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ABSTRACT

The Augmented Human Intellect System (AHI) has been designed to facilitate communication among knowledge workers who may accomplish their entire job utilizing this advanced technology. The system is capable of sending information to geographically distributed users. It permits access to and modification of stored information by a number of persons concurrently or independently. The effects of the system in a government research and development office are threefold: (1) the individual is no longer limited to the rigidity of written information; (2) an "augmented knowledge workshop" promotes the integration and synthesization of the efforts of individuals to yield increased group creativity; and (3) the organization can therefore operate around a visible, dynamic body of data generated by the various levels in its hierarchy and immediately communicate managerial or technical matters. The problems encountered include psychological resistance, system failures, weak training due to inexperience, and hardware unavailability. (Author/EE)

EXPERIENCES WITH AN AUGMENTED HUMAN INTELLECT SYSTEM: A REVOLUTION IN COMMUNICATION

by

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(The opinions expressed in this paper are those of the author and do not reflect official United States Government Policy, or represent the Information Sciences Division, RADC)

ABSTRACT

The implementation of the Augmented Human Intellect System (AHI) has permitted a new avenue for interaction: that of computer mediated communication. This paper is a description of experiences with this novel alternative to conventional ways of thinking and communicating in an organizational environment.

The AHI system has been designed to facilitate communication among knowledge workers who may accomplish their entire job utilizing this advanced technology. The system has the capability to send messages or other information to geographically distributed users. It permits access to and modification of stored information by a number of persons concurrently or independently.

The effects of the system in a government research and development office are threefold. (1) The individual is no longer limited to the rigidity of written information. Instead, he has an "information space" structured to his requirements through which he can "travel" rapidly, resulting in a flexibility approaching that of verbal thought.

(2) A team of users can also move with great ease through the information spaces of all team members to consolidate, collaborate, and reach a higher level of consensus. The result may be described as an "augmented knowledge workshop" that promotes the integration and synthesization of the efforts of individuals to yield increased group creativity.

(3) Consequently the organization can operate around a visible, dynamic body of information generated by the various levels in its hierarchy, and immediately communicate managerial as well as technical matters. The tradeoff from this increase in vertical communication has historically been a loss of efficiency, which AHI appears to prevent. As the problems of training a population of scientists and engineers are solved, this increase in communication is being observed.

The problems encountered include psychological resistance to this kind of major change in working habits, system failures, weak training due to inexperience, and hardware unavailability. Progression toward an Augmented Knowledge Workshop was marked by a transition from system use as an automatic typewriter to use for on-line composition. In addition, the system became transparent as the skills of operation were mastered. An unprecedented involvement with the system by individuals, especially when using the display terminal, was representative of the dramatic change in the work methods and communication patterns within the population.

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INTRODUCTION

Background

Computer technology has evolved with an almost incomprehensible rapidity over the past two decades. Applications of this technology have changed from purely numerical programs to sophisticated scientific problem solutions to manipulation and processing of natural language. The latter application has resulted in a man-computer symbiosis where the computer system becomes an extension of man's intellectual processes. In a now classic paper, J.C.R. Licklider (1968) outlined the total system with man and computer as integral components. Parallel to the development of computer capability over the past decade has been the development of a system designed to take maximum advantage of the computer's power to store, structure and retrieve textual information in a way congruent with the characteristics of an individual.

Appropriately, the name given was the Augmented Human Intellect System (AHI), developed under the leadership of Dr. Douglas Engelbart of the Stanford Research Institute. Originally, the purpose was to "...increase the capability of man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems." (Engelbart from Lindgren, 1971) The intention was to provide an extension to man's intellect by utilizing a set of powerful computer based tools. This was gradually broadened to provide an extension to a group's capability, to that of an organizational structure, and finally to numbers of organizations.

A general overview of the system will be presented here. Detailed descriptions of the hardware and the software ("software" refers to any functioning computer program, as opposed to the machinery it runs on) may be obtained from the references.

System Description

AHI is designed to take full advantage of the state-of-the-art in computer technology. It is an on-line, real time, time-sharing system with a full duplex (simultaneous transmission and reception) terminal-to-system link. The result is a highly interactive interface between the computer and the user. Indeed, there is a great deal of similarity between this man-computer interface and a man-to-man interface.

Once an individual user establishes a connection with the main computer he is able to create, store, structure and view written textual material.

Every user-identified unit of text is automatically numbered and assigned a user-determined level in a hierarchical structure which establishes a relationship to the text as a whole. The structure permits addressing and viewing the text by units of the hierarchy such as statements and branches.

The Viewspecification system controls the viewing of text in many different ways analogous to "windows" into the stored information. The "viewspecs" control the levels in the hierarchy and the number of lines for each statement that the user wants to display or print.

Another structural unit is the file which is analogous to a document or book. Files provide a means of further structuring text. They can be combined, in part or in whole, with any other file, and the user can "jump" between various files. Part of the AHI capability is similar to a library where a person merely types his request and all relevant books are presented to him for immediate composition into a report or other new textual entity. Not only are the files in his own library ("directory") available to him, but all system users' files are available unless otherwise specified.

The addressing and Viewspecification systems are key features of AHI. They illustrate some of the additional power of AHI relative to the numerous operational text editing software systems. A survey by van Dam (1971) states that:

AHI "...embodies much more than just a text editor; their aim is to provide a new way of thinking and working by utilizing the power of the computer in all aspects of one's work." (Van Dam, 1971, 110)

According to Engelbart (1973), the additional capabilities include communication among teams with joint and/or simultaneous preparation of text -- a "collaborative dialogue"; sending documents, correspondence, and coordinating work -- "documentation production and control"; and a library system for the storage and retrieval of relevant literature, etc. -- a "research intelligence".

