultimate ASA product. In particular, they claim that a sufficient condition for good analysis is simply that all steps be considered in one or more iterations of arbitrary starting point and sequence.

Experience at IIASA and elsewhere indicates that this prevalent view of process irrelevance is almost certainly wrong, and perniciously so at that.¹³ The argument is not a rigorous or particularly edifying one, to be sure. But a review of the available evidence strongly suggests that we would be justified - and as proponents of ASA may be obliged - to undertake a study of the ASA process in its own right. I will summarize below the three most obvious lines of related

argument, the first dealing with the particular disciplinary prejudices introduced into the analysis by each of the component steps; the second with the product implications imposed by the initial orientation adopted in a given ASA process; and the last - really more speculation than argument - with possible implications of alternative sequences of process iteration.

It should be stressed that I do not pretend to fully comprehend the implications of these process considerations for ASA practice and utilization. My aim is not to show which process we should be using, but merely to argue that process considerations are almost certainly bound to make a difference in the character of our analysis results. If this is in fact the case, or even if it is only a plausible case, then the study of ASA process per se becomes a prerequisite to development of a self-conscious and useful science of applied systems analysis. It is our failure to effectively recognize the propriety and importance of such a study, rather than any anticipation of its results, which has provided the motivation for this Section.

Disciplinary Prejudices

The analysis steps referred to by Raiffa consist of fairly narrow discipline oriented activities, whose integration is one goal of the ASA process. It is readily apparent that these disciplinary steps are in no way neutral processors of the analysis problem. Rather, each step tends to impart certain characteristics of its own to the analysis, thereby introducing a more or less systematic distortion of the problem initially addressed. In order to compensate for

these distortions through the overall analysis process, it is necessary to understand their nature and origins in some detail. We do not yet have such an understanding - at least not in any systematic, ASA-relevant sense - but several concrete examples will serve to illustrate the sorts of points at issue.

Ad hoc modelling: Starting close to home, there is the forest pest or budworm project of IIASA's Ecology Group.¹⁴ To give us due credit, this is a good ASA study by state-of-the-art standards. It has incorporated substantial research at each step of the ASA process illustrated in Figure 1, and has been concerned from the beginning with serving the management needs of its clients. But we began the analysis, as ecologists, with a dynamic simulation of forest/insect interactions. And 15 or more man-years into the study, anyone can see that what we really have is still an ecological model with some ASA technique stuck on.

Our decision analysis, optimization, alternative evaluation, and even implementation activities were, above all else, acts performed on an ecological model, and only incidentally integral steps in the analysis of a policy problem. It is clear to all of us involved that the results of our analysis are qualitatively different than those likely to have been obtained had (say) a team of economists taken a lead role in the analysis. Would it have been more appropriate for our forest manager clients to consult a team of economists, trading ecological for economic bias? Would some alternative process of iterating through Figure 1's steps have mitigated the ecological bias of the analysis?

These are the sorts of urgent questions which ASA as a would-be discipline has not even begun to ask.

If the Ecology Group allowed its analysis to be dominated by cause-and-effect dynamics, however, other studies have had other problems. Referring again to Figure 1, it is possible to draw from contemporary experience the likely prejudices to be introduced by each of the disciplinary areas involved.

Boundary conditions: Brewer's review of urban ASA work shows how the ultimate analysis product can be dominated by the ostensibly tactical goal of assessing boundary conditions. The same assessment could be made of most work done under the International Biological Program (IBP) and its heir-apparent Man and the Biosphere (MAB). All of these cases show that the most likely result of an initial orientation to boundary condition assessment is simply stagnation of the analysis. In those few efforts which do not die of this affliction, an extremely conservative bias invariably persists through the ensuing ASA effort. It appears that with so much committed to detailed description of some initial view of the analysis problem, the process becomes very reluctant to modify that view as the analysis proceeds through its iterations. To do so would be to render large components of the previously assembled data base irrelevant or obsolete, and to reveal other components previously uninvestigated. The problem, of course, is that it is precisely such an iterative revision and redefinition of the analysis problem which a good ASA effort must accomplish.

