PEOPLE, ORGANIZATIONS AND COMMUNICATION

Joel N. Bloom
The Franklin Institute
Philadelphia 3, Pennsylvania

Benedict R. Jacobellis
Technical Assistant to Director of Operations
Defence Communications Agency

First Joint National Meeting
Operations Research Society of America
and
The Institute of Management Sciences

November 8-10, 1961

THE FRANKLIN INSTITUTE

LABORATORIES FOR RESEARCH AND DEVELOPMENT

PHILADELPHIA PENNSYLVANIA

PEOPLE, ORGANIZATIONS AND COMMUNICATIONS

Joel N. Bloom
The Franklin Institute
Philadelphia 3, Pennsylvania

Benedict R. Jacobellis
Technical Assistant to Director of Operations
Defence Communications Agency

First Joint National Meeting
Operations Research Society of America
and
The Institute of Management Sciences

November 8-10, 1961

ABSTRACT

Military communication systems are designed to convey information from its point of origin as human thought through its dissemination to the points of action. Current equipment development programs should aim at an optimum relationship between humans and automatic equipment. Consequently, determination of the factors associated with the interrelationship of people, communication methods, and organizational concepts must constitute a fundamental element of system analysis and design. This paper deals with the methodology, execution, and results of an empirical program for assessing the effectiveness of the human and organizational elements in military communication networks in terms of a trade off between the control of error and the delay involved in error control. As all information to be transmitted by the system does not inherently require equal freedom from error and delay, an information characterization scheme is introduced. Information is characterized in terms of its (a) urgency, (b) importance, and (c) policy status. The operating characteristics of the various system elements in terms of error and delay are then measured and examined in terms of homogeneous groupings of the information characteristics. Problems involved in the execution of the data collection program in operating Army headquarters are considered and a number of instruments for route tracing and delay and error measurement are discussed. Selected results are presented and their implications for the design of new systems discussed.

PEOPLE, ORGANIZATIONS AND COMMUNICATIONS*

The change in the time scale of modern war and the considerable extension of our worldwide military commitments has resulted in an extension of, and altered requirements for, communication facilities. During the past decade, progress in the electronic technology of communication systems has been impressive. In fact, technological development has progressed to the point at which the technical problems no longer impose the major limitations upon the system. Indeed, there is at present a lack of balance in our communications engineering knowledge, for the greatest delays and the most serious errors are due, not to the shortcomings of the equipment, but to the fallibility of the user, man. It is necessary, therefore, that those responsible for military communications become increasingly concerned with the interface between man and his communication equipment, so that they may continue to provide fast, accurate, and economical communications service. The communicator, then, must be concerned with properly matching men, organizations, and equipment to the communication needs of the military. Such matching is dependent upon an understanding of the fundamental operating characteristics, not only of the communications equipment used or contemplated, but also of the human and organizational system elements.

---

*The research described in this paper was conducted under Department of Army Contract DA-36-039-SC78332 administered by the Army Communication Systems Division, Office of the Chief Signal Officer.

To meet this need, the Army Communication Systems Division, Office of the Chief Signal Officer, contracted with the Franklin Institute to undertake an Operations Research Study of Army Headquarters Communications. The basic objective of this study is the determination of the fundamental principles of the interrelationship of people, organizations, and communications. This paper will present a brief report on the development of our approach to this problem and some of our results.

We may begin by considering the Army command and control network whose nodes are the major Headquarters, ranging from Department of the Army down to, and including, the field Armies. In recent years, a great deal of emphasis has been placed on the development of direct lines between these major commands, with the terminating instruments placed in actual direct physical proximity to the commanders. This type of service is, of course, important, in that it facilitates direct personal contact between commanders. It is, however, addressed to but a small portion of the total problem, since military operations cannot be conducted by commanders alone but require an extensive supporting staff function.

The typical military communication originates as a thought in the mind of a staff officer, whom we refer to as an Action Officer (AO), which he wishes to transfer to his opposite number at another headquarters. It terminates when it is received and understood by the destination Action Officer. The basic system elements in this process are indicated in Figure 1. The first element is semantic processing, in this case encoding - the conversion of thought to language. The next element is coordination -