Collaborative dialogue: There are computer aids for the composition of messages and for their subsequent reviewing, cross-referencing, modification, transmission, storage, indexing, and full-text retrieval. A "message" may be one word in length, or several hundred printed pages. In any message there may be formalized citations pointing to specific passages in prior messages, so that a group of related messages becomes a network of recorded-dialogue contributions. There is also:

automatic delivery of messages; full cataloging and indexing; on-line accessibility both to message notification and to the full text of all messages; and open-ended storage of the dialogue records. These services enable a community of people who are distributed in space and time to maintain recorded, collaborative dialogue.

Document development, production, and control: There is a rich set of computer aids for the composition, study, and modification of document drafts, and for automatically generating high-quality photocomposition output with flexible controls for font-designation and formatting, to enable the production of publication-grade hardcopy (printing masters, or microform masters). There are processes for collaboration between several writers, and with an editor, in the process of evolving a final draft. There are also aids for the people who must keep control of changes, new-version distributions, etc., and provide the indexing to complex documents or sets of documents. Most of these particular aids are presently available only at SRI.

Research intelligence: The provisions within the Dialogue Support System for cataloging and indexing internally generated items also support the management of externally generated items -- bibliography, contact reports, clippings, notes, etc. With these centrally supplied (therefore uniformly available) services, a community can maintain a dynamic and highly useful "intelligence" data base to help it keep up to date on external happenings that particularly affect it. Computer-generated indexes or on-line retrieval can facilitate access. Citations of external items from within the internally-generated dialogue base -- in the form of annotations, miscellaneous commentary, or supportive references -- offer computer-sensible interlinking of the external information with the internal, and considerably facilitate browsing, retrieval, back-citation searching, etc. (Engelbart, 1973)

To be augmented is to have a powerful set of tools residing in a state-of-the-art computer system that are used in every aspect of knowledge work, ie. activity that involves individual and joint preparation of communications, documentation, etc., and sharing the results with communities of knowledge workers. (Engelbart, et. al., 1967)

The Setting

We are implementing AHI at the Rome Air Development Center (RADC) in part to observe its effects. This prodigious undertaking is motivated by a number of factors: (1) the desire to determine

whether or not it can be applied to this working environment, (2) the fact that it appears to be a powerful tool for the team that developed it, (3) the costs (over $10 million for development and hardware), and (4) the fascinating technology. Realizing that those who created the system have a special motivation to use it, we decided that implementation in our own offices would provide a more realistic test environment. Thus, certain organizational units in the Information Sciences Division of RADC are accessing the computer at SRI through the ARPA Network, and using it in the daily performance of their jobs, while a descriptive analysis is done.

At present, we have a user group of 20 persons including three levels of management. Most of the personnel are engineers, scientists or managers. We plan to double the population and to include one more level of management by the summer of 1973. There is a considerable amount of development to be done to provide the software and hardware support for such a large group, but we are gradually overcoming the current limitations.

PREDICTED OUTCOMES OF IMPLEMENTATION

This investigation is concerned with effects on the population in three areas: (1) the individual, (2) the communication amoung individuals, and (3) the organization. A statement in each area of the effects that are ultimately expected as the population becomes an "Augmented Knowledge Workshop" follows to provide a structure for the descriptive observations.

The three predictions and a discussion of each:

1. The individual's thought processes will be modified by the rapid availability of his own information, the ease of changing that information both in its content and structure, and the flexible control of structure viewing. (cf. Engelbart, 1973)

The rigidity of written information has a relatively unexplored effect on the development of a person's ideas, thoughts, etc. He traditionally is limited to handwriting or typing to make thoughts initially visible, and then to rewriting each time clarification, correction, up-dating, restructuring, etc., is necessary. This may require the intervention of a typist and communication of the necessary changes to this second party. The longer the paper or whatever, the greater the problem of revision. Once a lengthy paper is prepared, the thinker's ability to massage, manipulate and creatively deal with those ideas is curtailed.

When thoughts, etc., are entered into the AHI system, it is predicted that they will not lose the flexibilty inherent in the

thought process, but conceivably will gain additional flexibility resulting from the visibility of written information. The capability of AHI to permit rapid changes in stored text of any kind was described in the Introduction. From this it can be expected that an individual will move through his stored ideas with great ease -- massaging, and creatively engaging words, concepts, facts, patterns, and the various nuances of recorded thought. He also has, at any time, a copy to share with whomever he chooses.

In addition to the flexibility gained, the hierarchical structure adds what may be a new dimension to computer stored thought. The structure permits verbal units to be placed at a level indicating relative importance, source, category, etc. Thus, it is predicted that relationships can be captured or established which otherwise might be obscured by semantic limitations.

2. The communication of individuals accomplishing their work on the system will be modified by the free access permitted to all individual's work as stored into the system, by the ease of making changes in the written work of groups, by the capability to transmit messages or other information through the computer, and by the capability to simultaneously access and modify stored information by numbers of persons.

Knowledge may be collected and compiled thus taking maximum advantage of the resources of the on-line working group resulting in better decisions and actions.

The result would be an "augmented knowledge workshop" promoting the integration and synthesization of the efforts of individuals to yield a new level of group creativity. Consensus would be represented by a stored record created simultaneously over time. The leaders of the Augmentation Research Center (ARC), Messrs. Engelbart, Norton, and Watson, elaborate on the concept of the "knowledge workshop" as follows.

