U. S. AIR FORCE

PROJECT RAND

RESEARCH MEMORANDUM

OBSERVATIONS AND COMMENTS
ON THE ORGANIZATION STUDIES
OF THE
SYSTEMS RESEARCH LABORATORY (U)

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RM-922

29 August 1952

Assigned to _____

This research is sponsored by the United States Air Force under contract No. AF 49(638)-700 monitored by the Directorate of Development Planning, Deputy Chief of Staff, Research and Technology, Hq USAF.

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PREFACE

The general program of the Systems Research Laboratory was outlined in RM-890. In that memorandum, the concept of "growing" human organizations under a set of realistic but controlled or controllable conditions was discussed. A particular man-machine organization, that of a Ground-Controlled Intercept Station (ADDC) of the Air Defense Net, was selected for laboratory study. RM-887 describes, in a preliminary fashion, the results of the first experiment with a crew of twenty-eight college students. The present memorandum, prepared by Herbert A. Simon, Consultant to the Mathematics Division of The RAND Corporation, is the result of many discussions with SRL staff concerning the concepts from organization theory which might be useful in the analysis of the data of the experiment.

The reader who is not familiar with the special vocabulary of the Air Defense Net will find a short glossary of abbreviations and symbols at the end of the memorandum.

I.

INTRODUCTION

This memorandum will summarize some of my observations regarding the Systems Research Laboratory, and more particularly the discussions in which I have participated with members of the staff. In the course of our discussions a number of points were touched upon that may be worth recalling for their application to the data analysis now going on.

II.

THE RELATIONSHIP BETWEEN EXPERIMENTERS AND SUBJECTS

The complete behavior system to be described and explained includes the pattern of behavior of the subjects, the behaviors of the experimenters, and the influence of the latter upon the former. (We assume that there is no significant feedback in the opposite direction--from the behaviors of subjects to the behaviors of experimenters, or at the least, that there is no feedback from the behaviors of the subjects to the strategy of the experimenters. Hence the behaviors--or at least strategies--of the experimenters can be regarded as independent variables.)

By the pattern of behavior of the subjects is meant the whole hierarchy or system of programs that govern their behavior at a particular time. The pattern of behavior at any time can be pictured as having been selected from a large set of possible patterns of behavior. Various influences on the pattern (i.e., on the selection process) can be described by subsets of patterns within which the final selection must take place.

By their formulation of the problem to be solved by the subjects, including the problem goal and the technology, the experimenters select the subset of behavior patterns that are relevant to the problem. The statement and reinforcement of the problem goal influence the subjects to select from this subset those behavior patterns that appear optimal for achieving the goal. We might describe this by an ordering relation on the behavior patterns in the relevant subset.

Now the experimenters may impose other restrictions on the subjects--besides defining the goal and the technology. These restrictions (e.g., S.O.P's.) can again be defined in terms of the subsets of patterns to which they limit the subjects' behaviors. Consider the intersection of the subset of relevant behaviors with the subset of behaviors permitted by the specified operating procedures. This intersection may or may not include that relevant pattern which is optimal for goal achievement. One of the considerations that entered into the planning of this study was that if operating procedures were specified in detail, and the specification enforced, the optimal pattern would, in fact, lie outside the subset of permitted patterns.

How can we represent in the model that the subjects were instructed in certain operating procedures, but were given freedom to alter them? In a dynamic model we could classify the limits imposed by the experimenters in two groups: (1) constraints established and enforced throughout the experiment, and (2) initial conditions which the subjects were permitted to change. To simplify the model, the constraints can be regarded as part of the problem technology. The influence of the experimenters upon the subject can be described, then, in terms of (1) the patterns of behavior relevant to the problem and its given technology, and (2) the limits, imposed by operating procedures and training, upon the behavior patterns permitted at the outset.

One kind of influence upon the subjects is not included in the above: placing particular persons in particular positions in

the organization in order to have a role played in a particular way. This kind of intermittent intervention appears to involve a "jump" of the dynamic system through a shift to new initial conditions.

So much for the general framework of the experiment. Within this framework, we can discuss: (A) the kinds of propositions of organization theory that might be meaningful in this setting, and (B) the strategy of the experimenters.