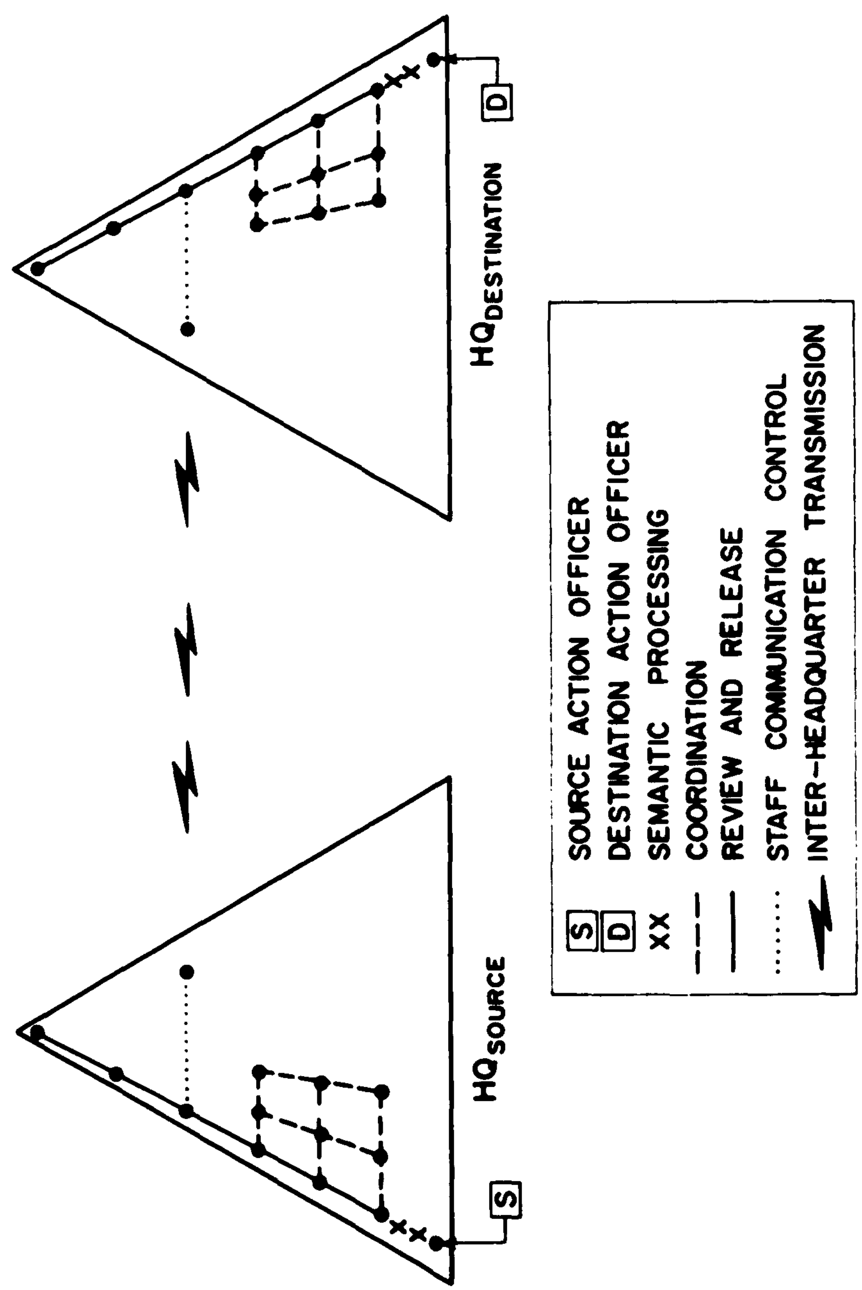


FIGURE 1
ARMY COMMUNICATION PROCESS

the processing of the communication in an essentially lateral fashion for concurrence and information of other interested staff sections. The third element is review and release - the approval of the communication by the Action Officer's superiors, in some cases up to the commander himself. The next element we term staff communications control - the processing of the communication by organizational segments specifically charged with communications control, such as a staff message control section. Finally, we reach the inter-headquarters transmission element, traditionally the domain of the communicator, but actually only a small part of the total communication process. When the communication arrives at the destination headquarters, it must traverse the entire sequence of elements, essentially in reverse, until it terminates as thought in the mind of the destination Action Officer. The true terminals of the communication network are, then, the hundreds of individual Action Officers in each headquarters. The communications which they exchange are routed via such media as electrical message, mail, telephone, TELECON, and even face-to-face conversation and conference. The communications themselves range from official record command communications to informal questions and exchanges of information and ideas, with the latter two generally required to support and expand the official traffic.

Our general approach to the problem was closely akin to the methods engineering approach of the industrial engineer. We first defined the elements which constitute the family of communication systems (in this process, we endeavored to consider all possible elements for use through the 1965-75 time frame, and we were not limited by current availability of hardware). Armed with an array of possible system elements, we developed measures for quality of performance for each element, measures which can be used as guidelines for the development of future communication systems. Our primary objective was to furnish the system designer with the operating characteristics of his human and organizational elements in much the same manner as he is furnished with electrical component characteristics.

Our course, then, was the development of a series of Operating Characteristics to enable us to test the effectiveness of a given communication system or its individual elements. As a starting point, we have defined the overall system objective as "the transmission of information from source to destination", as depicted in Figure 2. The word "information" is used in the non-technical sense, i.e., commands, ideas, questions, etc.

Two criteria measurements are appropriate to evaluate the extent to which a system meets its overall objective. These are delay and error.

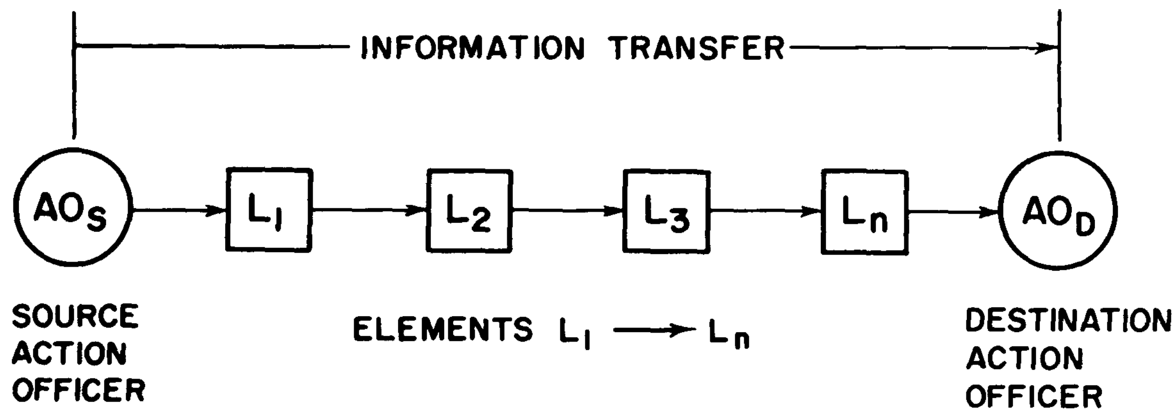
We define delay as:

$$T_{destination} - T_{source} = D$$

where T = Time

D = Delay

SYSTEM OBJECTIVE:



CRITERIA:

$T_{DESTINATION} - T_{SOURCE} = D$

$I_{DESTINATION} - I_{SOURCE} = E$

WHERE:

T = Time
I = Information
E = Error
D = Delay

FIGURE 2
SYSTEM OBJECTIVE

We define error in like manner as:

$$I_{destination} - I_{source} = E$$

where I = Information

E = Error

An idealized communication system would operate with zero error and zero delay; that is to say, the identical information would be simultaneously available at both source and destination. In the real world, all communications systems are subject to disturbances and a perfect system is not physically realizable. Thus, all real systems exhibit both delay and error and our design objective must be directed toward minimizing these factors consistent with the systems' contemplated use and cost allocation.

In the military communication system, we note that, despite the formal address and signature, source and destination are, in fact, individual Action Officers. Delay can then be expressed, at least conceptually, in terms of:

$$T_{Destination\ AO\ thought} - T_{Source\ AO\ thought} = D$$

i.e., time from thought to thought.

The expression of error is somewhat more complex. We must recall that neither Source nor Destination Action Officers are operating as individuals but rather as components of that complex entity we term a military staff, and that in exchanging communications they are actually acting for their respective commanders. This suggests the extension of the error criterion into a three part sub-system as the basis for more meaningful measurements of error as indicated in Figure 3.

Consider a number of stages in the communication of a "chunk" of information from Source to Destination Action Officer. Let us begin with the middle block on the left, representing the thought of the Source Action Officer. This consists of some information which he wishes to convey to an Action Officer in a distant headquarters. He must process this into either spoken or written language, e.g., a letter, an electrical message form, a telephone conversation. We indicate this as the Action Officer output block. This output is transmitted to the destination headquarters and arrives at the Destination Action Officer as a physical input, e.g., a letter, a teletype printout, a telephone conversation. This physical input is then converted by the Destination Action Officer into Action Officer thought.

