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POSSIBLE SANDIA LABORATORIES' INVOLVEMENT IN THE INFILTRATION-INTERDICTION PROBLEM (U)

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January 1969

ABSTRACT (U)

Sandia Laboratories can contribute to the solution of the infiltration-interdiction problem in several ways. This study preliminarily investigates the overall structure of infiltration and interdiction and suggests how Sandia may participate at the various levels of involvement.

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SECTION 1 - THE NATURE OF THE INFILTRATION-INTERDICTION PROBLEM

For purposes of this document the word infiltration is taken to mean the movement of hostile items, items here being personnel, equipment or supplies, into or through any area of interest. This definition is intentionally broad with the hope that it will encompass all those situations which might intuitively be considered infiltration.

In this general context, the authors regard the infiltration-interdiction problem as the problem of recording or controlling infiltration in areas of interest without causing unacceptable effects on one's other objectives. Although the recording of the movement of hostile items may normally be thought of as a prelude to their control, one can envision circumstances in which records of movement are made for appreciable periods of time prior to initiating any control activities. For example, it may be desirable to record hostile troop movements in areas not even controlled by oneself with a view toward estimating or predicting when such troops may enter an area where control of them is possible. For this reason, it was felt that the recording of infiltration may be an infiltration-interdiction objective in itself without any immediate reference to control. With this rather general objective in infiltration-interdiction in mind, interdiction is defined to be that action which is taken to achieve the objective of controlling or recording movement of hostile items.

Because of the very general character of the definition of infiltration and interdiction and of the objective associated with the infiltration-interdiction problem, much of what follows has a very general applicability. To begin with, the problem formulation is broad enough to encompass activities associated with both territory that may be termed "hostile" and territory over which one has some direct physical control. At the same time, the framework seems broad enough to consider infiltration-interdiction as it may relate to guerilla warfare as well as infiltration-interdiction as it relates to urban insurrection.

Our own immediate interest in looking at the infiltration-interdiction problem is related to guerilla warfare in Southeast Asia. This problem appears to be an extremely important one. In support of this statement we offer a quotation from

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"Report on USAF Scientific Advisory Board ADHOC Committee on Infiltration-Interdiction" (U), Vol. 1, July 1968.

> "The committee believes that the I-I is a problem of such importance to warrant this kind of priority and action. Our I-I capability as demonstrated in Southeast Asia is inadequate and, despite enormous, costly, and widespread development activities, progress is slow and success is uncertain. In our opinion, a major improvement is possible only if some organization is given the responsibility to develop the doctrine and concepts of employment, and conducts the training essential to successful deployment. In addition, an organization must be given the responsibility and resources to design and acquire a system capability to perform the I-I mission."

The importance of the infiltration-interdiction problem alone might warrant the investigation of possible Sandia Laboratories' involvement in the resolution of this problem. Another reason for the assessment of possible Sandia Laboratories' involvement in this problem is that we may be asked to participate. Quoting, again, the above-referenced document: "We suggest that an organization such as AFWL possibly supported by Sandia Corporation could be given the job." Here, "the job" means to "design, acquire and implement a system capability to perform the I-I mission." Since there does exist the possibility that Sandia Laboratories will be asked to assist in doing this rather ill-defined job, the authors felt that it would be appropriate to determine more precisely what such a job might involve. Accordingly, the remainder of this document is devoted to a description of the infiltration-interdiction problem as seen by the authors and to a discussion of the possible areas for Sandia Laboratories' involvement in this problem.

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SECTION 2 - THE STRUCTURE OF THE INFILTRATION-INTERDICTION PROBLEM

To motivate the material that occurs in the next three sections we again quote the United States Air Force Scientific Advisory Board document cited in Section 1. It states "... we believe that much can be gained by looking at the overall problem, subdividing it into well-defined tasks, and paying close attention to all the interfaces between subsystems." Clearly, the implication is that this has not yet been done. To begin, then, we observe that the objective associated with the infiltration-interdiction problem, stated in Section 1, divides quite naturally into two subobjectives: The desire to record infiltration and the desire to control infiltration, respectively. We will discuss each of these in turn.

2.1 - Recording Infiltration

In order that the recording of infiltration be a successful activity several things appear necessary. First, one must be able to detect presence of potentially hostile items (i.e., infiltrators) and, secondly, one must in fact be able to judge whether these items are indeed hostile--personnel or equipment or supplies. The detection problem concerns itself with the recognition of movement as a function of time; the identification problem concerns itself with the nature of the items that are moving. It seems essential that both the detection and identification problems be resolved in order that one have an effective means of recording infiltration.

There is a third element associated with the problem of recording infiltration. This third element relates to the ability to receive and store the data transmitted as the result of the detection and identification of infiltrators. The three problem areas (detection, identification, and data transmission and storage) have the property that their resolution implies that the problem of recording infiltration is solved and conversely, to solve this latter problem one must solve the first three. Thus, the problem of recording infiltration may be viewed as three problems: (1) detecting location of movement as a function of time, (2) the identification of moving items so detected, and (3) the transmitting and receiving of detection and identification data. More will be said about each of these later.

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2.2 - Controlling Infiltration

There are basically two ways in which infiltration may be controlled: It may be destroyed or it may, in some sense, be neutralized or made ineffective. The meaning of the first category is clear enough. The second category of control, neutralization, includes such things as disabling, capturing, diverting or assimilating infiltrators. None of these represent actual physical destruction of infiltrators but at the same time they represent activities which render infiltration ineffective. We will now examine the two categories of control, namely, destruction and neutralization, in some more detail.

2.2.1 - Destruction of Infiltrators

There are three major scenarios for the destruction of hostile personnel, equipment, and/or supplies. In the first, some sensing of the presence of these hostile items takes place just as it did in the recording of infiltration. This is subsequently followed by an identification in the same spirit as above. Finally, having sensed the movement of something and having identified it as hostile personnel, equipment and/or supplies, the appropriate means of destruction is employed. Thus, this scenario is of a detection-identification-destruction type. It is not necessary to identify an item to destroy it, of course, and in many situations a less elaborate detection-destruction sequence is more appropriate than a detection-identification-destruction sequence. Thus, the second scenario takes the form detection-destruction. The third scenario dispenses altogether with any attempt at detection or identification. This category may be used only upon indirect knowledge of the presence of some hostile items or the expectation of their presence. For example, in the context of Southeast Asia, indirect information may lead one to suspect the existence of enemy storage depots in a given area. Bombing of the area may be initiated based upon this expectation with the hope of destroying equipment and supplies. This scenario then is destruction without benefit of direct detection or identification.