A. Propositions in Organization Theory.

At least three classes of propositions in organization theory must be distinguished. The first class refers only to the behavior patterns of the subjects. The second and third classes refer to the relation between the behaviors of the experimenters and the behavior patterns of the subjects.

1. Propositions of the first class state properties of optimal points in the set of relevant behavior patterns. That is, they state which of the relevant behavior patterns the subjects would have to choose in order to behave optimally with respect to the goal.

2. Propositions of the second class state how changes in initial conditions or constraints effect the path the system follows or the equilibrium position that is reached.

3. Propositions of the third class state how changes in the constraints and initial conditions can be brought about by the behaviors of the experimenters.

Some rough examples may make the distinctions clearer. A proposition that has been suggested under (1) is that an optimal behavior pattern requires "maintenance" activities as part of it.

Another is that movement toward optimality involves the evolution of successive levels of programs.

An illustrative proposition under (2) is that a role tends to expand rapidly when played by an aggressive person, but to contract much less rapidly when the aggressive subject is replaced by one less aggressive. A proposition under (3) would be that a feedback from the experimenters of information about performance will weaken the subjects' feeling about legitimacy that restrain the modification of S.O.P's initially established.

It appears from these examples that the line between classes (2) and (3) is not as sharp as the line between (1) and the other two classes. That is, it is not always easy to distinguish between the behaviors of the experimenters and the changes in constraints or initial conditions brought about by these behaviors. Nevertheless, it is probably desirable to retain this conceptual distinction. The two become distinguishable as soon as the experimenters use influences other than authority to bring about changes, and as soon as the attitudes of legitimacy in the subjects are insufficiently strong to secure complete and immediate acceptance of the experimenters' authority. For example, the imposition (attempted) of certain S.O.P's might be followed, not by incorporation of these in the behavior pattern, but by behavior aimed at concealing noncompliance. (Query: Did the very complete surveillance the experimenters were able to exercise over the subjects induce additional forces toward compliance that are absent from most administrative organizations?) Another way of stating the distinction between (2) and (3) is that the constraints and initial conditions are

intervening variables between the behaviors of the experimenters and the resulting behavior pattern of the subjects.

B. The Strategy of the Experimenters.

The strategy of the experimenters can now be characterized as follows:

1. It was assumed that in a sufficiently stable environment, the subjects would in time evolve a behavior pattern that was nearly optimal for goal attainment, in terms of the goals operable for the subjects.

2. It was assumed that by reinforcing only the goal desired by the experimenters, and by permitting the development of strong group cohesiveness in the subjects, the goal desired by the experimenters would become the operable goal for the subjects.

3. It was assumed that the attainment of an optimal pattern could be facilitated by the exercise of some control of the assignment of subjects to roles (e.g., assigning an aggressive subject to a role in order to "enlarge" it).

Of course, in a single experimental run, without controls, these assumptions cannot be tested. The observations show that under the actual conditions of the experiment, the subjects continued to evolve a more and more effective behavior pattern and arrived at one which, judged from rough knowledge of performance in actual stations, was highly effective. The observations also show little evidence of the creation of conflicting goals, within subgroups, group goals conflicting with the experimenters' goals, or other subgoal formation. Finally, there is evidence that

evolution of the behavior pattern was accelerated by reassignment of personnel. At present these observations are largely subjective, and need to be objectified, and even then, need to be compared with performance with different experimental strategies.

III.

THE EVOLUTION OF PROGRAMS

By "program" is meant the rules that guide the behavior of the subjects in choice situations. At the outset of the experimental runs, the subjects' program was presumably characterized by:

1. The S.O.P's established initially by the experimenters.
2. Beliefs, attitudes, and habits, with respect to behavior in groups, teams, and organizations brought into the situation by the subjects. For example, a subject possessing attitudes that are typical in our culture would bring in certain habits of behavior toward another subject who had been designated by the experimenters as a hierarchical superior.

As the trials proceeded, and as the load was increased, this initial program did not always appear adequate to the subjects for achieving the goals. The subjects then began to modify some operating procedures and to add others (e.g., establishing priorities for reporting plots).