The first segment of the total error we term E_A (Error of Accuracy). This is a measurement of the congruence between the Source Action Officer's output and the Destination Action Officer's input. Errors of this type tend to be relatively infrequent, and are often controllable by simple means; for example, in the U. S. Army-operated network, numbers and unusual or unexpected words are usually transmitted twice. Indeed, for certain communications systems, such as the U. S. mail, where the output and input are the same piece of paper, E_A is virtually zero. It is, however, not unknown to have zero E_A (Error of Accuracy), yet almost complete lack of congruence between source and destination thought. In such cases,

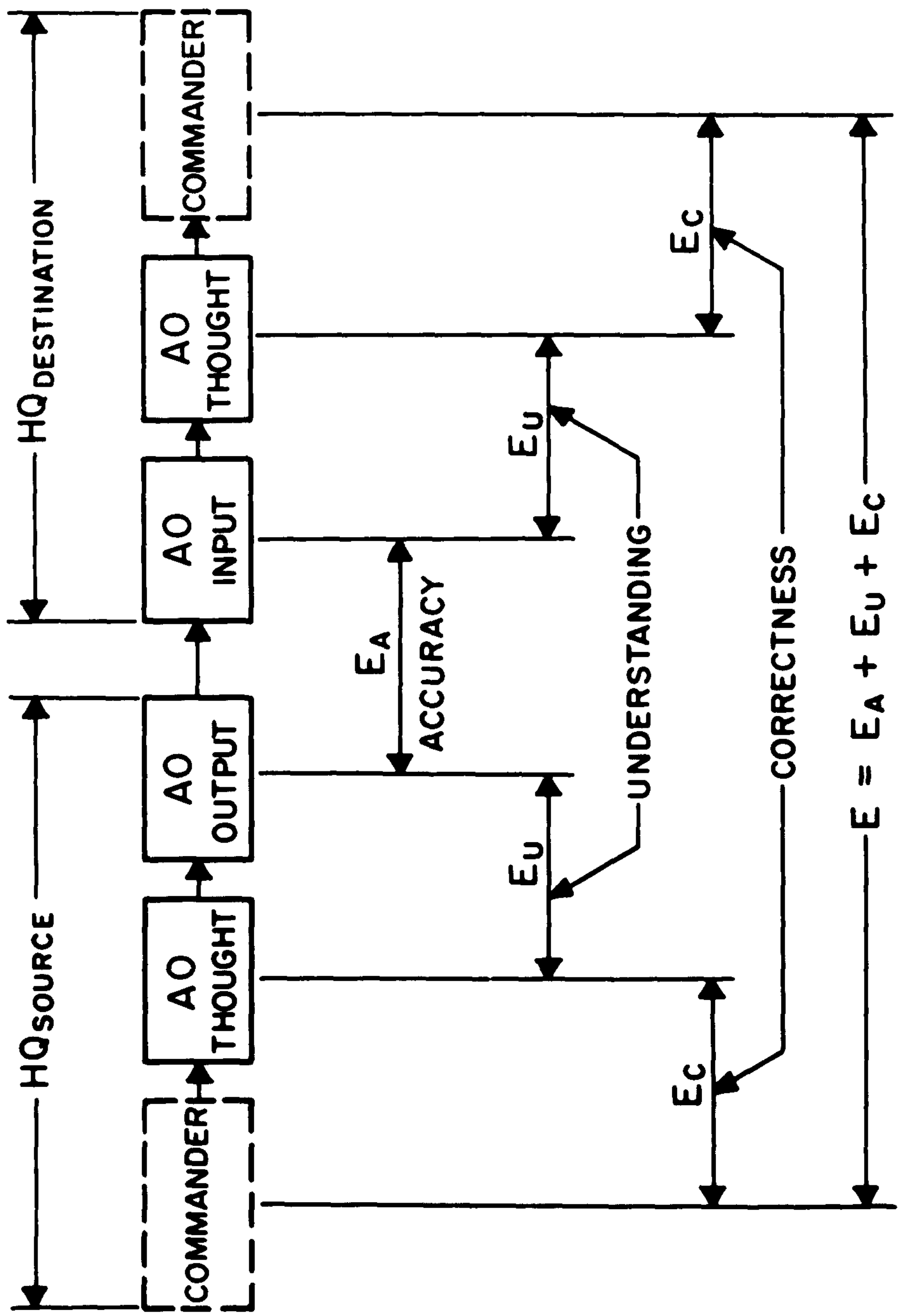


FIGURE 3

MEASUREMENT OF ERROR

the semantic decoding and encoding elements - that is, the conversion of thought to language and vice versa - were not functioning effectively. In other words, the writer had difficulty expressing himself or the reader had difficulty understanding the writer's language. We term this E_U (Error of Understanding) and suggest that errors of this type are of considerable importance in military communications.

The third and last segment of total error is termed E_C (Error of Correctness) and is indicated on either end of the figure. Recalling that the Action Officer is in fact representing his commander, it is essential that there be congruence between the Action Officer's thought and the commander's position on the matter in question.

In somewhat broader terms, the communication must be as substantively correct as would be the case if the commander himself were writing the communication with the advice of his staff. Indeed, most of the internal processing of military communications is designed to reduce E_C (Error of Correctness). Thus, an outgoing communication is passed up the headquarters command structure for review and release in order to secure the approval of persons "closer" to the commander, as it were. In like manner, it may be passed laterally - "coordinated" - to secure approval of persons who represent the commander on related aspects of the problem.

Certain general observations on the possible interrelationships of our two principal criteria are now appropriate. Delay and Error are both related to a third system parameter - cost, which is of necessity a major factor in optimization of overall system design. It is possible to reduce delay by increasing cost; (for example, by substituting a pneumatic tube system for a twice daily message service), or reduce errors caused by transmission garbles with improved and usually more costly transmission equipment. Within a given fixed cost system, it is often possible to trade off delay for error and vice versa. For example, it would be possible to transmit all messages twice to reduce error but at the price of increased delay. Similarly, internal headquarters administrative processing could be eliminated (i.e., allow each Action Officer to release his messages directly to the electrical network); this would reduce delay but might lead to increased error, in particular E_C (Error of Correctness).

This trade off between error and delay offers an attractive approach toward the analysis of the administrative aspects of military communication systems. Thus, communication system elements, be they coordination, review, release, or staff message control, are justified to the extent that the delay they impose is accompanied by a significant reduction in error, whether of accuracy, understanding, or correctness. In effect, then, we must determine an optimum or near optimum point on the Error, Delay Trade-Off Curve (Figure 4). Here we suggest that as the number of elements increases - particularly administrative processing elements - error is reduced and delay is increased. However, there exists a point beyond which the increase of administrative elements tends to increase error as well. This hypothesized upturn in error is indicated by the dotted portion of the curve.