Thus, the problem of the destruction of infiltrators becomes a problem of destroying infiltrators in one of three ways: (1) through a detection-identification-destruction sequence, (2) through a detection-destruction sequence, or (3) destruction based solely on indirect expectation. Each of these three categories will be discussed more fully later.

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2.2.2 - Neutralization of Infiltrators

Neutralization of infiltrators may be achieved in one of four ways: capture, disablement, diversion or assimilation. Each of these four activities may be accomplished in three ways as with destruction. These take the form detect, identify, and act, or detect and act or merely act. Here the action referred to can be either disablement, capture, diversion or assimilation. In general, capture will follow the pattern, detect-identify-capture more often than the other sequences. Disablement of infiltrators follows any of the patterns much as does destruction. Diversion may follow any of the three sequences and it should be noted that this may be done in two ways: physically or psychologically. It may be possible to physically bar infiltrators from a given area either by detecting, identifying and barring their way or by detecting something and barring its way without identification or simply by the creation of some physical barrier which prevents any movement. Psychological diversion most often would take place without any detection or identification sequence directly aimed at the diversion activity. Finally, assimilation may take place in any one of the three sequences as well. Generally, however, one would expect to assimilate infiltrators without any detection or identification by providing an environment in which they cease to be hostile.

2.3 - The Elements of the Infiltration-Interdiction Problem

The discussion of the previous section is summarized graphically in Figure 1. In an analysis such as this it is appropriate whenever possible to look for common patterns. In this instance, the identification of common patterns is quite straightforward. Figure 1 shows that independent of the final action initiated to achieve the objective associated with the infiltration-interdiction problem, those actions must take place in one of three sequences; i.e., one must:

a. detect-identify-act

b. detect-act and/or

c. act.

The action taken in each case depends upon the subobjective that one is trying to achieve. These three generic sequences are called the elements of the infiltration-interdiction problem. The importance of these elements lies in the implication that if one can execute the sequences so defined with various types of action taking place then one can presumably achieve the objective associated with the infiltration-interdiction problem. Thus, it seems appropriate to further study each of these

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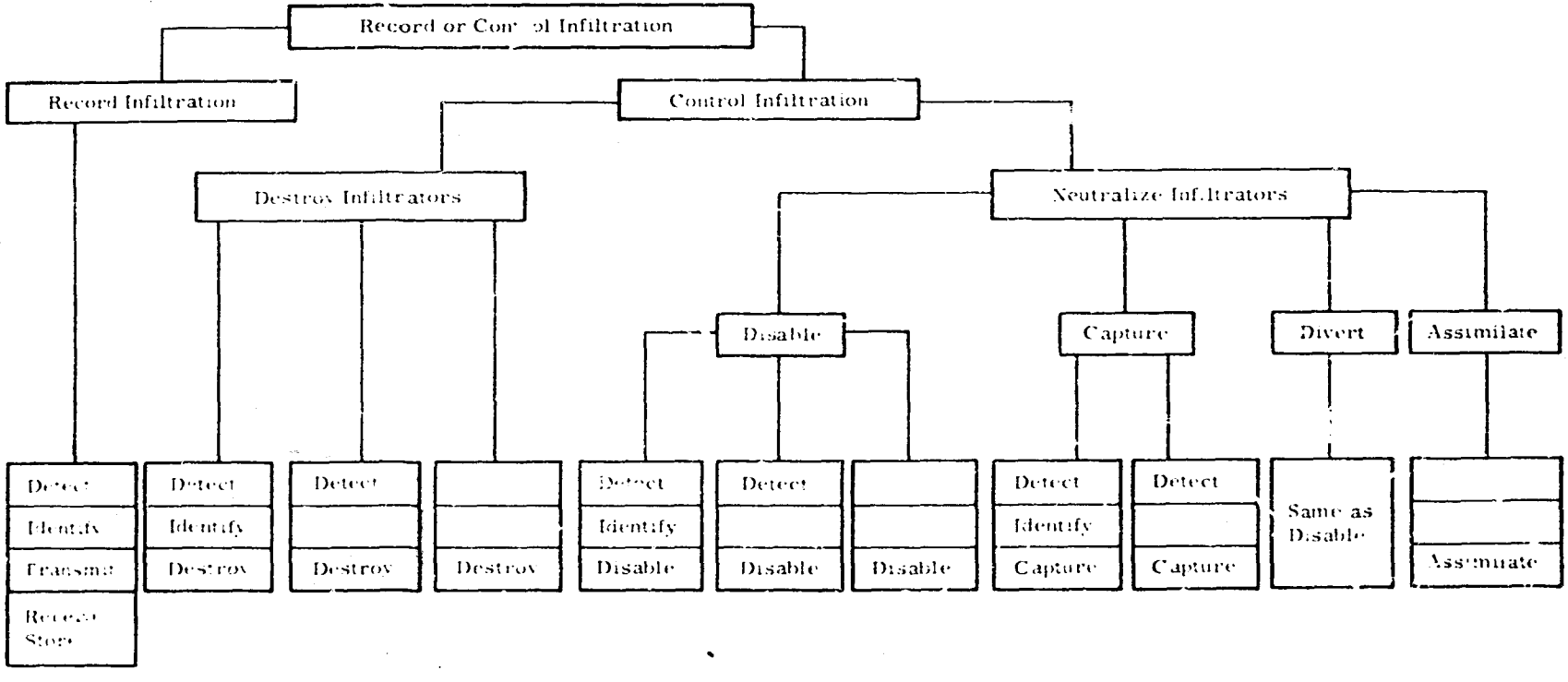

Figure 1. The Elements of Infiltration-Interdiction

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elements of the infiltration-interdiction problem and each possible action mode. The action modes in this case are seen to be defined as record, destroy, capture, disable, divert, and assimilate. In each of these action modes the detection and identification portion of the infiltration-interdiction elements have essentially the same general character. Thus, these two portions will be analyzed further in the following paragraphs with no regard to the action mode in which they are to be used. The "act" portion of the infiltration-interdiction problem elements must be analyzed separately in each action mode.