A. Characterization of Programs

It now becomes necessary to raise the question of how the programs are to be characterized. First, is it useful to distinguish between the pattern of behavior and the program? The pattern of behavior depends, of course, upon the environmental stimuli. The program, on the other hand, may be defined as the strategy for

responding to a whole set of possible environmental stimuli. The behavior pattern, then, is the dependent variable, with the actual stimuli and the program as the independent variables. The program will undergo gradual modification to produce a behavior pattern appropriate for goal achievement in the face of the experienced class of environmental stimuli. A change in the stimuli may now make the program inappropriate to goal achievement (e.g., the breakdown in the final run).

B. Program "Levels"

Second, is it useful or necessary to introduce a concept of program "levels"? In game theory there is no need for introducing the notion of higher levels of strategy. But game theory deals with organisms possessing powerful computing abilities--they do not require approximations or simplified models of the problem, but deal with it all at once and in all its complexity. In organization theory, we may wish concepts that are more nearly descriptive of actual human problem-solving capacities and behaviors. In problem-solving behavior, the behavior pattern in response to an environmental stimulus depends on "set". The set is the program, a change in set is a change in program. If the organism possesses, however, additional systematic responses that bring about changes in set, also as a result of stimuli, we may wish to describe these set-changing programs as programs of a higher level.

If this is to be the basis for our concept of program levels, then not every change in a program through elaboration is to be regarded as the creation of a program at a higher level. If, for example, under conditions of high load the group develops a system

of priorities, the priority rules are simply part of the new zero-level program. If, however, the group switches back and forth from a program with priorities at high load levels, and if the environmental stimuli that bring about the switch can be described in programatic rules, then these latter rules constitute a first-level program.

Another, related, way of characterizing the level of a program is by establishing the range of environments over which it is applicable. Thus, the switching rules mentioned above are applicable to both high and low loads, while the program with priorities, and the program without priorities are each applicable only to a specified range of loads. There are other program elements besides switching rules that are invariant over a wide range of environments. In terms of the present criterion these would be regarded as belonging to higher level programs. One example is a program for maintaining the zero-level program--checking and enforcement activities. Another example is a program for dealing with the unexpected ("disaster program"). A common rule in such a program is: "Inform your superior promptly and await a decision by higher levels of the hierarchy."

It is not at all clear from this whether discrete program levels can be sharply distinguished. Nor is it clear which of the criteria that have been mentioned (or some other) should establish the level of a program element.

To confound the confusion further, one is inclined to feel that there is some relation between the hierarchical level at

which a strategy is executed and the program level to which the strategy is to be assigned. Some such notion is implicit in the usual distinction between "policy" decisions and "administrative" decisions that implement policy. To what level of program do the personnel assignment decisions of the crew chief belong? When the SD asks the ASC why a particular track was scrubbed, at what program level does the decision lie to ask this question? Is it the same as the level at which the SD decides to ask the ASC to report an altitude to him?

One way of answering these questions would retain one or the other of the original criteria that were suggested for assigning program levels. One could then add the empirical proposition (subject to empirical confirmation) that in fact the decisions of subordinates largely relate to lower program levels, the decisions of subordinates largely relate to lower program levels, the decisions of hierarchical superiors largely to higher program levels. In terms of "sets", this would amount to saying that the principal behaviors of hierarchical superiors relate to the alteration of sets of their subordinates. Or, in terms of the broader definition of levels, this would mean that maintenance programs, disaster programs, and the like are the primary concern of hierarchical superiors. Life is probably not as simple as this, but this may provide a reasonable first approximation. (One example will show why this is an oversimplification, at least if higher levels are identified with switching rules. By this criterion, load balancing would be part of the zero-level program. Yet,

because he is in possession of better information, the load balancing function tends to be handled by the ASC--or the Supervisor--rather than the individual plotters and tellers.)

C. The Description of Programs

The totality of programs evolved by the subjects is extremely complex. Nevertheless, it does not seem impossible to describe it approximately in very concrete terms. The S.O.P's constitute a first approximation to such a description. Closer approximations become quite voluminous, but, in principle, appear to be possible to construct. For purposes of organization theory, however, we would want to characterize optimal programs in terms that are not specific to the technology and requirements of this particular problem. Unless we can discuss programs in terms that are relatively abstract and that permit interorganizational comparison, the program descriptions are useless for theory.