Theory and "laws": much of the history of applied economics can be seen as the intentional direction of entire societies' policy design systems by a normative model of "efficient resource allocation", even though normative theory and "laws" are supposed to represent only one step of the overall analysis process.

Outside of the Marxist tradition, Lewis Mumford's writings constitute one of the most thoughtful and extensive investigations of this phenomenon.¹⁶ And, however weak and reactionary its detailed arguments, the essentially Luddist stance of much of the environmental crisis literature should at least receive credit for recognizing the value content of the efficiency credo. Finally, the archetype example of theory achieving a dominant role in the process is provided by benefit-cost analysis and its enthusiastic adoption by a great variety of decision makers. Once more, good benefit-cost work can certainly play an important role in articulating a framework for policy analysis. We need not denigrate this potential to observe that in practice the "favourable benefit-cost ratio" has all too often become a goal in itself.¹⁷ This, of course, is an instance of where ASA-process considerations spill over into ASA-product considerations of the previous Section.

Specifying goals and objectives: Unwanted process effects have also resulted from a preoccupation with the specification of goals and objectives. The best documented case is probably that of the Programmed Planning and Budgeting System (PPBS), a self-styled "systems approach" disasterously introduced into government budgeting without

consideration (or recognition) of its own substantial impact on that system.¹⁸ Alternatively, there is the critique of obsessive ends-orientation advanced by the incrementalist school in their attacks on comprehensive planning.¹⁹

Optimization: Optimization techniques are the stock-in-trade of operations researchers, and operations researchers probably constitute the majority of self-conscious applied systems analysts. It should not be surprising, in this context, that ostensibly broad ranging ASA studies turn out to be narrow optimization exercises in a regrettably large number of cases. The problem here is that successful optimizations require relatively simple views of both problem and objectives, and analysts determined to employ formal optimization techniques invariably impose the requisite simplicity on their problems.

Of course, one of the most important arts of ASA is problem simplification and bounding - Raiffa even lists these activities among his basic analysis steps. But simplification is a means properly directed towards the end of better decision making per se. If it is justified instead in terms of the requirements of analytic technique, then we are back again in the product trap of defining successful analysis itself as our goal. One look at the publication titles emerging from RAND, IIASA, and their brethren is enough to confirm one's suspicion that optimization requirements often do dominate the character of the ASA product.²⁰

Decision analysis: As much as its practitioners would like to believe to the contrary, even decision analysis (even decision analysis with multiple conflicting objectives, preferences, and value tradeoffs) tends to impart a persistent disciplinary prejudice to analysis problems. As in the case of optimization, much of the potentially distorting effect of the decision analysis step derives from its technical limitations. The (misguided?) skill and vigor with which a good applied decision analyst will try to convince his client of the irrelevance of these technical constraints must be experienced to be believed! A related but much more subtle point concerns the discrepancy between people's willingness to take risks as reflected in their answers to decision analysts' questions, and their willingness to take risks as reflected in their own behaviour.²¹ Until decision analysis as a discipline is able and willing to differentiate between preferences in action and preferences under interrogation, the proper mode of utilization and integration of their techniques in the overall ASA process will be impossible to assess.

Initial Orientation of the Analysis

As noted earlier, for nearly all of us the majority of our training and experience lies in very few techniques, problem solving philosophies, and/or subject matter areas.²² In this world, problems are not attacked by "applied systems analysts", but by operations researchers, economists, decision theorists, or whatever, who have adopted to greater or lesser extent what Raiffa calls the ASA "framework of thought". And most interdisciplinary research, whatever its strengths,

does not alter this situation.

As a result of this inescapable preconditioning, even the truest of believers in ASA carry with them a great store of essentially disciplinary preconceptions and pre-delictions. This heritage almost invariably determines the effective initial orientation of their analyses. Thus, faced with the same ASA problem and agreeing wholeheartedly and sincerely on the necessary steps to be taken in the analysis, the erstwhile decision theorist begins with a look at the political role players; the mathematician searches for structural analogies; the OR refugee seeks a quantity to be optimized; the economist establishes a foothold on existing misallocations of something or other; one breed of natural scientists begins manipulating existing behavioural data; another inquires after causal relationships of the relevant system.