2.3.1 - The Nature of Detection

For our purposes, detection is taken to mean the accurate recognition of the movement or the presence in a specified area of something in that area. Ideally, one would hope to do this as a function of time. That is, ideally, one would first have an indication of the movement or presence of some items in a given area at some initial contact time t_0. Then one needs the ability to maintain and/or re-establish contact based upon the initial contact. This can be done in time either continuously, if possible, or discretely; but, practically, this may be represented by further contacts at times t_1, t_2, t_3, etc. Associated with the contact taking place at each t_i, one must have an accurate location. Thus, the basis of the detection problem lies in two areas: contact and location. From a sufficiently well designed and developed detection system based on only time of contact-location information, one would hope to be able to deduce information about the configuration of the unknown items, such as the number of items present, the spacial distribution of the items present, the general direction and velocity of the movement of the items. More will be said about the nature of such a system later.

In order that one be able to detect, in the above sense, it is necessary that one either have the ability to visually observe the area in question or that one have a system of sensors in the area. The term sensors as used here denotes electrical, mechanical, acoustical or magnetic devices capable of recognizing the movement or presence of items in a given area. If one is thinking in terms of sensors, there is implied the ability to locate them accurately, receive data from them, and place them in such a way that a sufficient amount of information is gained to allow a reasonable estimation of the configuration of the items in question.

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2.3.2 - The Nature of Identification

In order that identification be accomplished one must answer two basic questions. First, what have I detected? And second, whom have I detected? The "what" of the first question refers to personnel, equipment and/or supplies. The "whom" refers to whether the "what" is hostile or friendly. Communication with a visual observer will often provide answers to either of these questions. It is conceivable that in some situations sensor systems can provide an answer to these questions as well, particularly to the "what" question. On the other hand, the question of "what" has been detected may well be answered indirectly using prior information and intelligence to make predictions. This is a particularly reasonable approach if the items in question turn out to be friendly. The "whom" may be resolved indirectly as well by comparing the detection information with information relating to the possible presence of friendly personnel or equipment in the area when the latter type of information is available.

Thus, the question of identification involves, to various degrees, the ability to observe and/or sense differences in the items that have been detected and to gather and process information about friendly and hostile items known or expected to be in the area of concern.

2.3.3 - Recording of Infiltration

In order that one successfully record infiltration it is first necessary that movement of possibly infiltrating items be detected. Second, it is desirable that the nature of the detected items be established, that is, that they be identified. Finally, one must make some record of this detection and identification. Thus, the basic element associated with the subobjective of recording infiltration is of the form detect-identify-act where in this case the action refers to the making of a record. In order that such a record be of any more than very local interest, the detection and identification data must be transmitted to some appropriate location, received at that location, and stored and possibly processed. Thus, essential to any ability to record infiltration are the abilities to transmit, record, process and store data.

If one is in the situation where the detection and identification of infiltrators is undertaken visually and if, indeed, there is no need for this data to be recorded hastily, then the problem of recording infiltration is fairly straightforward. At the other extreme where sensors are used to obtain detection and identification data, and where recording is desired in something approximating real-time, the problem can be quite complex technically. Nonetheless these four basic factors remain the same. Thus

the means of achieving these lower level subobjectives associated with transmitting, receiving, processing, and storage of data are highly dependent upon the framework in which one desires to record infiltration. Sections 3 and 4 discuss these possible frameworks in somewhat more detail.

2.3.4 - Destruction of Infiltrators

In any of the sequences detect-identify-destroy, detect-destroy, or destroy, there are three basic types of destruction mechanisms that may be employed. These three types of mechanisms generically are: (1) airborne destructive mechanisms (including less maneuverable ground- or sea-based shells and missiles), (2) portable ground destructive mechanisms, and (3) implanted ground destructive mechanisms. In turn, the successful employment of weapons in any of these three generic categories depends upon three factors: acquisition, accuracy, and fire power. In practice, the problem of acquisition is not unlike, and may be directly related to, the problem of detection discussed earlier. Questions of accuracy and firepower become essentially technological questions.

Again, the means chosen for acquiring targets depend largely upon the framework in which this activity is to take place. The essential feature in acquisition is that it should be linked insofar as possible with the previous detection identification data. Some examples of the possible types of linkage in specific cases will be discussed later.

2.3.5 - Capturing Infiltrators

The means used to actually capture infiltrators are highly dependent upon the framework in which one is trying to achieve capture. Thus, without reference to a specific infiltration-interdiction situation it is difficult to identify generic subobjectives associated with capturing infiltrators except to note as above that this would normally be proceeded by detection and identification of the infiltrators. Capture itself very likely falls into two categories: (1) that which is planned and which may involve communications and personnel deployments aimed specifically at capturing infiltrators, and (2) those captures which result from actions taken to achieve other objectives such as destruction and disablement. One's concern when trying to achieve an objective associated with capturing infiltrators lies with the former category and this involves the transmission, reception, and processing of infiltration data and the subsequent deployment of personnel. This latter situation again involves the problem of acquisition, accuracy, and fire power where the objective of the weapons being

employed is to capture rather than destroy. Thus, in a sense, capturing infiltrators becomes a special sort of disabling activity.

2.3.6 - Disabling Infiltrators

The problem of successfully disabling infiltrators may be viewed in much the same spirit as the problem of destroying them: the basic difference is in the weapons or the intent when using the weapons actually employed. Thus one again may envision three general categories of weapons: airborne, portable ground and implanted weapons. The success that one achieves in disabling infiltrators depends, as with destruction, on the ability to acquire the targets and upon the accuracy and fire power of the weapons involved. The comments made in the destruction category about each of these factors are applicable here.

2.3.7 - Diverting Infiltrators

The diversion of infiltration may take place in any one of the three elemental sequences discussed above. Here the term "act" refers to the creation of a barrier which infiltrators cannot, or are unwilling to, penetrate. In this way infiltrators are of necessity diverted around the area containing the barrier.

A barrier designed for diverting infiltrators may be one of two types: physical or psychological. An absolute physical barrier of the type envisioned here is rather difficult to come by and for this reason diversion activities would seem most likely to fall into the psychological category. The effectiveness of a psychological barrier must follow from the ability to destroy, capture and/or disable infiltrators very efficiently. Because of this the analysis of the diversion problem is very similar to that found in the other categories already mentioned although the actual weapons employed may be different in each case.