> "The term "knowledge workshop" is built directly upon the terms "knowledge work" and "knowledge worker", whose special use is from Peter Drucker (1969). He develops a much larger theme about these concepts, adding terms such as "knowledge technologies", "knowledge economy", and "knowledge society", and pointing out that the growing level and importance of knowledge-work activity in our society will produce a discontinuity in our cultural evolution of a scale commensurate with that of the industrial revolution.
>
> "The knowledge workshop is the specially provided environment in which knowledge workers do their knowledge work. We can

talk about a small knowledge workshop for an individual, or a large knowledge workshop for an organization. Knowledge workshops have existed for centuries, but here we consider maximizing their effectiveness by systematically evolving tools, methods, etc., with heavy dependence upon the new technologies of computer time sharing and networking. The result is the "Augmented Knowledge Worker" (AKW) which describes an individual effectively using AHI.

> "Basic workshop functions will serve the daily handling of the AKW's working information -- of their notes, things-to-do lists, memos, letters, designs, plans, budgets, announcements, commentary, proposals, reports, programs, documentation, item-control catalogs, etc. And before it can sensibly be of much value, as Engelbart has stated, the Augmentation System has to provide for the grubby cut-and-try detail involved in the minute-by-minute, day-after-day worker's handling of this information: in the user's composition, studying, commenting upon, arguing about, modifying, communicating, publishing, presenting, etc." (Engelbart, Norton, Watson, 1973)

3. The ease of handling Knowledge Worker tasks and the openness among AKWs will have a strong impact on an organization where groups and teams are augmented, by changing the vertical communication in that organization and ultimately, the organization itself.

> When the AKWs are at all levels in an organization, management and subordinates can communicate through the system with the same ease that co-workers can interact. The message transmission capability would facilitate the conduct of most of the organization's business through AHI.
>
> The tradeoff from these increases in communication has historically been a loss of efficiency. (cf. March, 1965) However, a very important product of AHI is predicted to be the implementation of modern, "open" management techniques without loss of efficiency.
>
> The overall effects in our organization would serve to move it toward being an Augmented Knowledge Workshop, a process very much worth documenting.

METHODS

Four means were employed to build an accurate description of the subjective experiences of the population, a chronicle, interviews, observations and personal account.

The Chronicle

The chronicle was established as a vehicle for recording the serendipity experiences by members of the population. Any experience that was perceived as noteworthy by a subject was recorded in a special file named CHRON. Originally, a CHRON file was established in each subject's directory to permit easy insertion of a statement or two describing the experience with AHI. The observer then could peruse the files of the population and compile a summary, collating and synthesizing similar events. In addition, a CHRON file was established in the author's directory as an alternative. This provided some valuable data along the lines of a case study. It was not expected that the subjects would be very conscientious about recording unique experiences, thus other methods were relied upon for more consistant and thorough "data".

Interviews

Interviews were conducted at intervals throughout the period that began with system availability to the population of 20 persons. A non-member of the organization was employed to conduct an unstructured interview that allowed the maximum opportunity for open ended responses. Hopefully this enabled the respondant to introduce those things which were most important to him, while minimizing the structuring of these perceptions by the interviewer. General questions such as, "Could you tell me more about that?" were followed by more specific questions only when deamed necessary by the interviewer to gain some more detailed information from reluctant respondants. The interviews were non-directive to the point of resembling a discussion. Although the style was intended to be Rogerian, suggestions were used when certain problems were anticipated, eg. "Did you have trouble with output directives?"

The following techniques were relied upon to fill in the gaps between the voluntary responses.

Unstructured observation

There was more available data than could be collected through the foregoing methods. It shed important light on what people were experiencing as they learned and attempted to use the system for required work. This was collected as it drew the attention of the author, who then recorded the event. These events included conversations that were overheard ("eavesdropping"), random participation in conversations, sessions arising out of a request for assistance on the system, observing the process of document

preparation and the end product of system use, and reviews of the contents of subject's files.

This kind of record is highly impressionistic and is dependent even moreso than the other techniques upon the observer's perceptual set. In this case it was mitigated by the working environment in which subjects were non-volunteers involved primarily because of their location in the organization. There were no direct rewards for participation and no lessening of the workload imposed by management. A minimum of additional obtrusion into the working world of the subjects was imperative, thus supporting the use of techniques such as this one.

Personal account

The author has been a heavy user of the system for over a year and has been using the display system for about 7 months since its initial availability outside the Stanford Research Institute. This as well as other papers have been prepared on the system. No attempt has been made to distinguish between author and population experiences although in many cases this is obvious. The author is, in fact, a member of the population and his experiences are treated as any other's.

Although the subjectivity of this kind of study is high, attempts were made at all times to corroborate conclusions with the experiences of the population as a whole, in many cases directly consulting other users on the accuracy of the observations. Thus, although the personal experiences of the author played an important role, the conclusions drawn should represent the population in general. The other techniques utilized additional observers in the form of hired interviewers, consultants, and colleagues external to this environment.

LEARNING TO USE THE SYSTEM

Becoming an Augmented Knowledge Worker

The traditional work patterns were adhered to with a great deal of persistance by the population. The methods of communicating and accomplishing daily work are habitual and consequently some extinction had to occur before new habits could be learned.

The resistance to learning a new system as a way of doing one's daily knowledge work was higher than expected. The symptoms were manifested as excuses for not using the system. These were things like, "there isn't a terminal around," "I can't remember how to do it," "there isn't a good manual that I can understand," "I have too much work to do," etc. It seems worthwhile to discuss some of these, how we dealt with them, and offer some speculation about

the reasons behind this behavior. (The problem here, of course, is that the reasons are largely a function of individual personalities. With our population size, any generalization must be done with this factor in mind.)

There are twelve portable typewriter terminals and 3 IMLAC displays for 20 subjects. The jobs for approximatey 70% of these individuals require, on the average, a great deal of written work. An important exception is programming for another system. This is a major task for at least 1/3 of the population and has not been done on AHI. At SRI, however, all programming has been done on the system since its inception. This will be discussed further in the section on population characteristics.