This discipline-determined selection of starting points for the ASA process is characteristic of almost all actual systems work (as opposed to systems philosophy), and describes the situation at IIASA quite accurately. It follows that the "natural" ASA process is one in which an initial disciplinary orientation - and, by inference from the arguments advanced earlier, an initial disciplinary prejudice - is imposed on the analysis as an incidental consequence of the analyst's upbringing. This might constitute little more than a curiosity if those initial prejudices were systematically dissipated in the course of the ensuing ASA process. In fact, however, they are not. There seem to be two reasons for this.

The first is that the vast majority of analysis efforts

badly underestimate time requirements and, whatever their pious intentions, end up devoting (say) 90% of the analysis to 10% of the problem. Predictably, most of that analysis time is consumed in the step with which the process begins.²³

The second factor responsible for perpetuating the disciplinary prejudices of the initial analysis orientation is more subtle but at least as important as the first. Perhaps the easiest way to envision the situation I have in mind is as one of analysis "inertia", which would work something like this:

A particular initial orientation to the analysis process imparts a specific disciplinary character to the early analysis results, in the fashion suggested earlier. The process then moves on to subsequent steps inherently capable of moving the analysis in a direction which dilutes the influence of the starting position. But these subsequent analysis steps do not work with the pure, unformed problem originally encountered in the analysis (shades of structuralism). Rather, they receive the problem after one or more steps of previous analysis, with a more or less strong disciplinary component already incorporated. Again, for a self-conscious science of ASA we would need to understand better the nature of these "inertial" effects following from initial analysis orientation. We presently lack such understanding and have shown no signs of wanting to alleviate our ignorance.

Sequence of Iteration

It seems very likely that not only the starting point but also the specific sequence of analysis steps will have an effect on the final ASA product. We can plausibly extend

the notion of "inertial" effect referred to in the discussion of initial process orientation to suggest that a sequence "SPECIFYING GOALS - MODELING - DEVELOPING POLICY ALTERNATIVES - ..." would lead to a different product than the sequence "SPECIFYING GOALS - DEVELOPING POLICY ALTERNATIVES - MODELING - ...".

Furthermore, on a priori grounds alone it would seem highly unlikely that ASA problems should have formally unique solutions. It follows that different process (i.e. sequence) approaches to a given analysis problem would be likely to yield different answers. It requires but one more little leap of faith to assume that some such answers would be "better" than others and thus, once again, the understanding and choice of ASA process becomes a matter of real practical concern. Unfortunately, the lack of good ASA efforts with adequate process documentation forces me to leave this last aspect of the process argument at a largely hypothetical level. But it would seem reasonable to suggest that the burden of proof lies with those who contend that one can proceed through an arbitrary sequence of Figure 1's steps without concern for the effect of that sequence on our analysis results.

In summary, despite the ambiguities and incidental nature of the arguments cited here, the following conclusions seem justified:

* Each component of the ASA process imparts a distinct disciplinary character to the ultimate product of the analysis.

* The sequence in which each disciplinary component is invoked in a given ASA process is likely to influence the

the relative contribution of each component to the ultimate product.

* The effective sequence in which components are invoked is a largely implicit function of the disciplinary background of the analysis group, rather than an explicit choice based on analysis goals.

In short, the specific character of the ASA process is highly relevant to the specific character of ASA product. In order to improve that product it is necessary to better understand the nature of these relationships. In particular, we need to better understand the intrinsic prejudices of both problem recognition and solution generation which characterize various ASA techniques, and the sequential interplay of these techniques in the dynamic analysis process. It seems almost certain that such an understanding would lead to specification of nonarbitrary sequencing rules for the ASA process. Such understanding is equally certain to be a prerequisite for a nontrivial and self-conscious science of ASA per se, a science consisting of more than the present blithe check-list approach to disciplinary "integration". Whether IIASA or its scientists have an interest in developing or even discussing this sort of ASA science remains to be seen. It would be important research, and it would, of necessity, be highly original. But it would also be difficult, uncertain and not particularly ingratiating to those committed to elegant displays of their present presumed proficiency. The issue is an important one but, in all fairness, IIASA's stance on it probably is not.