Now the terms appropriate for describing higher level programs (assuming that we know what this means) appear more abstract than the terms appropriate for describing the zero-level program. Such terms as "switching rule," "priority system," "redundancy," "load balancing," et cetera, have meaning outside the context of this particular problem, while terms like "TD'ing", "assigning a track number," et cetera, do not. It would be very useful to construct an abstract vocabulary for higher-level programs, or, what amounts to the same thing, a taxonomy of the categories into which such programs fall. In any one organization, we would not expect to find examples of all the species belonging to such a taxonomy,

but we might arrive at a fairly complete classification by examining a relatively small number of organizations. We may draw an analogy with game theory. In chess, there is a very specific program for mating an opponent with knight and bishop. A more general program, applicable in most situations where a player has a superiority of pieces, is to bring about even exchanges. This program also applies to checkers. A still more general program, applicable to all two-person zero-sum games, is the maximin rule. It is to be hoped that in organizations there are optimal programs, applicable to a fair range of organizations and situations, that are at an intermediate level of abstraction--more abstract than the mating procedure with knight and bishop, but less abstract than the maximin rule.

There is no reason to suppose that the construction of the appropriate categories for discussion of organization programs can be carried out on an a priori basis. Rather, the problem is one of induction from observed behavior in organizations. In fact, one cannot dissociate the construction of this taxonomy from the construction of organization theory itself--that is, propositions relating the program elements as categorized. Some of the concepts that have been suggested for categorizing various aspects of the organization's program are the following: priority, storage, redundancy, uncertainty absorption and the stipulation of facts, initiation, load balancing, error-control, maintenance, feedback, switching.

If we had a complete description of the program in concrete form, then we could examine each rule in the program to see which of the foregoing terms can properly be predicated of that rule--that is, is it a "priority" rule, a "load-balancing" rule, or what not? From the nature of the terms, it is clear that the analysis is "functional"--it seeks to determine the function of the rule in the system of behavior. Functions can be assessed objectively by asking questions like: in what respects would goal attainment of the group suffer if this rule were absent from the program?

It should be possible to capture the program, described in concrete terms, in a manual of fifty or one hundred pages--at least this should provide a reasonable approximation to the program. A suitable set of categories could then be gradually evolved by attempting to assign functions to the individual rules in the manual. This seems to be the way (although without this systematic approach) that the present suggestions of possible abstract categories were arrived at.

Among the important rules in the program are the assignment rules--those that specify who is to perform a particular activity. One way in which we can learn something about the function performed by particular parts of the program is to discover what would happen (or did happen) if the assignment of this part of the program were changed. For example, in the course of the trials responsibility for TD'ing tracks appearing on two boards or scopes tended to be transferred from the ASC and Sup to the plotters. On the other hand, the decision to give responsibility for particular

tracks to particular scopes remained with the ASC and Sup. The difference in the history of these two parts of the program is not unrelated to the fact that the first is concerned primarily with uncertainty absorption, the second with load-balancing. From the standpoint of availability of information, either program could have been carried out from either position.

IV.

THE DESCRIPTION OF THE ORGANIZATION

The foregoing paragraphs suggest that to describe the "organization" is simply to describe the program in terms of relatively abstract "functional" categories. This sounds a little too simple to be true, but perhaps it provides a starting point. It at least eliminates the troublesome metaphysics that arise when one tries to describe the organization as something separate and apart from the system of interpersonal behaviors:

Let us see what we think we already know (or conjecture) in terms of the functional categories thus far identified.

A. Internal Prediction

An optimal behavior pattern requires internal coordination in the following sense:

For a particular subject, given the state of his information about the external environment, the behavior that is optimal will depend on the program and state of information of the other subjects. Less formally, each subject must form accurate expectations of the behaviors of other subjects. There appear to be at least four coordinating mechanisms that can be made use of in an organization program:

1. Self-containment. Activities can be assigned to individuals in such a way that the extent to which the optimal behavior of each is dependent on the behaviors of others is minimized. Thus, if the areas covered by two scopes do not overlap, there is greater self-containment in the activities of the respective

tellers than if there is a large area of overlap between the scopes. In part, the degree of self-containment is built into the technology of the problem, but it may also be increased or decreased by the assignment rules built into the program. For example, self-containment would be increased by a programmatic rule that: "All tracks in the northern half of the overlap between scopes A and B will be followed by the former, all tracks in the southern half by the latter."