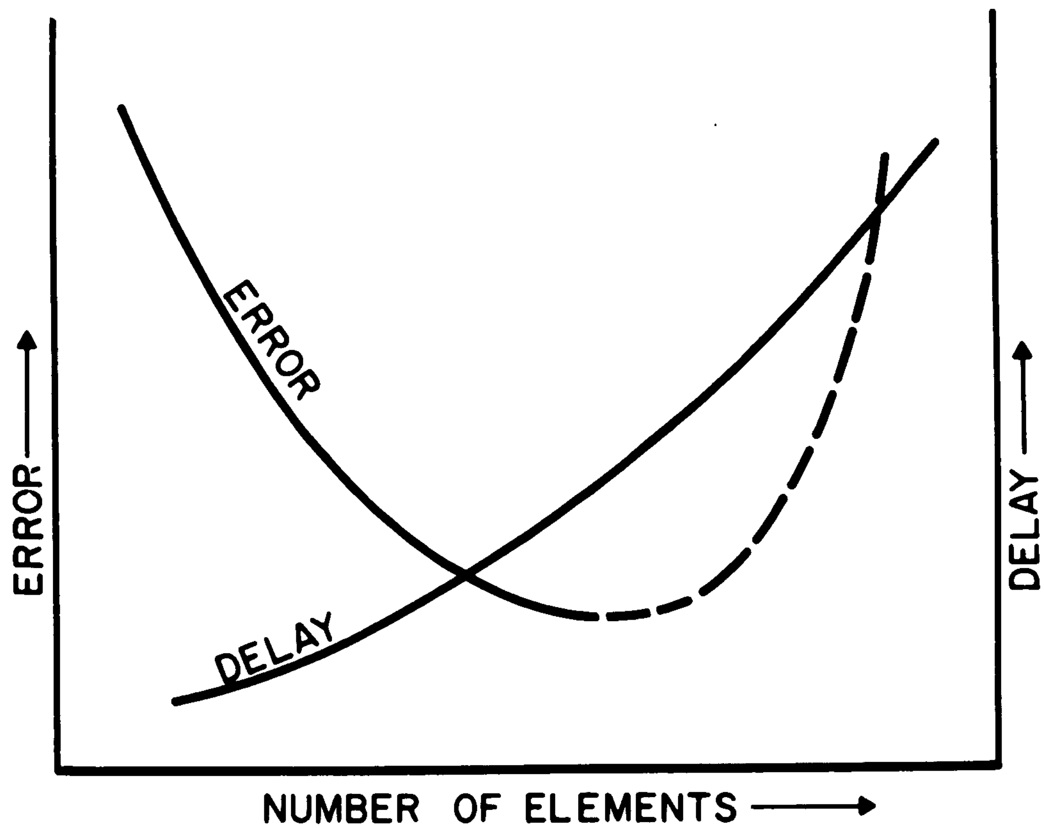


FIGURE 4

ERROR, DELAY TRADE-OFF

If all information transmitted by the communication system were homogeneous, our criteria would be adequate for system analysis. Unfortunately, this is not the case. Present day military communication systems handle traffic ranging from minor administrative details, which can tolerate extensive delay and error, to matters of extreme national significance, where even a minor error or delay would be disastrous. Thus, statements of Delay and Error averaged over all types of traffic are apt to be almost meaningless. In order to assess the performance of an element or route, we first have to specify the type of message under consideration. Fundamentally, we wish to know the operating characteristics of a given route for a specific type of message, so that alternate routes may be properly compared. It is necessary, then, to develop a means for grouping like communications. We do this by characterizing communications in terms of three information content characteristics, Urgency, Importance, and Policy Status. Time does not permit me to discuss our development of these characteristics. They are, however, employed principally to secure homogeneous sets of communications for analysis.

Now that we have discussed the conceptual background of our work, let us proceed to a consideration of the measurement program itself. Data collection in an operating Army Headquarters is greatly complicated by the necessity of minimizing disturbance to the day-to-day operating pattern of the Headquarters. Not only is such a disturbance undesirable from the Army's standpoint, but it may generate false results. For example, communications may well tend to move faster when operating personnel sense that they are under observation. Thus, the rather popular single "test message" prominently marked "test" is inadequate as a data collection technique, when time measures are desired. The solution to this problem revolves about the following:

(1) Sample design

(2) Method of observation

(3) Disturbance check

Choice of adequately long sample periods permit the disturbance caused by data collection to be measured and to damp out. Thus, observation of sequences of ten or twenty messages are, in general, better than a like number of individual messages. Properly planned observation schedules and techniques can also serve to reduce the potential disturbance by minimizing the actual intrusion. A combination of the foregoing, coupled with a close measurement of the remaining disturbance effect, so that appropriate compensations may be made, is a reasonable solution to this problem.

Rather than attempt to cover in brief the many measurement techniques we have developed and utilized for specific aspects of the problem, I would like to review in some detail one of our most widely used tools - the headquarters delay and error measurement program. Let us consider a typical communication sequence as indicated in Figure 5. The inbound communication is first processed by a control unit, say a staff message control section. It then undergoes administrative processing within