2.3.8 - Assimilation of Infiltrators

The problem of assimilating infiltrators is primarily a social-economic-political problem generally unaccompanied by detection and identification of the infiltrators involved. This problem divides into two subproblems. The first problem is that of stimulating an infiltrator's desire toward nonhostility by joining with friendly personnel in an environment deemed by the infiltrator to be more desirable than his previous environment. The second problem is that of making possible an assimilation after such a desire has been stimulated. While these two are not unrelated, the second requires not only a "desirable" environment but also the general acceptance of infiltrators by

people already in this environment. This problem in the context of infiltration-interdiction is not unlike the problem associated with the integration of minorities into a majority society.

The actual physical actions taken to achieve assimilation of infiltrators are, as suggested by the above remarks, highly dependent upon the framework in which this is trying to be achieved. One factor which is fairly readily identified in almost any context however is social-political stability. Another generic factor may be the education of friendly personnel.

SECTION 3 - THE INFILTRATION-INTERDICTION SPECTRUM

In the previous sections we have attempted to define the infiltration-interdiction problem, state the objective associated with it, and identify many of the factors that may be involved in achieving that objective. In particular, in the previous section we singled out the subobjectives associated with the ability to record, destroy, capture, disable, divert, and assimilate infiltrators and in each case relate these subobjectives to generic-type factors which will influence their achievement. The fact that there are many such factors indicates that one has a great deal of latitude in his approach to solving the infiltration-interdiction problem. For example, one has a great deal of latitude in choosing a weapon to be used for destruction in a given situation or to be used in facilitating the diversion of infiltrators. Perhaps more basically, one has a great deal of latitude in deciding whether the objective is best achieved by various levels of destruction versus neutralization.

It is difficult, and probably impossible, to say at this point in time which mixture of actions would "best" achieve the over-all objective in, say, Southeast Asia. Some inroads could be made in this direction if it were possible to assess the cost of taking the various possible actions indicated. For example, what are the relative costs associated with destruction of an infiltrator and the neutralization of an infiltrator? This in turn is determined by ascertaining the costs of destruction of infiltrators through the various modes mentioned and their neutralization through the many possible modes mentioned earlier.

Because of the difficulty involved in attempting to determine a "best" mixture of actions in a given infiltration-interdiction problem we would like to discuss two examples pertinent to the Southeast Asia infiltration-interdiction problem which seemed to us to be "extremes" among the possible alternative approaches to the resolution of that problem.

3.1 - A Minimum Change

Let us begin by examining the current infiltration-interdiction system in existence in Southeast Asia. This will be done against the background of the foregoing discussion.

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There is quite a sophisticated detection system in existence in Southeast Asia termed IGLOO-WHITE. This system involves primarily seismic and acoustic sensors to locate movements. When these sensors are activated the data is transmitted to an airborne receiver and subsequently transmitted to a central processing facility. This phase of the infiltration-interdiction problem is operated in almost real-time and is marked by only one major flaw: the location of the sensor from which the data is taken is often impossible to establish accurately. Thus, of the two subobjectives (time of contact and location) associated with detection of infiltration as determined earlier, one can currently be consistently attained and the other cannot.

Moving on to the identification problem, the current system employed involves airborne identification of infiltrators. As the system now stands this involves a redetection phase which occurs some long while after the initial detection was made. There are a number of difficulties associated with this which tend to make this approach relatively ineffective. First, of course, is the inaccuracy in the initial location provided by the detection devices. Second, even if this were overcome, the time lapse between detection and identification makes it necessary to search large areas for the infiltrators. Third, there do not exist highly reliable airborne detection devices of either a visual aid or sensor nature. Finally, the transmission of identification (and, incidentally, redetection) data so that action may be taken is complicated many times by the fact that different services use different radio frequencies and navigational charts and by the fact that identification information may never be relayed to the central data collection facility to be compared with the detection data.

This latter problem makes difficult any meaningful recording of infiltration should this be deemed desirable.

Any action which is taken subsequent to identification can be effective only if the action is taken where the infiltrators are. Thus, there is some requirement for a short time period between identification (which involves redetection) and any action which is to be taken against the infiltrators. Because, in general, in the system now in existence communications between air observers and ground forces are fairly cumbersome, actions which are taken tend to fall into the airborne category. Even here the question of acquisition is a difficult one for it appears that the observation craft and the fighter craft cannot communicate by radio. Thus, at least some small amount of redetection must be undertaken by the fighter aircraft.

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This having been done, the current system has problems associated with the accuracy in the fire power of the weapons that the attacking craft can bring to bear upon the infiltrators. By virtue of the nature of the weapons and their mode of delivery, destruction efforts are often highly inefficient.

In seeking an infiltration-interdiction system which represents a "minimum" change from the existing system but which has some hope of being effective we outline the following scenario.

Imagine first that there exists a signal-generating device in each sensor which can be activated by a signal from the receiving aircraft in the IGLOO-WHITE system. This signal is imagined to be activated only if the detection level of the device has exceeded a certain threshold within some short prior time period. Thus, when the signal-receiving plane receives a detection signal it activates the additional signal in the sensing device and obtains an accurate fix on its location. This information is then sent to the IGLOO-WHITE central information facility and a spotter plane is dispatched to the area. If the time period in which the sensor's signal-generating device can be actuated is sufficiently long, then the spotter craft can again use its signal to determine the point of initial contact. If the spotter aircraft has sufficiently good airborne visual aids or sensors for seeking infiltrators (see Reference, page 8), this redetection phase should be facilitated. Once the infiltrators have been found again, the search plane may drop a further signal-generating device or other marker to be used as a homing device by the attack craft. This latter device may be actuated at the time it is dropped or actuated by the attack craft as it approaches the target area, depending upon the amount of time involved between the identification and the attack.

A system such as this represents an attempt simply to fill some of the obvious technological gaps in the current system. It requires no change in the communications links or the command and control system.

To obtain such a system, the following types of developments seem implied:

a. A signal-generating device in sensors which can be activated on command for some specified time period after some detection threshold has been exceeded.

b. Better airborne visual aids and/or sensors for search based upon initial location data provided by detection sensors.

c. Same navigation charts for IGLOO-WHITE system and observer aircraft or easy correlation of different charts.

d. Locating device, possibly a signal generator, to be placed by spotter aircraft and used as homing device for attack craft.

e. More effective weapons for use by attack craft.