Terminal availability is a crucial variable affecting the learning process. There is strong resistance to leaving one's work space to physically carry a terminal to that area from some other work space. Ideally, every user would have his own terminal. This is not warranted by current usage levels here, nor is it feasible financially. However, it has become a problem to the point where it has caused some people not to use the system. (Management and the observer have tried to overcome this by carrying terminals to people who have use for them but resist getting their own.)

The system use manual cannot serve as a training manual. It is over 200 pages in length and is not organized in a self apparent way. It does not serve the beginner well as a reference because its use requires an understanding of the system. The syntax for the command language is complex (although functional and very effective for those who have learned to use the system) and requires that detailed explanation be available for reference. The command language summary provided at the time was too cryptic to serve this purpose.

An introductory, self explanatory training manual was not available. Perhaps the complexity and richness of AHI rendered it a formidable task. The stopgap measure was to have capable users stand by in the immediate vicinity to aid the struggling neophyte at a moments notice while an introductory command summary was developed.

Learning to use AHI was assigned a low priority when the subject was under pressure to get other jobs done. Of course this could be an excuse that might in fact not be the actual cause. Admittedly, it is a real nuisance to change the tools

for doing one's job and learn a new skill in the middle of things.

However, after a trial period of approximately one month, it was concluded in light of these problems that a policy regarding use should be established by management. The decision to require use was made in light of the hypothesis that any work that can be hand written can be done on the system with the exception of that requiring special alphanumerics.

This was based on the following assumptions.

If the system is only used occasionally, i.e. a couple of times a week, then the level of proficiency necessary to make the system truly an improvement will never be attained. Practice through regular use is necessary.

If new users are instructed to use the system for all possible knowledge work, then we can determine what work is not appropriate for AHI by observation.

The system offers alternatives to habitual ways of communicating in written form. New users will naturally be reluctant to use the system unless strongly encouraged.

The requirement is enforced by instructing the secretaries of the population not to accept any hand-written drafts for typing unless an exception was specifically authorized by their supervisor. Work that necessitated the supervisors review and coordiation would only be reviewed through AHI. (Drafts are printed out for transmission elsewhere.)

It was expected that there would be an initial drop in work output until some level of proficiency was reached, estimated to be about 1 month. A little friendly persuasion seemed appropriate to overcome initial problems -- "Try it, you'll like it".

The requirement that all personnel within the section use this system met with definite negative reactions of an emotional nature.

All persons involved were given at least a month and in some cases up to 4 months to voluntarily use AHI for whatever they wished. They were encouraged to use it for a status

report to their immediate manager, himself a user. A secretary was employed to enter into the system any written work that had already been completed, which then would be available for updating, etc. This also met with resistance.

Individuals manifested a range of actions, from trying to simply ignore the whole thing to actively campaigning against it. Some of those who tried became distressed when system problems were encountered. Indeed, system performance did leave a lot to be desired in dependability, but was not much different from any experimental computer facility. The reactions seem to correlate with the observer's assessment of personality type. Those who seemed to fall toward the closed end of Rokeach's open and closed mind, were the most threatened by required use. Those manifesting a high ego involvement with their work reacted more negatively than did others.

Factors other than personality and demographic attributes were relatively consistant. Equipment and training have been available for about four months. Everyone has been exposed to the system, either through classes or by being in the area where the system is being used. Age of the potential user does not seem to be a factor affecting motivation to begin the task of learning; neither does experience with computers, or job task type. The variable is one that is most obvious and generally true of any new tool-- aggressiveness (generic use). The least aggressive subjects initially ignored the system. As the more inhibited persons saw their colleagues becoming involved with AHI, they responded to the pressure to become real AKWs.

Ego threat was estimated on the basis of verbal and non-verbal behaviors over a period of several months. When questioned about their work, a subject's defensiveness was noted by facial flushing, elusive or aggressive statements, or reverse attack where the subject would say, "if I had nothing else to do like you, I'd learn it...." Complaining within earshot of the observer usually centered around how busy and how important it was that he not be imposed upon. These are examples of very impressionistic obsevations. However, most psychologists would allow some credence to impressions about work involvement over a period of several months of intense contact.

Interviews of two subjects who are system programmers revealed that they were not able, in their judgement, to use

the system for a long report. The joint effort was to be published. The primary reason was a lack of time to gain the proficiency necessary.

More specific reasons were given that reflect upon the difficulty of gaining that proficiency and the limitations of the teletype oriented TNLS (as opposed to the display version of AHI, DNLS, which will be discussed in a later section). The information was not visible enough for maintenance of the train of thought. Some subjects felt that they could not see previous pages or the context of the current location of the pointer (the position in the text where any editing commands will take effect) easily enough. (It requires that enough text be printed for the user to identify it in relation to the document). Addressing was not "natural" enough. Inadequate training was probably a significant causal factor here. The installation of a printer for quality hardcopy output encouraged use and improved the situation considerably.

It would be misleading to discuss the problems experienced by the trainees without mentioning the trainers. Teaching the use of such a complex system is difficult under any circumstances, and in this case it was the first attempt. We had some help from the staff at SRI(ARC) but this was limited for a number of good reasons. Thus, we were on our own learning about learning and the system at the same time. There does not seem to be much point in trying to assess the influence of teaching personnel and method, but it can be concluded that experienced and more skilled teachers would have lessened some of the problems encontered.