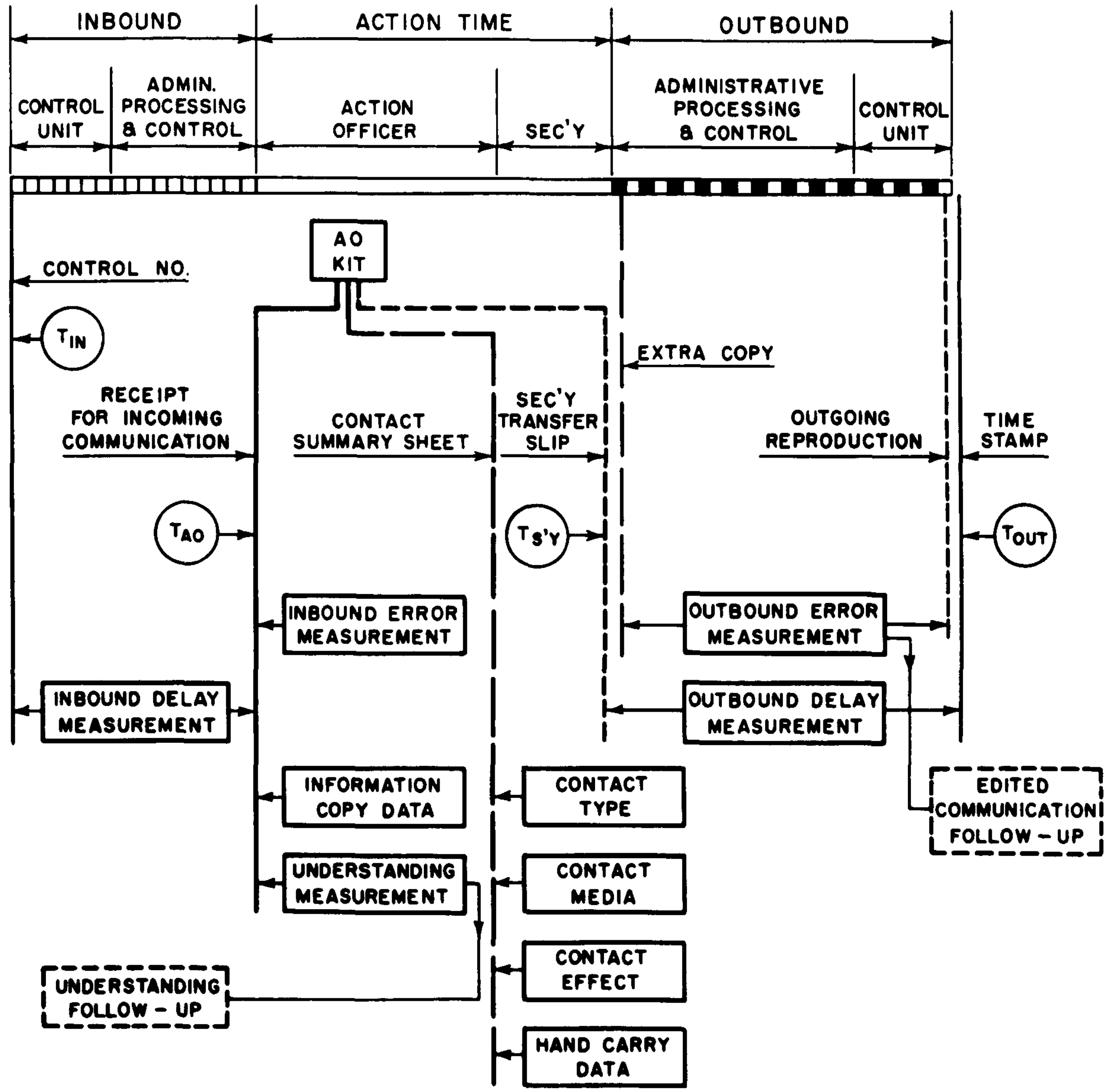


FIGURE 5.

SCHEMATIC OF BASIC DELAY AND ERROR MEASUREMENT PROGRAM the staff structure of the headquarters, completing its inbound leg when it reaches the Action Officer. After processing by the Action Officer, the reply begins the outbound leg when it leaves his secretary's desk, thence to administrative processing, which includes review, release, and coordination, and finally to staff message control. We would like to measure both inbound and outbound error and delay on a sequence of ten communications from a relatively large sample of Action Officers in the headquarters. This is done in the following fashion:

Kits containing detailed instructions for both Action Officers and their secretaries and ten copies of a three-part communications record form are distributed to all Action Officers in the sample. The form-sets are numbered serially and each of the three parts bears the same serial number.

A few days before this distribution, observers are stationed at the entry points of the headquarters (staff message control and mail and distribution units) and all incoming communications are stamped with a consecutive sequential number. The point in the sequence is noted at half hour intervals so that the sequential number series is, in effect, a time stamp. For example, the numbers between 9152 and 9520 might represent the time interval from 1300 to 1330. The sequential number also serves as an identification number whose purpose will be indicated in a moment. Parenthetically, we have found that sequential numbers keyed to time segments cause far less disturbance to the headquarters than actual time stamps and that 1/2 hour intervals give ample time resolution. When the Action Officer receives the communication, he uses the first part of the three-part communications records form (Figure 6) to indicate his time of receipt and the identification number of the communication. He also indicates by a check mark his answers to a number of questions relating to inbound error control such as: "Superior officer indicated action that he wanted taken". In addition, questions relative to information copies, their use and value, are asked, as is a question about the understandability of the incoming communication. I may note that all communications not indicated as fully understandable are followed up by a separate questionnaire and analysis program designed to isolate and identify the significant factors in communication understandability. Each page of the communications record form is designed as a mailer so that the Action Officer has merely to fold, staple, and place it in his out basket for return to the study group. The entire processing of these forms, including the accuracy of the Action Officers' time estimates, are monitored by a quality control program and thus far we have found an extraordinarily high level of both cooperation and accuracy of reporting.

At this point, we have sufficient information to determine inbound delay and inbound error, both in terms of understanding and inbound control. By subtracting the time of receipt as reported by the Action Officer from the time of entry into the headquarters as developed from the sequential numbering, we determine the inbound delay and, by an analysis of the replies to the questions, we establish the extent and

16011
FIL NO.

RECEIPT FOR INCOMING COMMUNICATION

Instructions:

Fill out this Receipt as soon as you receive an incoming communication routed to you for action. In case there is no incoming (you are initiating a communication), simply check this box and disregard items 1-3 on this page.

Initiated outgoing (no incoming) ☐

Please note that it is imperative for the success of this program that you fill out this slip and dispatch via your normal "out basket" immediately upon receipt of the incoming communication.

---

1. Enter the "In No." found stamped on the incoming communication. In No. 9152

2. Record the date and hour (in local time). Date: 10/17/60 Time: 1300 Hours

3. Please answer the following questions:

   a. Have you received any preliminary notification that this communication was coming? (check one or more answers):

      1. No advanced notification whatsoever. ☐
      2. Advance notice received. ☐
      3. Superior officer indicated action that he wanted taken. ☑
      4. Request to speed up action on the outgoing communication. ☐

   b. Is it, or would it be, of any help to you if other staff sections had copies of this communication at this very moment?

      yes ☑ no ☐

   c. If "yes", which sections?

      G-4

   d. Do you find this communication to be written:

      1. In a completely clear and understandable manner? ☑
      2. In a moderately clear and understandable manner? ☐
      3. Rather unclearly and not fully understandable? ☐

4. Detach the Receipt For Incoming Communications, to [illegible] and staple (so that your replies will be kept confidential), and drop into your outgoing mail basket.

   Then attach, for later reference, the remaining pages of this form to your working file on this action.

FIGURE 6

COMMUNICATIONS RECORD FORM - PART I

FORM D-876 9-27-60 10M

nature of inbound control on error.

We may now turn to the outbound leg. The Action Officer is instructed to retain the second and third part of the record form with his working file on the action. When the Action Officer completes his reply, he is asked to return the second part of the form (Figure 7) with his answers to a series of questions about the internal headquarters contacts he made in processing the communication. I shall not comment on this part of the form at this time beyond noting that the various aspects of the internal contact process - reasons for, volume, and media employed - constitute an important aspect of the total communication process.

The Action Officer is then asked to turn over the third part of the form, Figure 8, to his secretary when she is ready to type the outgoing message. The secretary is instructed to type an extra copy of the outgoing communication and to indicate the form serial number (in the example depicted, 16011) on both the headquarters file copy and the extra copy of the communication. She is also asked to indicate the time of typing. The form itself serves as a mailer for the extra copy, which is immediately returned to the study group. The secretary's adherence to these instructions and her accuracy in recording time are also monitored by a study group quality control team. The actual communication now goes through the normal staffing sequence of review by supervisors, concurrence at various levels, and formal release. If the communication is returned for retyping as a result of changes incurred during the staffing function, the secretary is instructed to transfer the serial number to the file copy

CONTACT SUMMARY SHEET

16011
FIL NO.

You may wish to jot down a description of the incoming communication as a convenience to you in case this sheet should become separated from your working file on this communication.