A system such as this representing a "minimum" change to the already existing system still has some major drawbacks. First, the time lags that occur would tend to make the system ineffective although certainly better than that which now exists. Second, it relies very heavily upon airborne forces and makes little provision for efficient use of ground forces. This latter is probably the largest objection to the system but, without changes in the communication links and command and control system, effective use of ground forces and ground- and sea-based weapons seems nearly impossible.

3.2 - A Computerized System

If one allows for unlimited change in communication links and the command and control system, then the number of possible infiltration-interdiction systems increases greatly, based on the previous analysis. Many of the options in that analysis cannot be implemented without considerable change to the already existing system. In this subsection we outline a possible computerized system which represents a considerable change from the system now in existence.

In this scenario the basic blocks of the computerized system are one or more command and control centers that contain both data processing facilities and personnel for making command decisions. If there are more than one of these command and control centers, rapid data transmission and communication links between them must be available.

Each command and control center must receive a great deal of varied information on a periodic basis. This information falls basically into four different categories: (1) information about one's own organization and its allies, (2) intelligence information, (3) information about the geographical areas of concern, and (4) some general information. One might envision that the following types of specific information might be required in each of these categories.

3.2.1 - Own Organization and Allies

a. Civilian

Probable patterns in each area

b. Personnel, Equipment, and Supplies

Location as function of time in each area of concern

Capabilities for reaction to presence of infiltrators in real-time period

c. Scheduled Plans

Expected movements of personnel, equipment, and supplies

Objectives by area of interest

Desired treatment of infiltration of different types

New facilities or equipment, etc.

3.2.2 - Intelligence Information

a. As much information about infiltrators as possible in categories a, b, and c listed above

b. Predictions of future behavior of infiltrators

3.2.3 - Geographic and Other Information About Areas of Concern

a. Location

Boundaries

b. Physical Properties

Terrain

Special features

Population, including distribution, occupation, friendliness, etc.

c. Strategic or Tactical Importance

3.2.4 - General Information

a. Weather

As a function of time and location

b. Political

c. Social

We note that some of the information listed above requires almost real-time input capability. This type of information is required about operating military units primarily. The bulk of the information required is required only on a periodic, perhaps daily, basis.

The computerized system for infiltration-interdiction that we are envisioning in this scenario requires certain data inputs as well as information. The input data is related specifically to the detection and identification of infiltrators. Specifically, one would like to have input data which tells at what time and where items were detected, what types of items are involved (that is, primarily, personnel, equipment and/or supplies) and sufficient detection data to deduce the configuration of the items that have been detected. We note that at this point the "whom" part of the identification problem has not been addressed. Before addressing this question, and others, a few remarks about the sensor system designed to obtain such data seemed called for.

In a computerized system for addressing the infiltration-interdiction problem, the sensor system can be quite elaborate because the data obtained from it can be used very rapidly. For example, we might envision a variety of sensing devices (seismic, magnetic, acoustic, etc.) each playing a role in attempting to determine what types of items have been detected. In addition we might envision fairly impenetrable unmanned receiving stations located on the ground throughout the areas of concern. These might be located in such a fashion that any sensor signal could be immediately triangulated. The data received from the sensor signals at these remote locations would then be immediately transmitted to the nearest command and control center. If the sensing system is adequately designed, one might hope to obtain sufficient information to allow an estimation of the configuration of the items that have been detected. This estimate would include the number of items, their spacial distribution, their direction, and speed of movement.

Detection data of the type just mentioned, when transmitted to a command and control center, can be compared with information about the location and the movement of one's own personnel, equipment, and supplies. Thus, if this latter information can be made available to command and control centers on a near-real-time basis, a system such as this would allow the identification function to be performed indirectly without visual observation. Identification in this case could be established in milliseconds rather than minutes.

[redacted]

Given the kind of data and information inputs mentioned above to a data processing facility at the command and control center, one can imagine outputs for use at that center of the following types. First, one has outputs related to an immediate command decision regarding any action to be taken against the newly detected infiltrators. These outputs have the form

a. Nature of Encounter

Location of encounter
When encounter takes place
What items were encountered
How many of each item

b. Reaction Criteria

Based on military objectives in the area
Based on probable or possible mission of infiltrators

c. Alternative Actions

Based on real-time assessment of response capability
Includes probable success of each alternative, if appropriate

d. Implementing Instructions

Including a prediction, if possible, of approximate current target location

Outputs of the form above are presumed to be automatic whenever the appropriate data processing program has determined that the items detected were to be considered hostile on the comparative basis mentioned earlier. Given these outputs there is a latitude allowed for response based upon an assessment of what responses may be made at that time. The response, then, requires a decision which is to be made in the command and control center in question, and the implementation of that decided-upon response requires that certain actions be initiated as spelled out in the implementing instructions.

There are other outputs of a more general character that one would hope from an infiltration-interdiction system of this form. These are not automatic outputs but rather outputs available upon request or possibly available continuously. Some of these types of outputs might be:

[redacted]

a. An Activities "Map"

A continuous visual display of current and perhaps some past infiltration activity

Displayed geographically

Indicating response and possibly effectiveness

b. An Estimate of Possible or Probable Enemy Objectives

Based on all collected infiltration data and intelligence information

c. Interdiction Effectiveness Report

This latter information is of a general character designed for use in determining reaction criteria (mentioned in the automated output) and for determining the effectiveness of the infiltration responses being made. We should note that the systems outputs are no different from the types of information that are normally desirable in making a response decision. The system only offers this information very rapidly, which in an infiltration-interdiction problem makes it more probable that the decided-upon response will be effective. A highly developed system of this form could rely very little upon visual search procedures and rely very heavily upon electronic, magnetic, etc., detection and tracking procedures.

A system that permits rapid communication of infiltrator location and strength to response forces also permits a wider variety of potential responses that can be undertaken successfully. For example, it would be difficult to employ small ground-based missiles effectively against infiltrators in the current system because of the time delay in identification and redetection by a spotter aircraft and the time delay required to transmit this information to a missile site. In a highly computerized system with rapid identification and communication abilities, such weapons could probably be employed very effectively.