Briefly, initial instruction was done in small groups. Each person was given a terminal so that he could do the operation as it was described by the instructor. The loggin operation, entering the appropriate subsystem, status listings, error messages, etc., were covered in the order they would normally be used. After that, operations were described in the order of usefulness, a function of usage frequency. After two or three days of this the trainees were told to practice, while the instructors stood by to give assistance. In the future, a conceptual overview of the system would probably help prior to any attempted usage.

The difference between on-line composition and use as an automatic typewriter became an important factor as new users progressed. This

differentiation was remarkably discrete as evidenced by the work methods employed.

On-line composition was the modis operandi with the first few persons to learn, who have been "on" the system for over a year. It is characterized by little use of paper, either for the original composition of new ideas or for the proofreading of drafted papers. Instead, all structuring, outlining, wording and phrasing, etc., is done while on-line.

Use as an automatic typewriter is characterized by handwriting outlines and original drafts often creating a complete draft that is typed into the system by a secretary. A printout is then used for proofreading and revising which are done on the printout itself. These are then entered into the system on-line. Further reviewing is done in a similar manner. There is no effort to enter ideas directly using an on-line terminal.

There may be multiple reasons for this, not the least of which is the non-availability of a CRT display or inability to use the display version of AHI. As mentioned above, typing skill is another limiting factor, although those who have used the system for on-line composition have found that a typing ability evolves naturally.

The psychology of the situation also played an important role. Certain subjects expressed a reluctance to use a teletype because typing was beneath them. Comments such as, "what will the secretaries do," or "I wasn't hired as a typist," etc., were noted.

The transition from automatic typewriter use to intellect augmentation appears to be an important threshold in the process of becoming an AKW.

Continuing usage on a day to day basis begins to make the system transparent, which is probably necessary for the full realization of intellect augmentation. The command language, addressing, viewing, operating the terminal, and the other mechanisms necessary for usage become of less concern freeing the individual to deal directly with the subject matter at hand. None of our population has experienced total system transparency, but a few have come close. We are limited somewhat by technical difficulties such as computer crashes.

Observations of true AKWs at SRI are evidence that a transparency can be acheived, at least for a large percentage of the kinds of work done. Those observed had been on the system for a number of years leading us to believe that full capability may take years. This is, of course, a function of what the user selects to do

on-line -- little used facilities, such as other ARPA network resources residing on other computers, would be less transparent.

Transparency is also characteristic of the rules of the spontaneous use of language, as in conversational speech. The experience and process of learning to use AHI is analogous to the acquisition of natural language and reminds one of the work of the noted psychologist, Jean Piaget. There is a definite syntax applied to the vocabulary that enables the person to combine command words to perform novel operations, thus generating new and acceptable patterns of language. These in turn facilitate different procedures and sequences of operations by the programs. It is quite obvious at the outset that there are many different ways to do the same thing. This permits a personal "style" to evolve for each individual that is supposedly most effective for him.

As with natural language, a subliminal knowledge of the basic rules is used to generate new command "sentences" from the given vocabulary that the computer will recognize. The subliminal attribute is closely related to the transparency discussed above.

We can speculate that a person's ability to generalize from the command listings will be a decisive factor in his successful utilization of the system, especially as a tool for creative efforts.

Once a person becomes adept at "speaking the system's language", different reactions are observable as he becomes increasingly dependent upon the system.

OBSERVATIONS

Effects on the Individual

One of the most prominent experiences observed was a kind of pressure that exists on the user to work at a high capacity while he is on-line. A great deal of involvement occurs, especially when the user is on a display terminal.

One causal factor may be the automatic logout if nothing is done for about fifteen minutes, resulting in some anxiety whenever one is distracted. This is not sufficient cause for things such as an extraordinary reluctance to engage any person who wishes to interrupt an AKW. Another possiblility is limited system availability due to "down time" and hardware "bugs". An available system, functioning reliably and rapidly is a strong incentive to "use it while you can". These factors are influential, but the reasons appear to be more profound.

The act of creating something that will be highly dynamic, not permanent or rigid, is very attractive, albeit subliminally. A person experiences a freedom and release from the responsibility of having to live with some document that is set in ink. Its analogous to thinking through ideas and structuring a draft mentally. It can be altered in any way at any time, thus facilitating creative experimentation.

Not only is there an increase in the freedom to be creative with content, but there tends to be an uninhibited work rate, limited only by the present hardware devices. If a writer is aware that he will have to "mess up" or retype his paper if he makes an error or forgets an idea, the rate at which he proceeds must necessarily be restrained.

In fact, a new user may have to learn to be less inhibited about rendering his ideas visible. Perhaps more important is that he feels free to change and remould whatever he "dumped" into the system. There has traditionally been a lot of negative reinforcement associated with changing written matter, even if it is only a personal working document, which AHI minimizes.

AHI appears to provide unprecedented flexibility and freedom with textual information for the individual. (This is partly dependent upon the use of the display terminal (DNLS) which is not availble to all subjects at present. Since this is a matter of time, no distinction will be made in this section -- observations include both types of terminals. The DNLS subsystem will be described in a later section.)

It is interesting to note that freedom and flexibility seem to require structure, rather than being inconsistant or contradictory. The ability to position ideas so that their relative importance is clearly shown, to control what level of detail one is viewing, to show trees of relations, is crucial to the flexibility gained by AHI. The utility of the addressing structure terminology, the various informaton units, etc., is illustrated by the tendency of AKW's to think in similar terms. For example, "Well, 'expunge' that file or 'delete plex 1', it was rejected...."

Freedom and flexibility are not limited to individual usage of AHI, but are extended to groups, teams, and the organization by the interpersonal communication capabilities.

Use of the Communication Facilities

There are two specific sub-systems for on-line communication (part

of the TENEX Executive software) and an extensive communication capability as part of the "Journal", a subset of the Dialog Support System.