Tank repair

Instructions:

1. In the drafting of this communication you may have to contact other persons within this headquarters by telephone, face-to-face, or written DF or memo. Would you please indicate the total number of such contacts for each of the following categories:
(Extra space is provided in case you wish to keep a running tally.)

   a) obtaining needed information, instructions, suggestions, or clarifications. 2

   b) providing other persons with information to keep them "informed". 3

   c) SOLELY for the purpose of facilitating or accelerating the obtaining of formal concurrence, approval, or release. 1

2. Would you kindly approximate how many of these contacts were made by

   Telephone 4 Face to face or conference 1 Written memo or DF 1

3. Did any of these contacts result in a substantive change in the outgoing communication? Yes ☐ No ☑
If so, give a brief description of each change, and the position and office symbol of the person(s) who suggested the change

4. How many additional contacts do you anticipate making during the period the communication is being formally processed for release? (If none, write "None".) None

5. Will you or your secretary hand carry this communication while it is being processed for release?

   You Yes ☐ No ☑ Secretary Yes ☐ No ☑

When you have completed your draft of the outgoing communication and have finished making all your contacts, complete and detach this Contact Summary Sheet, fold over and staple (so your replies will be kept confidential), and drop in your outgoing mail basket.

Then hand the next page (Secretary Transfer Slip) to your secretary along with your draft of the outgoing communication

FIGURE 7

COMMUNICATIONS RECORD FORM - PART 2

FORM D-877 9-27-60 10M

16011
FIL NO.

SECRETARY TRANSFER SLIP

Instructions:

1. Please prepare an EXTRA carbon copy, on plain white tissue, of this outgoing communication. Do not, however, make EXTRA copies of preliminary working drafts. Include on the EXTRA Copy all the information which appears on the official Record File Copy such as Memos for Records, names of concurring and approving officers, etc.

2. The FIL No. appearing above at the right must be typed on both the official Record File Copy and the EXTRA Copy. Please type it in the upper right hand corner of both.

3. If the communication has more than one page, please repeat the FIL No. on each page.

4. As soon as you have finished typing the communication, please enter the date and local time in this space.

Date: 10/21/60	Time: 1430 hours

5. Fold the EXTRA Copy(s) inside this Slip (which serves as a mailer), staple and drop in your outgoing basket. It is vital for the success of this program that you do this immediately upon completing the typing. Do not wait for review, concurrence, or release of the actual communication.

6. If, during review and release, the communication is returned to you for retyping, please make absolutely certain that you transfer the FIL No. from the original Record File Copy to the revised Record File Copy. However, it is not necessary to type an EXTRA Copy of the revised communication.

Before stapling, please make certain that:

- The FIL No. appears on both the EXTRA Copy and the Record File Copy.
- The date and time is entered on this form (No. 4 above).

Also make certain that the FIL No. appears on the Record File Copy of any revisions.

FORM D-878 9-27-60 10M

FIGURE 8

COMMUNICATIONS RECORD FORM - PART 3

of the revision. Our observers now monitor all outgoing communications at the exit point of the headquarters and time stamp and make a reproduction of all communications bearing our serial number.

We can now measure outbound delay by subtracting the exit time from the secretary's initial completion time. By comparing the extra copy from the first typing with the copy which actually left the headquarters - we use transparency illuminators and actually match both sheets - we can detect any change introduced by the outbound administrative processing. This change is, of course, a direct measure of defacto error.
For example, Figure 9 shows a pair of outgoing communications. The one on the top is the extra copy of the first typing and the one on the bottom is the message as it actually left the headquarters. The notations on the margin enable us to reconstruct the path of review, release, and concurrence.

In this particular case, the communication was changed as shown by the circled areas. In order to evaluate the changes, we have developed a multi-dimensional coding system which enables us to rate both the <u>nature</u> of the change (i.e., whether the change involved re-writing a sentence, correcting spelling or punctuation, etc.) and also the <u>importance</u> of the change. Using this coding system, we classified the changes indicated by a "1" in parenthesis under the heading of "Trivia" and changes 2 and 3 as "Re-write words and phrases". Along the dimension of Importance all three changes were given a rating which indicates "No improvement in the communication". (In other words, these changes were

...-PM 350 1st Ind
SUBJECT: Request for Additional Funds for ... Activities

Headquarters ...

TO: ...
ATTN: ...

1. Reference is made to paragraphs 2 through 6, basic letter.

2. Additional funds in the amount of (1) $7,300.00 are required to implement the unprogrammed Hq ... Joint Education Program for the remainder of FY 1961, since limited Hq ... resources have already been committed to the support of other programmed activities.

3. (2) Further request that BF 2500 (9010) (3) be increased by $7,300.00. (1)

4. Since the post graduate program for ... graduates and officers attending the ... will be a continuing requirement in FY 1962, it is recommended that an estimated total annual funded cost of $10,000.00 (1) be included in the FY 1962 program.

FOR THE COMMANDER:

RO ____
Concur
G4 ____
COMP ____
Inform
G3 ____

2 Inc.
n/c

"EXTRA COPY" (FIRST TYPING)

...-PM 350 1st Ind
SUBJECT: Request for Additional Funds for ... Activities

Headquarters ...

TO: ...
ATTN: ...

1. Reference is made to paragraphs 2 through 6, basic letter.

2. Additional funds in the amount of (1) $7,300 are required to implement the unprogrammed Hq ... Joint Education Program for the remainder of FY 1961, since limited Hq ... resources have already been committed to the support of other programmed activities.

3. (2) Request that BP 2500 (9010) (3) of this Command be increased by $7,300. (1)

4. Since the post graduate program for ... graduates and officers attending the ... will be a continuing requirement in FY 1962, it is recommended that an estimated total annual funded cost of $10,000 (1) be included in the FY 1962 program.

FOR THE COMMANDER:

RO
Concur
G4
COMP
Inform
G3

2 Incl
n/c

"DISPATCHED" COPY

FIGURE 9

COMPARISON OF "EXTRA" COPY WITH "DISPATCHED" COPY

NOTE:- Communications and signatures have been changed to prevent identification of writer and headquarters of origin.

judged to have no practical effect upon the correctness or understandability of this communication.)

We wished to supplement our interpretation with the viewpoint of the person who actually authorized each change. Accordingly, we sent questionnaire follow-ups to all such persons, asking them why they felt the changes were necessary and asking them whether the change was "Essential" or "Not essential but desirable". (Incidentally, the person who made the changes in the sample communication considered them "Not essential but desirable".)