It is difficult in a short time to imagine all of those things which might be needed in order to implement a highly computerized system. Nevertheless there are a few elements in such a system that seem quite obvious. To begin with, one needs one or more command and control centers, as described above, containing data processing facilities capable of processing, we suspect, rather large amounts of data and information. Second, a number of fairly rapid communication links must be established. Figure 2 shows rather grossly the kinds of links that may be needed. Figure 3 gives an indication of the sequence of activities in this context. The first

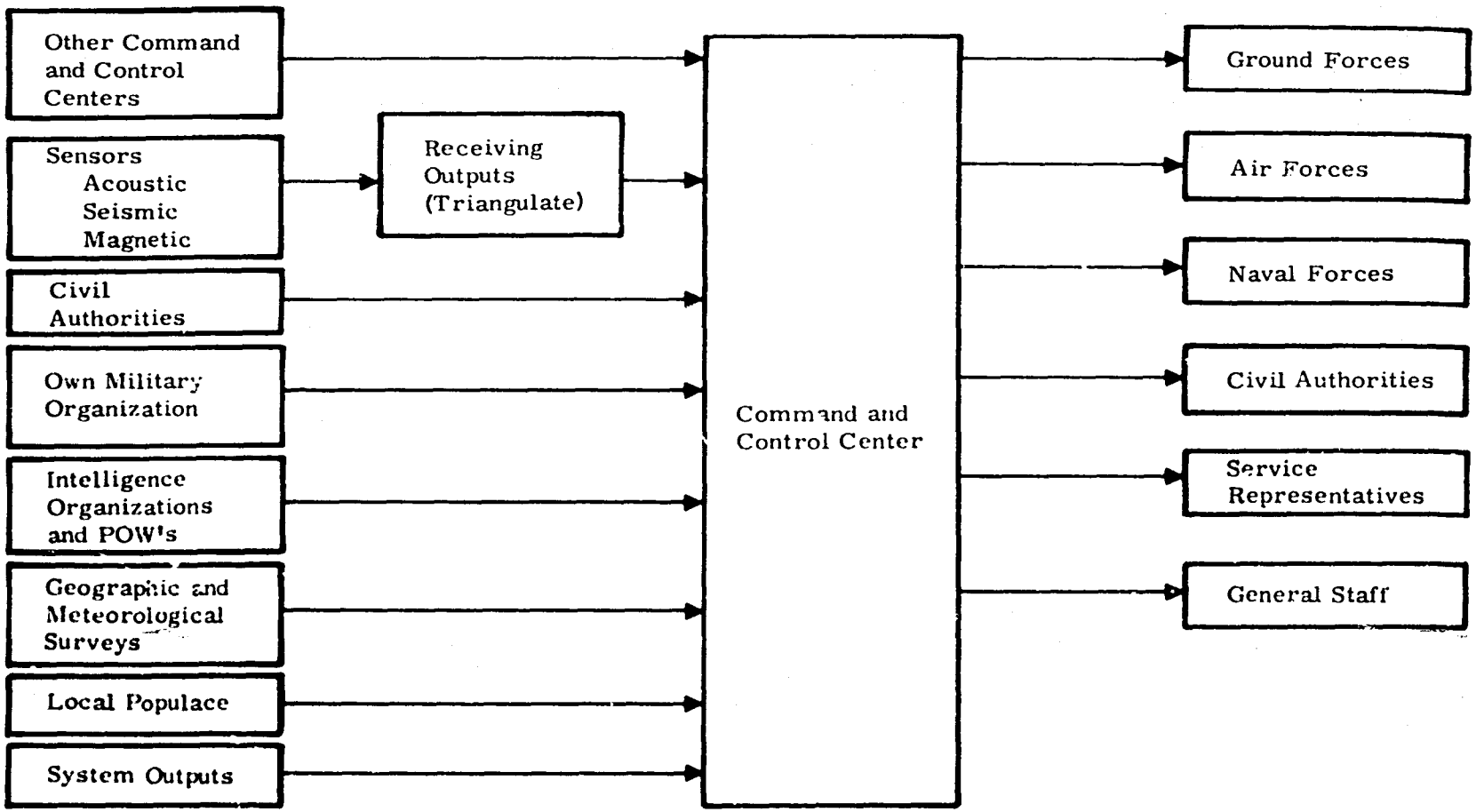

Figure 2. Information Flows in a Computerized System

Detect - Identify - Action

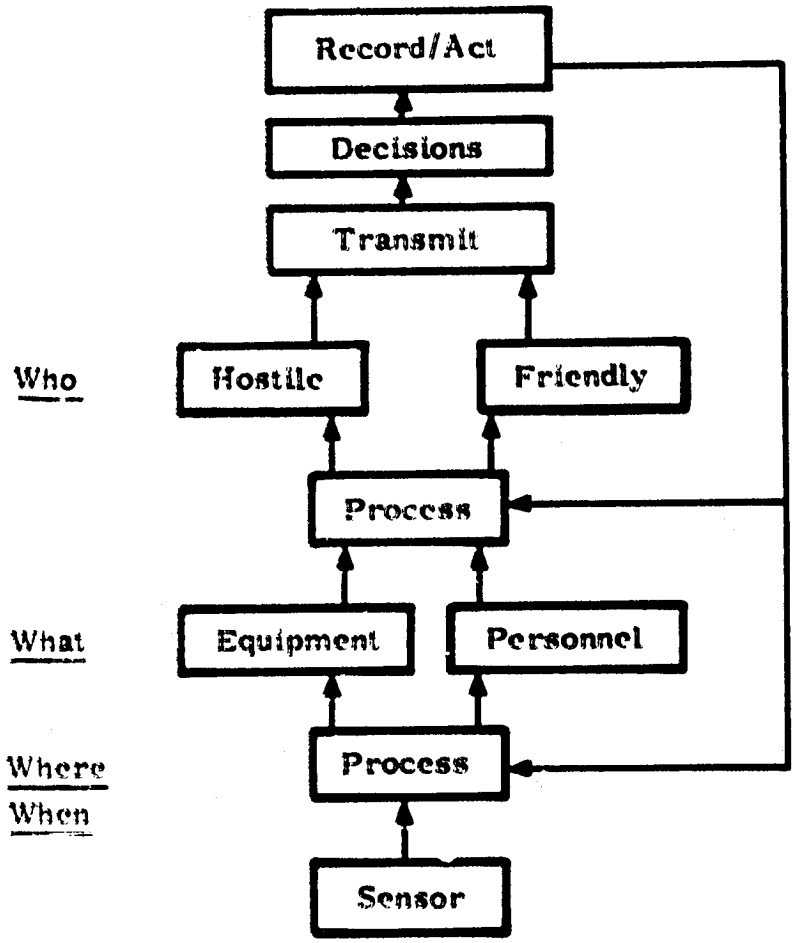

Figure 3. Hypothetical Computerized Activities Sequence

step toward obtaining such links might be the use of similar communicating frequencies by all armed forces and the establishment of reasonably streamlined communication centers. Also recommended would be the use of a single geographical locating system to facilitate the common identification of infiltrators. Sensors to yield more information than is currently possible would need to be designed and their optimal placement studied. There are certainly many other things that would be required in the way of elements of a command and control system or communication system and technological improvements in detection and weaponry.