"Send Message" permits message transmission by entering a literal and the names of any number of recipients at any node on the ARPA Network regardless of geographical location or use of AHI. The message is automatically sent to each user noting "copies to (username)", subject, and title. Notification occurs ("you have a message") upon initial system log in.

The "Link" command ties together 2 (or more) terminals so that messages may be transferred or one user may observe while the other works. "Advise" may be invoked enabling one user to work on the other's files thus facilitating a shared control over the editing, viewing, etc. This is the basis for on-line conferencing and is most useful in the display version of AHI with a supplemental audio (phone) link.

The Journal System is a collection of tools and procedures to manipulate documentation. The user may essentially send any on-line textual entity, a message, a letter, a document or a book to any number of users in any format merely by specifying the initials (id's) of the recipients. Distribution, recording, printing, mailing, library filing, and indexing are handled completely automatically with numerous options for the author.

These subsystems can be activated at any time. Journal and Send Message will deliver the item to a specified file (analogous to a mailbox) belonging to the receiver. Any amount of information may be so transmitted almost immediately for the recipient's perusal at his convenience. Again, this speed and ease appear to encourage "mailing" information.

The message sending feature is analogous to sending memos and has similar characteristics of ease and convenience although it tends to be less formal. It is an important advantage that the receiver does not have to be on-line at the time. We are able to retain copies of the messages when they are printed out for reading or by inserting them into the appropriate subsystem. However, they usually are not retained by the recipient.

Messages are transmitted more easily than memos in that they do not involve paper processing, a secretary-typist, or addressing and mailing. We have found that they are sent in situations where no written communication would have been used otherwise, resulting in an increase in communication, especially vertically within the organization.

A manager who is usually difficult to reach due to meetings and other preoccupations can be easily notified. Although advantageous from this standpoint, messages are easier to ignore due to the tentativeness of the computer storage. A memo or letter is a little more demanding -- perhaps due to its physical presence and visibility.

The interviews of users have surfaced an important potential disadvantage. The use of the message system can tend to depersonalize communication. This is in large part due to its ease of use as an alternative or substitute for face-to-face communication as was predicted by Turoff (1972). For example it may be selected as the mode of interaction because of a distasteful or negative content. On the other hand, face-to-face contact has resulted from a message, but this is infrequent.

The Journal System is being used ostensibly as a computer based mailing system for handling written communication of longer lengths. A hardcopy can literally be mailed but most of our users read their "mail" on-line using the easily executed retrieval commands.

It also has a message sending capability where, unlike the TENEX Send Message feature, messages are permanently stored, indexed, cross referenced, and catalogued. This is part of the Dialog Support System which has a potential impact much beyond what we have explored.

With few exceptions, the population has not been using the Journal for dialogue support. The Journal is perceived as a place to store items of permanent value, which is usually not felt to be the case with messages. This may represent a reluctance to store routine transactions -- they are feared in that they may return to "haunt" the originator.

The lack of understanding of the purposes and operation of the Journal may be more significant. "Dialogue support" is definitely a clue that continuing interactions might be recorded much as are the minutes of meetings. Not only does this provide the communicators with a history of transactions relevant to certain subject matter, but it provides the using community with an insight into developments that otherwise would have remained obscure.

The Augmented Community based at SRI is facilitated by the dialogue record as we may be with additional experience. Links (addresses that may be activated to load the information specified) are imbedded in subsequent dialogue

records providing cross references to previous or relevant transactions. Thus, an interested party may follow the progression of transactions at SRI and quickly grasp the meat of the issue.

The use of Link addresses may be supplemented by simply reading other's files. File read access and sharing has not been used as extensively as expected (our people tend not to be nosy....) A few of the users have perused others files to learn of their doings or to answer a pressing question in their absence. By and large, however, this access is limited to copying some information that was known of before hand or responding to specific requests. This will be described in the section dealing with effects on the organization.

Linking (note the entirely different use of the term) may be compared to a telephone conversation. The significant difference is that linking is more convenient when a user is on-line.

As mentioned above, when an AKW is on-line other interactions are resisted and interruptions are discouraged. However, it does not seem to constitute an interruption to engage in dialogue through the terminal. The novelty of this means of interacting may have some effect on its attractiveness.

It is unique in our experience. It has the tentativeness of oral communication, but lacks the paralinguistic, non-verbal cues that would be transmitted via the phone. It is limited by the typing ability of the users and has the immediate appearance of being a written communication. It differs in permanence (none), immediacy, spontaneity, and its real time interactiveness. There is no time to peruse the communication or deal with written text. It is usually relegated to short interactions. This results in a stylistic difference which requires, among other things, an explicitness not inherent in oral communication, eg. humorous jesting has to be labeled with a "ha, ha" or something similar to ensure correct interpretation.

Linking has been used extensively as an integral part of the AHI system. It is important to note here that although neither Send Message or Linking are unique to AHI, usage appears to be dependent upon the design and purpose of the entire system. If the system were not employed to accomplish the daily knowledge work of groups it is doubtful that either feature would have any significant utility. Both features are available for immediate use if the AKW is on-line and the need arises. We have linked among ourselves and with various users on the Network including our colleagues in Washington D.C. and the

team at SRI. In many cases contact occurred where there otherwise would have been none, thus promoting teamwork.

The link feature is being used within the teams for short, extemporaneous questions and comments. Surprisingly, links are utilized when AKWs are within close proximity in the same building, in neighboring rooms, or even within the same room. Novelty might play a part in this, but usage emphasizes the ease and convenience. It can be concluded from our observations that communications occurred where they would not have otherwise -- they were usually not important enough to warrant leaving one's working area.