In summary, then, the measurement program I have just described enabled us to determine delay and error for large numbers of real communications in operating headquarters. This data must, of course, be supplemented by numerous other investigative efforts.

I might mention, in passing, three coordinate programs designed to round out the one just described. First was a series of experiments or simulations introduced to provide more adequate control of some of the more important variables. Second was a critical incident technique designed to uncover the rare, but significant occurrence. Third was a questionnaire program which studied opinions and attitudes as they relate to the whole problem of communications.

Time permits me only to highlight some of the results of our data collection efforts. Figure 10 depicts a cumulative distribution of inbound delays measured in working days. The median is almost a day and a half and an appreciable number - approximately five per cent - are still

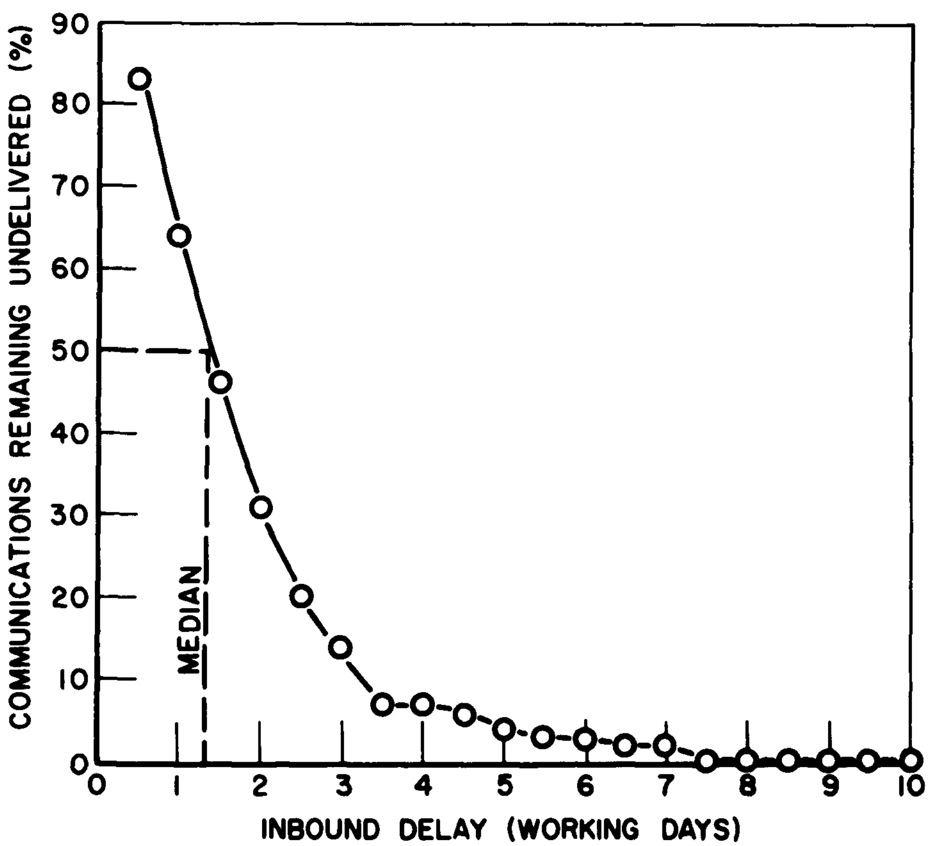


FIGURE 10
DELIVERY DELAYS FOR INBOUND COMMUNICATIONS

undelivered at the end of five working days. Figure 11 shows a similar plot for outbound delays. Here the median is two working days and a substantial number - some twelve per cent - remain undispatched five days after they are typed. Delay as a function of the hierarchical level of the releasing officer, the staff officer himself considered as level 1, branch chief as level 2, and so on, is depicted in Figure 12. Correspondence and electrical messages appear to follow the same general trend. The relative flatness of the curve between levels 2 and 4 is somewhat surprising and is perhaps indicative of the fact that delay is primarily a function of the total review process rather than simply of the number of administrative levels which review the communication. In other words, all communications which are reviewed, follow the same general physical route of successive message centers and, in effect, leave the individual staff section at the highest level. Communications which are released at level 5 - the command level - are, however, subjected to extraordinarily detailed examination, thereby extending delay. On the other hand, communications released at level 1 - the staff officer himself - are frequently taken directly to the communication center by his secretary.

Turning to the other side of the coin, we shall examine the degree of change, the defacto reduction of error which this delay buys. Figure 13 shows the overall incidence of change as detected by our comparison of the secretary's first copy with the copy which actually left the headquarters. We note that only 7.6 per cent of the communications are changed in any degree and that only 3.4 per cent are changed in an