3.3 - General Comments

We wish to stress that the two examples given above were no more than that: examples. No claim is made that either of these is particularly desirable. They were intended to point out that there are many options available for addressing the infiltration-interdiction problem as defined earlier in this report. A great deal of study would be necessary in order to determine the desirability of one approach over another.

It seems clear that while one system might be more desirable than another in a given context, the converse might be the case in a different infiltration-interdiction situation. Thus, what might serve well in Southeast Asia might serve poorly, indeed, in the context of urban insurrection.

Any combination of responses associated with Figure 1 designed to solve the infiltration-interdiction problem in some degree constitutes a part of the infiltration-interdiction spectrum. We have illustrated two "extremes." Many other options must be accompanied by a supporting system as our examples indicate. While specific systems have been discussed in connection with these examples, one can comment more generally upon the criteria and the nature of such systems. In the next section we attempt to do this.

SECTION 4 - INFILTRATION-INTERDICTION SYSTEMS

Since the actual implementation of any of the alternatives of actions listed in Section 2 involves some supporting communications and command and control systems, any attempt at the development of an infiltration-interdiction approach has two facets: (1) the development of an operating system to support the technology used in interdicting infiltrators, and (2) the development of a technology to support the system. Obviously, these two facets are highly interdependent.

4.1 - Technology Versus the System

We note that one approach, the "minimum" change, required some sort of homing or marking device to be used by spotter aircraft in order that the system be most effective. The highly computerized approach on the other hand required no such device, that is, while it might be useful in some situations with a highly computerized infiltration-interdiction system, it certainly did not appear to be an essential requisite. This illustrates one way in which the technology and the system are interrelated. It is important that the technological developments support the infiltration-interdiction system.

There is a converse to this proposition which is equally important: a system depending upon a nonexistent technology or an excessively expensive technology has little or no value. For example, a system which requires the use of tactical nuclear weapons to be effective would be unacceptable as an operational system at this time. Similarly, a system critically dependent upon molecular transport of supplies, a la science fiction stories, would prove equally unacceptable because of its current impracticality.

We can conclude, and quite strongly, that the implementation of an approach to infiltration-interdiction must involve concurrent and correlated activities in both the systems studies and technological areas. The advent of one without the other promises to lead to a considerably less effective attempt at solving the infiltration-interdiction problem.

[redacted]

4.2 - Infiltration-Interdiction System Dependence on the Total System

We have already commented upon the fact that any infiltration-interdiction system is dependent upon the infiltration-interdiction situation to which it is to be applied. The reasons for this dependence stem from the existence of different environments (in a broad sense) in which the infiltration-interdiction problem is being addressed.

The example of Southeast Asia versus urban insurrection has been cited. The difference arises in this example from many causes. Among them are such things as a difference in objectives regarding treatment of infiltrators, different "terrain" in which the infiltration is taking place, differences in degree of difficulty of identifying infiltrators, differences in personnel and weapons available to use in combating the infiltration, differences in equipment used for the same purpose, and so forth. Thus, the total "matrix" in which the infiltration-interdiction problem is embedded must play a very significant role in determining what system might best be used to interdict infiltration.

From the discussion in this and the previous subsection it should be apparent that the infiltration-interdiction problem is indeed a systems problem whose successful resolution can be attained only by consideration of the many "external" and "internal" elements which have a bearing on its importance.

4.3 - Infiltration-Interdiction Systems Studies

There are at least three major areas of systems studies responsibilities in attempting to resolve a given infiltration-interdiction problem.

First, it is necessary to determine insofar as possible the "best" mixture of alternatives that are technologically feasible. Such a determination involves a consideration of all of the total system elements alluded to in the preceding subsection and an assessment of the technological capabilities that might be employed in choosing possible alternative courses of action.

Most likely, concurrently with the preceding activity, a system must be designed that incorporates the alternatives chosen. The system design arrived at in this fashion must be practical in the sense that its cost must be acceptable and it must be capable of implementation in whatever time period is required. In order to do this one must understand how it would be implemented.

[redacted]

[redacted]

The third stage is the system implementation, that is, its actual installation and preliminary use. A systems study group responsible for the design and preparation of the system should feel responsible to aid in seeing that it does indeed perform as intended.

All of the activities needed to design and implement an infiltration-interdiction system cannot be confidently predicted a priori. Nevertheless, certain substudies do seem appropriate in relationship to almost any system. Among these are such things as: (1) optimal placement of sensors and receivers in order to extract or receive detection and identification information when and where it is desired, (2) optimal mix of types of sensors, (3) appropriate weapon responses as a function of time delay from initial detection, (4) optimal search strategies as a function of uncertainty in initial location, and so forth.

It is clear that the systems studies activities must support and be supported by an R&D activity to develop devices and weapons compatible with the system.

[redacted]

SECTION 5 - SOME OBSERVATIONS ABOUT POSSIBLE SANDIA INVOLVEMENT IN INFILTRATION-INTERDICTION

5.1 - Current Involvement

It seems appropriate at the outset to briefly discuss Sandia Laboratories' current involvement in the infiltration-interdiction problem. We should add the disclaimer that our knowledge is anything but perfect on this point so that what follows is more "guestimate" than fact.

It appears that Sandia Laboratories' primary involvement in the infiltration-interdiction problem lies in the area of the design and development of remote sensors. As best we can determine, this activity takes place under the auspices of the Defense Communication Planning Group, a task force reporting directly to the Secretary of Defense. The responsible Sandia Laboratories' individual is H. H. Patterson.

In addition to this primary involvement, there are some periodic proposals for different weapons coming out of Sandia Laboratories which have some direct bearing on the infiltration-interdiction problem. Some of these are by way of proposal only and others are developed and tested weapons such as the cable-cutting devices and the PAVE-PAT concept.