2. Comprehensive programming. If A can infer from his information about the environment, together with the program, what B's behavior will be, then the program can determine his (A's) behavior independently of explicit information about B's behavior. Thus, if MI knows that the teller will report a plot whenever it appears on the scope, then he can infer from the lack of a report the lack of a plot, and can behave accordingly (this was not, of course, the actual program).

3. Feedback. From a knowledge of the program rules governing interception, and a knowledge of the information he has provided to the control section, the MI Chief could infer the positions of friendly fighters. However, a more direct source of information is a report of actual plots. Here feedback rather than programming provides the basis for the MI Chief's expectations.

4. Explicit coordination. If A's optimal behavior depends on B's behavior, and vice versa, then C can choose a joint behavior for both A and B and instruct both to follow it. This was the process whereby the ASC and Sup instructed the various boards

and scopes which tracks to follow.

As the illustrations indicate, the actual program apparently employed all four devices. Most instructive would be the cases where a change was made in the mechanism during the course of the experiment. Hypotheses of the following kinds might be examined:

In a relatively stable environment, comprehensive programming gradually replaces feedback as a coordinating mechanism. With a sudden shift in environment which the program does not anticipate, feedback mechanisms again take over. (The comprehensive program is "homeostatic" in the sense that it provides a highly stable and predictable internal environment.)

Feedback devices will tend to be most prominent in those parts of the organization that are relatively close (communication-wise) to the external environment; programmatic devices in those parts of the organization that are more "internal."

Because of the possibilities of unstable oscillation (particularly with internal time lags in transmission of information) responses to feedbacks will be highly damped, hence relatively non-optimal for behavior changes that can be inferred from the program. (In other words, feedback is inefficient where prediction is possible.)

These hypotheses are intended only as samples of the kinds of things one might look for once the program has been characterized in functional terms.

B. Redundancy

It has been suggested that one of the characteristics of an

effective organization is a great deal of "redundancy." Redundancy appears to be a rather complex phenomenon with several distinct functional interpretations.

1. One aspect of redundancy is a certain flexibility in the technology of the problem that permits particular activities to be assigned in more than one way. For example, because of the overlap in the areas covered by boards and scopes, certain tracks could be followed by either of two scopes. The functional significance of this kind of redundancy lies in the opportunity it affords for load-balancing. This will be discussed more fully below.

2. Another aspect of redundancy is an overabundance of information--beyond the minimum required for certain inferences. One example is the frequent literal repetition of reports by tellers and plotters. A somewhat different example is the situation where MI identifies a track as friendly from an AMIS flight plan, but later confirms the identification by asking a friendly fighter in the vicinity to "look at" the plane. In both cases, the function performed is error control, but in the second case, uncertainty absorption is also involved. (Perhaps the first case should also be regarded as a rudimentary form of uncertainty absorption, but they are certainly different in degree if not qualitatively.)

3. A third aspect of redundancy is that it provides for social interaction above the minimum required for task performance. In this respect redundancy performs the same function as chit-chat

on the lines during quiet periods. The function here is the reinforcement of cohesiveness.

Whether it is useful to retain redundancy as a category of analysis would depend on how often the same redundant situation contributes to all three of the functions just mentioned.

C. Uncertainty Absorption

The environment provides the organization with a mass of evidence that in many cases is too complex to be processed through interpersonal communications channels (or even by the individual black box). For this evidence the organization substitutes a stipulated state of fact in the form of a simplified model of the real world. Most parts of the organization (particularly those that are "internal") behave in terms of the stipulated facts rather than the actual body of evidence or the real world (obviously they cannot behave in terms of the latter). The program includes rules for translating evidence into stipulated fact, and assigns the task of making translations, or absorbing uncertainty, to specified points in the organization.

In this organization, the movements board is the model of reality constructed out of the stipulated facts. Two of the principal tasks of uncertainty absorption are: (1) to designate planes as F or U, and (2) to assign plots to tracks. Since the possibilities of incorrect stipulation are greater in the former task than in any other part of the organization's program, the MI section plays a rather unique role. This is one possible explanation of the reactions to the MI section that were noted during

the experiment.