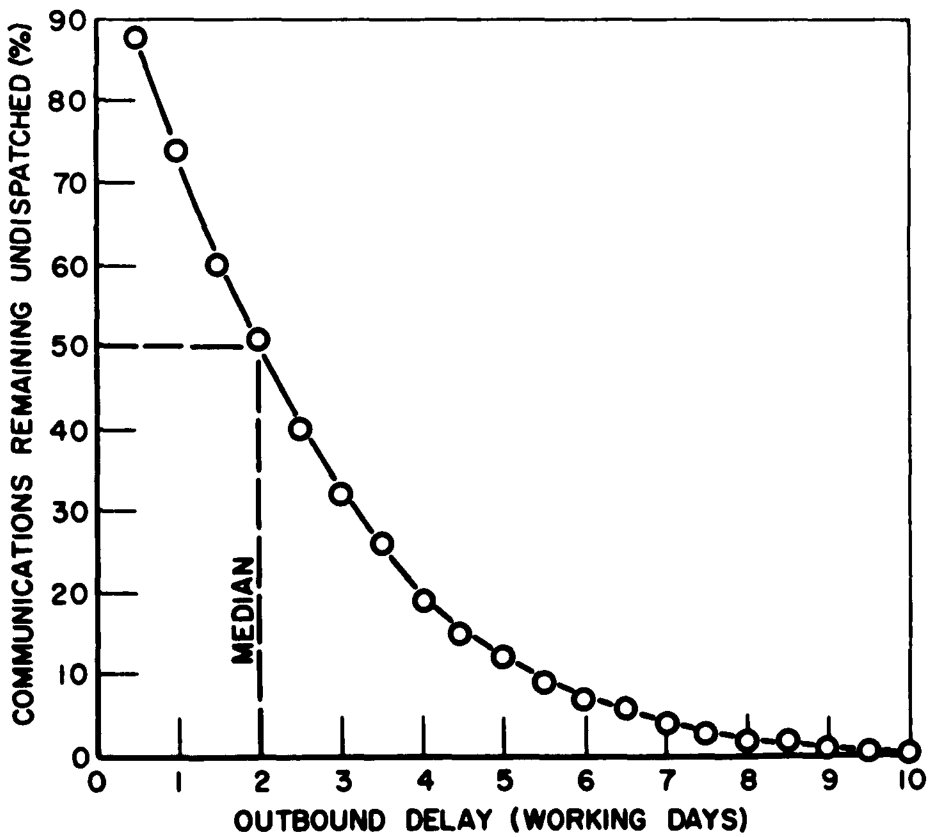


FIGURE 11
DISPATCH DELAYS FOR OUTBOUND COMMUNICATIONS

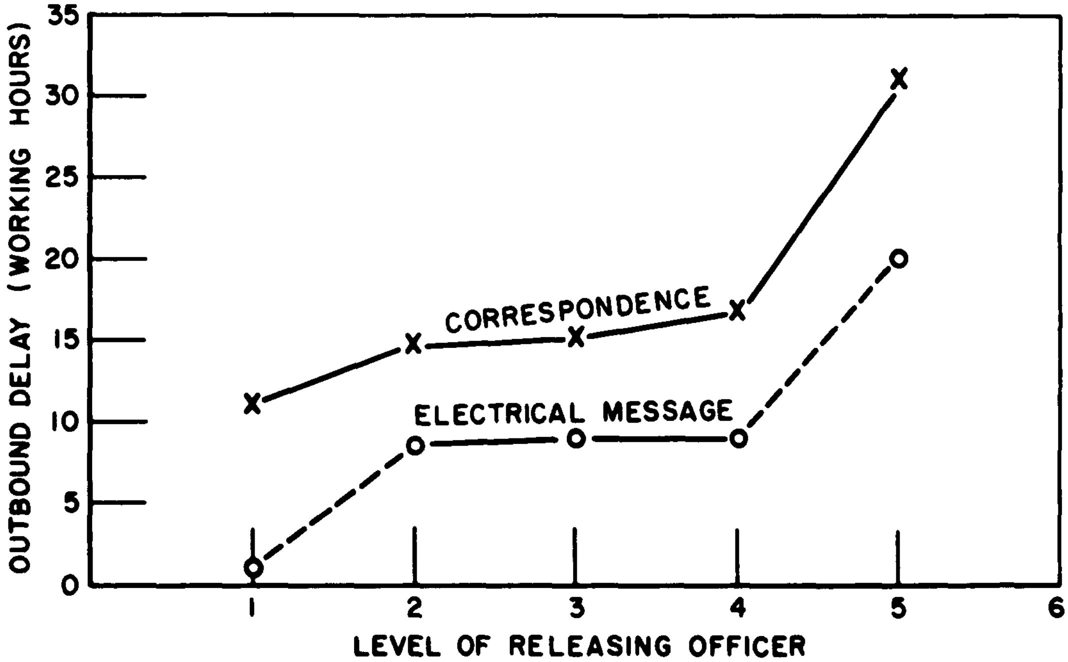


FIGURE 12
OUTBOUND DELAY BY LEVEL OF RELEASING OFFICER

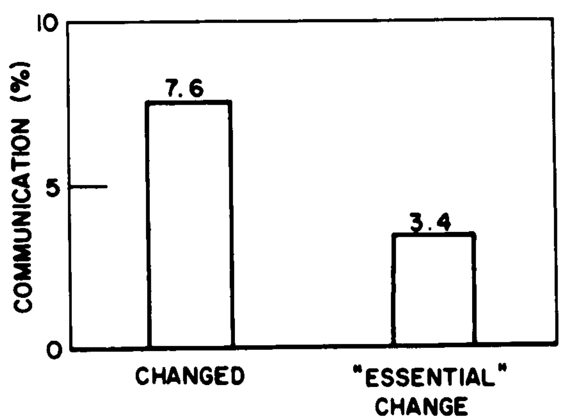


FIGURE 13
INCIDENCE OF CHANGE IN
ARMY COMMUNICATIONS

essential fashion. Incidentally, judgments as to essentiality of change were made by the person who actually made the change. Earlier, I mentioned that we were also interested in the individual's perceptions of the system as opposed to our observations. In this context, we found, from the answers to various questionnaire instruments, chiefs reported that they made changes in about 4 per cent of the communications they handled but both chiefs and staff officers felt that army-wide changes amounted to at least 27 per cent. These figures are not surprising when compared with the 7.6 per cent observed change. Individuals, no doubt, tend to underestimate their own contributions to what they consider to be an invidious situation and, in general, exaggerate the severity of the situation itself.

Figure 14 depicts the per cent change by level of releasing officer, which is a rough indication of the number of persons who reviewed the communication. The increasing gap between the curves for "essential change" and "change" is of great interest. We interpret it as indicating that the absolute number of changes, as differentiated from essential change, is essentially a function of the number of persons processing the communication - that change is simply related to a very human tendency to attempt to improve upon the output of subordinates.

Time requirements prohibit a full discussion of our complete results. I have selected but a few of our more significant findings as illustrations of the type of data it is possible to obtain utilizing this methodology.

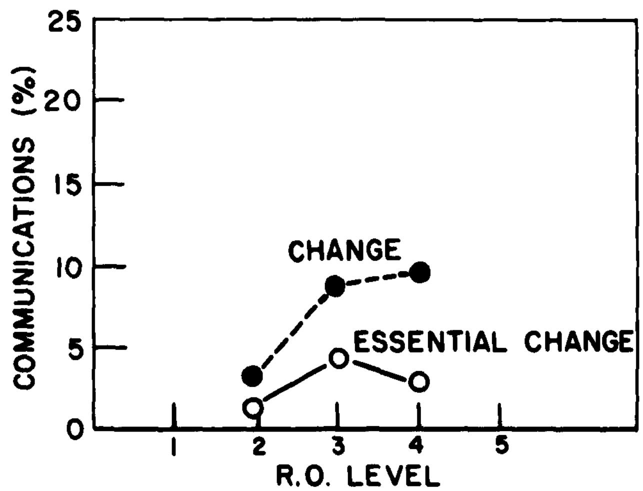


FIGURE 14
PERCENT CHANGE BY LEVEL
OF RELEASING OFFICER

Such data will eventually lead to the development of a body of comprehensive knowledge on the functioning of communication system elements for use by the system designer. For example, the advanced communication equipments conceived in the U. S. Army program for a Universal Integrated Communications System (UNICOM) would make it possible to provide direct "branch chief to branch chief" teletypewriter facilities. Would it be desirable, then, to allow each branch chief to release electrical messages directly to the network? Using element operating characteristic data, it is possible to make this decision by quantitatively assessing both the reduction in delay and the possible increase in error this would entail. System design decisions can thus be based on engineering-type data for both man and machine, thus leading to a truly effective matching of man, organization and communication equipment for optimum system performance.