The activities alluded to, and there may be others, appear to lean toward a " minimum change" system as discussed earlier but they represent unrelated developments which appear to be unallied to any general systems concept even for a "minimum change."

Since Sandia Laboratories is indeed involved in the technological aspects of infiltration-interdiction, we assume that, should we choose to stay involved in this problem, such activities will continue and possibly expand.

5.2 - Systems Involvement

As we have pointed out earlier, technological development, if it is to be effectively used, must be correlated in some way with the system in which it is to be used. So long as the system is well-defined, technological developments per se are a very reasonable activity. As one moves from already existing systems to newly imagined

systems there must necessarily be a great deal of communication between those responsible for the analysis and design of a system and those responsible for technological development necessary to make the designed system effective. Based on the assumption that Sandia Laboratories, if involved in the infiltration-interdiction problem, will be involved in the technological development associated with it, we now examine the possible involvement in the systems analysis and design area. There are many levels at which such an involvement might take place and these are listed below in terms of decreasing systems responsibility.

5.2.1 - Analysis and Design of an Infiltration-Interdiction System

5.2.2 - Analysis of an Infiltration-Interdiction System

5.2.3 - Design of an Infiltration-Interdiction System

5.2.4 - Analysis of Select Subproblems Associated with an Infiltration-Interdiction System

5.2.5 - Awareness of Other's Analyses and Designs of Infiltration-Interdiction Systems and Associated Liaison

5.2.6 - Nothing.

Our first observation about this list is that so long as Sandia Laboratories is involved in technological development for infiltration-interdiction the last alternative, "nothing," for systems involvement must be ruled out. In order that the design and development work be meaningful we should at least be aware of systems analysis and design work being done elsewhere. Thus, if we are to be involved at all it would seem that we should be involved at least level 5.2.5, Awareness and Liaison, in the systems studies area. Some of the advantages and disadvantages of the remaining alternatives for levels of systems studies activities are listed in the table below. Clearly, the assessment of disadvantages and advantages is a subjective matter and the authors' biases toward a fairly complete involvement have likely influenced this list.

Possible Systems Studies Involvement

Alternative	Advantages	Disadvantages
(a)	Control correlation between systems work and technological development and implementation activities at all levels Sole responsibility for success Most direct control over program	Sole responsibility for failure Large and potentially difficult to administer internally
(b)	Conceptual control of system Control correlation between concept and technological development Good measure of credit for success	Potentially high credit for failure Lack of control over design and implementation Large and potentially difficult to administer internally
(c)	Can affect final correlation between system and technology to some degree Potentially modest credit for success	Responsible for working (and effective) system based on other's concepts Potentially large credit for failure Large and potentially difficult to administer internally
(d)	Can affect some correlation between system and technology at conceptual level Control over level of effort	Working on pieces with possibly little direct assurance that they are relevant Only modest contribution to problem
(e)	Minimum effort and minimal administrative problems internally	Minimum influence for effective use of technological developments

Let us comment generally on our feelings about the table listing possible alternatives for systems studies involvement. It has been made on the assumption that technological development activities associated with infiltration-interdiction will probably be continued at Sandia Laboratories. It is also based upon the assumption that this will be done concurrently with the development of future infiltration-interdiction systems. It is one thing to design and develop instruments and devices to operate with an already existing system concept and design and another to do these two basic activities concurrently. When the technological development takes place

subsequent to a systems design, the compatibility of such developments, if they are possible, with the system being considered is not particularly difficult. On the other hand concurrent technological developments and system design imply, to the authors, a partnership relationship between both activities. It is our considered opinion that from evidence available from past and present reimbursables that such partnerships are difficult to attain between Sandia Laboratories and some external organization. Thus, the entries in the above table tend to reflect this belief.

On the other hand, the authors are aware of the difficulties associated with the correlation of a large program internally. This is the problem of forming a partnership within the laboratory itself. The advent of the case system makes available a framework in which such an internal partnership may be realized. While the problem of internal correlation is a real one we tend to feel that the basic problem internally is less with correlation of activities than with the appropriate choice of personnel. Alternatives (a), (b), and (c) each involve, in all likelihood, a respectable number of systems personnel at peak periods. Alternative (d) allows for a good deal of control of involvement as mentioned in the above table. Alternative (e) implies a minimal amount of systems involvement. There are many other considerations which enter into the choice of possible advantages and disadvantages for different levels of activity at Sandia Laboratories. Among these considerations are such things as: (1) trade-offs between the desirability of current systems activity and the systems activity implied by the various levels of infiltration-interdiction involvement, (2) the desirable distribution of systems effort between reimbursable activities and AEC weapons activities, (3) the assessment of internal managerial capabilities in large-scale systems work, (4) the desirability of being involved in nonnuclear tactical warfare problems, and so forth. The authors did not feel that it was within their province to address these questions although they recognize that the answers to such questions would have a large influence on the desirability or undesirability of systems involvement at various levels.

5.3 - Feasibility of Infiltration-Interdiction Involvement

The feasibility of undertaking infiltration-interdiction systems studies efforts at levels represented by alternatives (a), (b), or (c) and most particularly the former depends upon the achievement of two basic arrangements: suitable external arrangements and suitable internal arrangements. The notion of a suitable external arrangement is a partnership. This implies our ability to influence systems analysis and

design even if not directly responsible for it. We feel that this is most likely attainable with alternative (a) by working directly with the Defense Communications Planning Group or a similar high-level group. The alternatives (b) and (c) imply a partnership with a working-level government organization. In general, we feel that such a relationship is difficult to achieve and to maintain.

By a suitable internal arrangement, we mean a framework in which interaction of systems personnel and physical research and development personnel can take place freely and constructively. We might envision, in this regard, the following scenario: a case manager with a nucleus of systems personnel and physical research and development personnel reporting directly to him organizationally. This nucleus would be responsible for the conceptual analysis and design of a system and the assessment of feasibility for technological development associated with it. Specific systems analyses could be carried out by organizations in, say, 1700 or 1800 under the case system and postfeasibility design and development of physical devices carried out by organizations in 9200, again within the case system. We feel that sufficiently many qualified personnel exist at Sandia Laboratories to address the infiltration-interdiction at the level represented by alternative (a) above, and that within a framework such as just proposed, this involvement could be undertaken quite successfully if accompanied by the appropriate choice of personnel as case manager and nucleus group.

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