Probably the most difficult part of the program to write down are the sets of rules that govern the stipulation of facts. Perhaps where the stipulation process involves the mental processes of a single individual (as is approximately the case here) the program description can stop short of describing the rules governing these black boxes.

It is not necessary that the model of reality be entirely consistent throughout the organization. For example, although all planes may be definitely designated as U or F on the HT Board, the MI section may communicate with the SD in terms of possible states of fact. That is, MI may transmit: "One of those two planes is unknown, but we don't know which. You had better intercept both, if possible. However, if only one can be intercepted, we suggest that one."

The stipulation of facts may perform another function besides reducing complexity to manageable proportions. It may also perform an important coordinative function (this should have been added to the earlier list of coordinative devices). If A and B are presented with the same body of evidence, they may infer different facts from the evidence. Then each may make an incorrect prediction as to how the other will behave, with a resulting loss in coordination. If, however, the evidence has been translated into an "official" state of fact, each can predict with greater certainty what will be the behavior of the other.

It has earlier been suggested that one form of redundancy--the overabundance of evidence--may play a role in uncertainty absorption. The MI section sought means for overidentifying (in both the literal and statistical meanings of the term) the planes. This overidentification is a means of error control, and hence of securing a closer correspondence of the stipulated facts with the real world.

Two learning processes would permit an organization to gradually increase its effectiveness here. In the first place, the organization could learn to handle a more and more complex model, taking into account more and more features of the real world. In the second place, the organization could improve its processes of assessing evidence, inventing, for example, more and more ways of securing overidentification. Again, by comparing the programs at earlier and later stages of the experiment, it could be determined whether these learning processes actually took place, and to what extent.

Another point to be investigated is the locus of uncertainty absorption and the shifts in loci during the learning process. Why, for example, did TDing gradually shift from the ASC and Sup to the plotters (assuming that it did)?

D. Load-balancing

Load-balancing is a device for shifting tasks from parts of the organization that are operating at or near capacity to parts that are operating below capacity, thereby increasing the maximum load level that the organization as a whole can handle. Presumably load-balancing considerations would enter into the design of an

optimal technology for the subjects--that is, the capacities of the various parts of the system would be designed in relation to the load levels expected to be produced by some anticipated distribution of environmental stimuli.

Incorporation of additional load-balancing mechanisms in the program permits a better adaptation to be made to varying environments or environments different from those anticipated. On the other hand, the extent to which such mechanisms can be developed may depend again on the technology--on the amount of "flexibility" that is built into it. In general, flexibility over a range of environments is bought at the price of less than optimal adaptation to any specific environment. Presumably also, we could replace flexibility through substitution between the capacities of different parts of the system by additional capacity in each single part of the system.

As previously noted, capacity is made flexible by introducing certain kinds of redundancy--by making each of several parts of the system capable of performing the same function. Hence, in order to employ the flexibility built into the system, the program must include rules for reassigning tasks with load changes. These are the load-balancing rules. Since they are switching rules, they should perhaps be regarded as belonging to higher program levels. Among the load-balancing procedures employed by the subjects were reassignment of responsibility for tracks. There was undoubtedly a great deal of informal load-balancing between ASC and Sup--which accounts for the difficulty of distinguishing their functions.

One must recognize in the system load-balancing mechanisms of even broader scope--although mechanisms that are hard to characterize in terms of definite rules. Andrew Carnegie is reported to have said: "Take away my steel works and my money, but leave me my organization, and I will rebuild it all in two years." What did he mean by organization? Presumably he meant some very general kind of program that would permit effective performance in almost any environment. Admitting that Carnegie was perhaps a bit optimistic, something like his "organization" can be identified in the present system.