Effects on Groups and Teams

The system has promoted the evoluton of teams independent of geographical location. Although this was optimistically predicted, the nature of the teams is different than expected.

The teams centered around common problems, or at least tasks of mutual interest to the members. The novel outcome was that people within the same organizational unit did NOT become more unified, or experience any of the other characteristics of group identity. The subgroups remained isolated from each other when the user population was expanded to the present size (at the outset of organizational implementation). This was the case even when the subgroups were located in the same room.

Channels of communication that did open within the organization were based on training requirements and usually consisted of help from the more experienced users to the neophytes. Of course, the observer opened channels in order to gather the reactions of up and coming users. These spurious channels are certainly not representative of improved communication.

Judgement of this lack of increased interaction across task boundaries as an insufficient outcome is unfair. The task structure within the organizaton did not change. Individuals and subgroups continued to work on problems in separate areas of specialization thus minimizing the need for horizontal communication.

It is encouraging that the consistency and quality of communcation within a priori clusters of AKWs noticably improved, especially the vertical channels, which will be discussed in a separate section. The journal was the primary vehicle for sending messages, documents, interesting articles and references, plans and programs, copies of correspondence for non-AKWs, minutes and agendas of meetings, etc. Where these written communications

might have occured on a chance basis before, they were duly sent to the concerned team members and stored for usage through the Journal.

Team collaboration was very evident when an individual was in need of additional resources outside his own "information space". During the preparation of briefings, and papers on related topics, individuals drew directly upon the work of colleagues by either using their files in the briefing or by moving the appropriate information directly into their information space.

An exemplary transaction involved the development of a Technical Planning Objective intended for several levels up in the management hierarchy. The responsible writer generated a draft of the document covering all areas even though some individuals were not present. Then, via Send Message, he notified those people to examine the document for comments, and revise their particular portion. They simply copied it into their working space, rewrote as appropriate, and moved the finished product back into the master document.

The most exciting channels opened were those with SRI, a continent away. Concerned individuals were able to collaborate on papers for conferences, proposals for funding, and the necessary support of AHI users.

One case involved higher management at RADC who requested a paper be submitted for a conference within a deadline of a few days. Consequently, the paper was coordinated, formats and content agreed upon, and a final copy printed in the Manager's office, on time in spite of the mails.

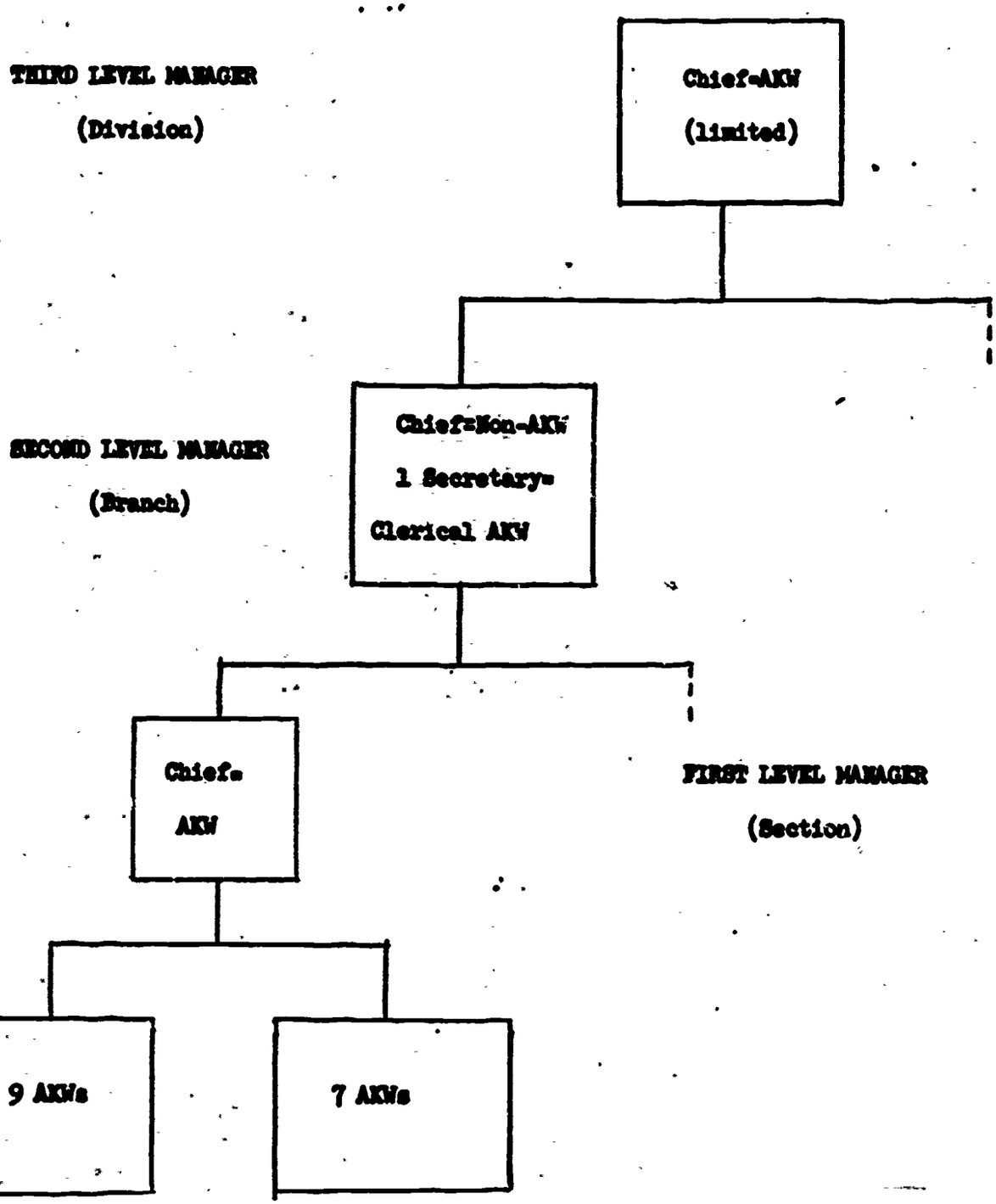
A similar situation was initiated by the California based AKWs. The proposal by which SRI/ARC is funded each year was prepared on-line prior to the final submission to the appropriate authorities. Our project monitor reviewed the proposal draft and made suggestions. SRI then re-examined it, the process continuing until it satisfied both parties. The ease with which revisions are made with real time interaction, not involving the preparation and mailing of written documentation, is quite apparent with these important, somewhat controversial, lengthy papers.