If IIASA doesn't choose seriously to pursue good applied systems analysis, someone else eventually will.²⁴

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4. H.A. Simon. 1957. Models of Man. Wiley; D. Braybrooke and C.E. Lindblom. 1963. A strategy of decision. Free Press; C.E. Lindblom. 1965. The intelligence of democracy. Free Press; A.O. Hirschman and C.E. Lindblom. 1962. Economic Development, research and development, policy making: some converging views. Behav. Sci. 7: 211-222.
5. M. Meyerson. 1956. Building the middle range bridge for comprehensive planning. J. Amer. Inst. Planners 22: 58-64.; E.C. Banfield. 1965. Big city politics. Random House, and 1958. The moral basis of a backward society. Free Press.; A.O. Hirschman. 1958. The strategy of economic development. Yale Univ. Press, and 1963. Journeys towards progress. Twentieth Century Fund.; A. Wildavsky. 1964. Politics of the budgetary process. Little, Brown.
6. K. Popper. 1963. The open society and its enemies. Vol. 1. Princeton Univ. Press See also M. Oakeshott. 1962. Rationalism in politics. Basic Books.
7. K.J. Arrow. 1951. Social choice and individual values. Wiley.
8. Quoted by E. Rothchild. 1975. How doomed are we? New York Review of Books. 22: 31-34. pg.34.
9. E. Goldsmith et al. (eds). 1972. Blueprint for survival. Houghton Mifflin.
10. Häfele. op. cit.
11. Some of the better work includes the following:
J.L. Pressman and A. Wildavsky. 1973. Implementation: Univ. California Press; E. Bardach. (in press). Implementation; H. Kaufman. The Forest Ranger. Johns Hopkins Press; B.A. Ackerman et al. 1974. The uncertain search for environmental quality. Free Press; R.L. Crain et al. 1969. Politics of community conflict: the fluoridation decision. Bobbs Merrill.
12. This is what David Braybrooke has so aptly referred to as the "issue machine" nature of decision-making in an open society. (D. Braybrooke. 1974. Traffic congestion goes through the issue machine. Routledge and Keegan Paul). On the subject of political legitimacy see also S.M. Lipset. 1963. Political Man. Anchor Books.

13. See the various IIASA Project Status Reports, all ostensibly reporting on application of the same "framework of thought". See also: Ackerman et al. op. cit.; E.S. Quade and W.I. Boucher, (eds.). 1969. Systems analysis and policy planning applications in defense. Elsevier.; H.R. Hamilton (ed). 1969. Systems simulation for regional analysis. MIT Press.; J. Forrester. 1969. Urban dynamics. MIT Press.; R.S. Rosenbloom and J.R. Russell. 1971. New tools for Urban Management. Harvard Busn.; L. Tribe. 1972. Policy science: analysis or ideology? Philos. and Publ. Affairs Oct. 1972.
14. For details of the budworm studies at IIASA see C.S. Holling et al. 1975. A case study of forest ecosystem/pest management. IIASA WP-75-60; C.S. Holling et al. 1974. Project Status Report. IIASA SR-74-2-EC; C. Winkler. 1975. An optimization technique for the budworm forest-pest model. IIASA RM-75-11; D.E. Bell. 1974 Defining and quantifying goals for measuring the state of an ecosystem. IIASA RR-74-26; G.B. Danzig. 1973. Comments on the budworm. Forest ecology model. IIASA WP-73-12.
15. G. Brewer. 1973. The politician, the bureaucrat, and the consultant. Basic Books.
16. L. Mumford. 1971. Technics and human development, and 1970. The pentagon of power both Harcourt Brace; and 1975. Prologue and our time. New Yorker. Mar.10:42-63.
17. A. Wildavsky. 1966. The political economy of efficiency: cost-benefit analysis, systems analysis, and program budgeting. Public Admin. Rev. 26: 292-310.; E.J. Mishan. 1970. Cost-benefit analysis: an informal introduction. Praeger.
18. A. Wildavsky. 1969. Rescuing policy analysis from PPBS. Public Admin. Rev. 29: 189-202.
19. See Braybrooke and Lindblom. op. cit.
20. It is interesting to note in this context that the Harvard Water Resources Program - a group which pioneered the introduction of optimization techniques into water resources research fifteen years ago - has recently drafted a research proposal for investigating the deleterious effects of overly enthusiastic and uncritical adoption of these techniques.
21. See P. Slovic and S. Lichtenstein. 1971. Comparison of Bayesian and regression approaches to the study of information processing in judgement. Organiz. Behav. and Human Performance 6: 649-744; P. Slovic, H. Kunreuther and G. White. 1974. Decision processes, rationality, and adjustment to natural hazards. (in) G.White (ed.) Natural Hazards: local, national and global. Oxford; C. Starr. 1969. Social benefit versus technological risk. Science 165: 1232-1238.