Suppose that a fire had broken out in the room where the experiment was being conducted (Perhaps one should arrange for this in the next run). What part of the program would the group have employed in dealing with the situation? It may be conjectured that they would have employed the hierarchy as a coordinating mechanism, and that the hierarchy (say, the SD) would have employed the manpower as completely fluid capacity (within physiological limitations) for dealing with the situation. The program would consist of the rules of hierarchy together with improvised feedback programs. According to the folklore at least, subjects who work together in performing some tasks do develop and elaborate these general programs. Queries: can a group be trained to improvise programs at this level of generality? Does the experience of operating in a stable environment with an elaborate, but specifically adapted program, increase or decrease the group's skill in improvisation?

E. Error Control

The function of error control has perhaps been sufficiently discussed in connection with the different forms of redundancy. We may simply summarize the types of errors over which control is sought: (1) errors in simple transmission of information, (2) errors in reduction of evidence to stipulated fact, and (3) errors due to non-correspondence of the simplified model to the complex reality.

F. Priorities

Priority rules also perform the function of increasing capacity, but in this case by specifying which facts will, and which will not, be represented in the model when a complete representation would produce a model too complex to be manageable, or when an attempt to represent all would tax the capacity of the communication network.

There is an intimate connection between rules of priority and rules as to who will initiate sequences of communication. If the teller initiates reports of plots, then he must apply the priority rules; if the plotter requests plots, then he applies the priority rules. Hence one aspect of the evolution of priority programs is the evolution of rules governing the locus of initiation. A possible hypothesis is that, at the outset, the locus of initiation will be the point where the environmental stimuli appear, while when capacity of certain parts of the system begins to be taxed, persons in these parts will attempt to take over the initiating function. In place of this mechanism (which essentially involves feedback) it is possible, of course that a definite program of rules of priority will in time emerge and again shift the locus of

initiation.

Other factors may also influence the locus of initiation. In his restaurant studies, Whyte observed that initiation always operated downward in the status hierarchy. Initiation may also be associated with responsibility for load-balancing.

G. Switching Rules

This is a category which, from the foregoing discussion, clearly cuts across categories already enumerated. If we have a clearcut criterion of "levels", it is easy to define switching rules. The switching rules in the k th level program are the rules that determine which part of the $(k-1)$ th level program the group will follow. Since we have not really succeeded in defining "level" in a satisfactory way, the definition of "switching rules" remains equally vague.

(At this point, free association leads to the following series of comments. Perhaps we are in error in attempting to associate with a given program a single objectively identified system of levels. Levels may be meaningful only in terms of the way in which the program is organized in the minds of the subjects--that is, the hierarchy of their "sets". The same program might be organized in a different hierarchical fashion by two groups of subjects, or even two subjects in the same group. Another way of stating it: the same body of propositions and concepts may be held in the minds of two different persons in two different systems of "Gestalts". The significance of this would be that one of the systems might lead to more effective performance and retention than the other,

and one--not necessarily the same--might lead to greater readiness to change set or to respond to a new environment than the other. Hence, if it were desired to predict performance over a period of time or under a new environment, it would be important to know not only the program but also the way in which it was organized by the subjects. Levels would then be determined by letting the subjects describe the program.)

H. Maintenance

It is suggested that the program include activities whose function it is to maintain the program intact. It is hard to identify specific program items with the maintenance function, but the following possibilities may be suggested:

1. Goal reinforcement. Maintenance may be interpreted to include activities designed to sustain the conditions necessary for motivation of the group toward the goal. Direct rewards are an obvious example. Beyond these, cohesiveness-maintaining activities (like certain forms of redundancy described previously) may be included.

2. Reinforcement of expectations. Given adequate motivation toward the goal, the subjects will need to receive reinforcement for their belief that the rules are appropriate for reaching the goal, and that their expectations of the behaviors of others are fulfilled. Important feedbacks are involved here, for the fact that B is fulfilling the program leads to a realization of A's expectations of B's behavior, and hence to reinforcement for A. Conversely, vicious cycles of non-reinforcement are possible.

(Is this present in the breakdown of the final session?)

Apart from the self-sustaining processes just described, the program may make formal provision for reinforcement by rules for checking the conformity of behavior to the program. (Are these rules in a higher level program?) This would be one possible interpretation of SD's question to ASC: "Why did you scrub that track?" An individual may also check the correctness of his own understanding of the program: "Are we supposed to follow intercepts back to their base?" One would expect hierarchical channels to be used for such checks and questions, because these provide an easy device for securing internal consistency in the rules, and consistency is important for reinforcement.

From these considerations one would be led to predict that reinforcement activities would be most prominent in those areas where the requirements of coordination are greatest. (On second thought, one could also argue the converse, since where there are coordinating mechanisms there may be sufficient self-reinforcement to obviate the need for additional maintenance activities.)

Query: Is there any evidence that the hierarchical superiors became conscious of their special role (at least their potential role) in the reinforcement process, and developed a program for intervening where reinforcement was inadequate?

V.

MISCELLANEOUS COMMENTS

The preceding comments are miscellaneous enough. The present section will be devoted to miscellaneous miscellaneous comments.

A. The comment has been made that subjects preferred assignments as HT clerk to other plotting assignments. A reading of some of the transcripts suggests one possible explanation. The HT clerk had more of an over-all picture of what was going on than did the other plotters, and appeared to get some feeling of "importance" and satisfaction from his central position.

B. In the foregoing list of categories, storage and filtering were not discussed. Filtering is an even vaguer term than some that were discussed, and seems to encompass both priorities and some aspects of uncertainty absorption. Storage can also be analyzed as a particular kind of elaboration of a program of priorities and uncertainty absorption.

C. It is possible that a set of mechanisms that would permit a gradual "evolutionary" change in program would not permit a change in program that would require all subjects to change at once. (e.g., a gauge change in a railroad). Can any distinction of this sort be detected from the data? The notion can be given a respectable mathematical representation. An "evolutionary" change would correspond to a shift from one local maximum to another (higher) one.

D. The minimization of any relations between this organization

and a larger embedding organization may account for the failure of the SD to assume a more positive role. Related to this is the fact that the organization was not required to undergo any change in its goal, or to engage in power struggles with coordinate or superordinate organizations.

E. Comment has been made already on the special role of the MI section. There are possible alternative interpretations (it was suggested above that the main burden of uncertainty absorption fell on this section). One is that the MI section was in the position of initiating activity for others without having the hierarchical status needed to make this initiation acceptable (this is essentially Whyte's hypothesis in the restaurant study previously mentioned). A third possibility is that the MI section developed a group identification separate from the identification of personnel under the ASC. Of course all of these phenomena (or none of them) may have been present. Some sociometric choice data would be nice to have.

VI.

IMPLICATIONS FOR DATA ANALYSIS

A couple of mild recommendations may be extracted from these comments:

A. An effort to write down the program in some detail, and in concrete terms related to the technology of the problem, seems almost unavoidable. If this is done, then it should be possible to summarize the program in functional terms. Out of this process a more satisfactory set of functional categories than the set suggested here should emerge.

B. To separate the important from the unimportant, a comparative study of the program as it existed in early trials and the program as it existed in late trials should be most revealing. In particular, such a comparison should help to indicate what it was that the subjects learned.

C. The framework indicated in Section I should help to maintain a distinction between propositions about optimal programs, propositions about the ways in which programs evolve, and propositions about the ways in which the experimenters can influence the evolution of programs and the program that is reached in equilibrium.

GLOSSARY

- (1) AMIS Air Movements Identification Service, the source of flight-plan information to the Air Defense Direction Center. This information is telephoned into the Center.
- (2) ASC Air Surveillance Chief, the man in charge of posting the Air picture on the Movements Board.
- (3) F Friendly.
- (4) HT Board A display board containing track number, identification, number of aircraft in track et cetera.
- (5) HT Clerk The man who keeps information up-to-date on the HT Board.
- (6) Movements Board The large board on which the air picture is displayed.
- (7) MI The movements identification section of the Air Defense Direction Center.
- (8) Plot Symbols on the Movements Board indicating direction, speed and number of track.
- (9) Plotter Operator who posts plots on the Movements Board.
- (10) SD Senior Director--the man in charge of the station.
- (11) S.O.P. Standing Operating Procedure--the program for information processing in the center.
- (12) Sup Supervisor--assistant to ASC.

- (13) Teller Reports aircraft movements from radar scope to plotter.
- (14) T.D. Correlation of tracks passing out of radar surveillance of one station into surveillance of another.
- (15) U Unknown--unknown tracks are intercepted and either identified as friendly or attacked as hostile.