22. For reasons I do not fully understand, this may be just as well. The notion of a "professional generalist" - as described, for instance, by G.J. Klir in his introduction to Trends in General Systems Theory (1972. Wiley) - has yet to demonstrate its practical worth. It would seem that one of the things needed by such an individual would be just the sort of studies called for here.
23. For post-hoc reviews of ASA efforts, see:
Brewer, op. cit.; E.S. Quade, 1970. Analysis for military decisions. North Holland; R. Cline. 1961. A survey and summary of mathematical and simulation models as applied to weapon system evaluation. ASD - Tech. Rpt. 61-376; M. Shubik and G. Brewer. 1972. Models, simulations and games - a survey. Rand Rpt. R-1060. ARPA/RC; B.W. Mar. 1974. Problems encountered in multidisciplinary resources and environmental simulation models development. J. Envir. Man. 2: 83-100; Ackerman et al., op. cit.
24. Steps in this direction are being taken by those seriously concerned with the role of science advice in social planning. See, for example, : A. Weinberg. 1972. Science and trans-science. Minerva 10: 209-222; H. Laski. 1930.; The limitations of the expert. Harpers Magazine. Dec. 1930.; H. Brooks. 1964. The scientific advisor (in) R. Gilpin and C. Wright (eds.) Scientists and national policy making. Columbia Univ. Press; D. MacRae. 1973. Normative assumptions in the study of public choice. Public Choice Fall 1973., and 1973. Science and the formation of policy in a democracy. Minerva 11: 228-242; A. Mazur. 1973. Disputes between experts. Minerva 11: 243-262; Anon. 1971. Guidelines for the practice of operations research. Opns. Res. 19: 1123-1158; P. Doty. 1972. Can investigations improve scientific advice? Minerva 10: 280-294; D.D. McCracken et al. 1971. Public policy and the expert. Council on Religion and Intl. Affairs; H.J. Miser. 1973. The scientist as adviser: the relevance of the early operations research experience. Minerva 11: 95-112; a large number of articles in earlier volumes of Minerva; H.L. and S.E. Dreyfus. 1975. An elaboration of the limits of scientific decision making. Unpublished ms.

Figure 1. What we do now in ASA

The figure represents a realistically dis-integrated perspective of what we do now in applied systems analysis.

Ideally, our perspective on ASA would come from the outside, looking in. That is, it would take its orientation from considerations of what I have referred to as the "Policy Design System", "Decision-Making Process", or "Issue-Machine".

Unfortunately, most ASA efforts get this quite backward and adopt a perspective originating on the inside, looking (a little bit) out. The majority of analysts come endowed with predilections towards one particular disciplinary step of the ASA process, (lower case terms in the figure). To all intents and purposes, they launch their analyses from these narrow, discipline-oriented perspectives and do little in any systematic way to escape the prejudices thereby inflicted on the ultimate ASA product. In particular, they have no well-developed rationale, - or, for that matter, concern - with how best to iterate through the remaining steps of the analysis.

The notions of "Prescription", "Description", and "Embedding" reflect some vague recognition of the need for such a sequencing rationale, and for a means of relating meaningfully to the broader policy design system. But, in general practice, these ideas tend to become empty, meaningless and ambiguous. Prescriptive statements emerge under the guise of system description; description of the status quo is fobbed off as prescriptive analysis; and the useful concept of embedding is stretched beyond its intended use to become a sanctioning invocation for the most simplistic of assumptions.

WHAT WE DO NOW IN ASA: A DISINTEGRATED PERSPECTIVE