Perhaps we will realize increased communication between subgroups with more time. For the present, however, satisfying teamwork on a given task is facilitated by the ease and timeliness of AHI.

Organizational Effect: Changes in Vertical Communication

FORMAL ORGANIZATIONAL CHART

OF POPULATION



Each Box Represents a Room in the Building

Predicted problems

The problems that were anticipated are discussed here to alert the reader to the cuing which may have biased our observations. It was predicted that managers would be hesitant to access the working files of their subordinates because of a kind of psychological anxiety about discovering something they should not see, and the potential overload of detail and sheer volume of information.

Managers above the immediate supervisor (already an AKW) would be reluctant to acquire the necessary skills because of the interruption of their tight schedule, the ease with which they can assign jobs to others, the nuisance of sitting down at a terminal especially with the numerous routine interruptions, and the fairly habituated mode of solving problems through conversation.

Consistant effort is required to become proficient on a basic level. Some of this problem would be alleviated by employing a CRT display terminal to be permanently installed in the managers' offices, providing a more attractive interface.

Engineers at the worker level would experience some reluctance to enter files into the system where they might be perused by a manager prematurely. The file access controls would be used reluctantly.

These predictions center around the problem of changing strongly ingrained work habits. There are numerous additional predictions which could be made, however, this should adequately indicate the expectations generated by experience to date.

Traditional patterns of organizational communication

The patterns of communication before AHI were typical of any large business or industry where the majority of people are scientific/professional. The patterns were dependent largely upon the formal authority structure and the task assignments.

There is a "section" of about 18 persons involved with the system. They were supervised by a "section chief" who r presents the first official level of management. A pseudo m nagement level between the section chief and the "worker bee", is called the group level, and is based on a specific system development activity which is the primary function of that group.

The section chief in this population managed in an easy going way where the primary means of direction were through scheduled meetings (rare), chance meetings, and direct contact. Few if any memos were ever used. Return communication to the manager was through the same means with the addition of periodic required status reports. An open door policy (and first name informality) were the norm.

Thus, a loosely knit structure existed at this level where much of the vertical interaction was by default. Directives--requirements which came down from higher levels were usually passed on by word of mouth.

New patterns

The systems message sending capability has been used extensivily. The section chief has been using this capability to schedule meetings, respond to questions, and make requests. Message traffic has been heavy and effective, even at early stages of its use. The most important usage has been to contact a subordinate who is not available at the time in an informal manner without the necessity of written records. Thus, the overhead in resources is low.

Scenarios of situations in which the message feature has been used to advantage are numerous in the chronicle. Quasi-official vertical communications are occuring where they might not have been possible.

For example, the third level manager was able to work directly with the first level manager, the section chief, in obtaining a guest speaker at a professional conference. In this case the second level was not involved as he would have been through the traditional chain of command. Arrangements for guests, etc., have been made in the same manner.

The system enables messages of an informative nature, not requiring action, but increasing the effectiveness of the recipient, to be sent directly to him without the usually prohibitive problems.

The Journal System has been appropriate for document coordination through the "chain of command". It has been relegated to more formal documents in most cases. The major power has been realized when lengthy documents must be revised numerous times to satisfy managers.

A recent plan to procure additional terminals is a case in

point. Over a period of 7 working days a plan was prepared and rejected as "too all encompassing", prepared again and met upon, revised as a result of the meeting, revised as a result of the minutes of the meeting, and submitted to the Division Chief in finished form.

Another instance involved the creation of special working documentation which has been created for management to provide an up-to-date description of research and development "efforts". These are prepared by the individual in charge and may represent a procurement, or particular investigation or development activity.

The procedure utilizes the editing power of AHI between users directories. A standard format is copied by the individual who then "fills in" his information. Previously, any such periodic and lengthy paperwork (monthly) would have to be completely retyped after updating even though much of the actual verbage remained the same. Now revisions are entered on-line and the finished product is sent to the manager on-line with a hardcopy printout for backup. A marked increase in the promptness with which this kind of job is completed attests to AHI's effectiveness.

This is an especially good example of information availability to augmented managers. The on-line effort description may be read at any time, whether the originator is available or not, including the latest updates. "What's going on", a question so often asked by managers, is easily and quickly answered by procedures such as this.

Trip reports, a standard government form, are also handled in this way. Availability to team members and other interested colleagues is an added advantage, especially for establishing contacts.

Minutes of meetings, whether held locally or on a business trip, are entered in a commonly labeled file in each user's directory. The standard format again provides an easy way of employing a common structure to prepare documentation for management.

Vertical communication has been facilitated more through the sharing of special, "open" files than through any of the other channels. "Open" refers to files that have been created with read and write permission for the organizational unit.

A file called "Staffmeet" is used by the section chief to record items of interest to his subordinates by membership in one of two task groups. Occasionally, items are entered that are for one or two individuals. The file is continually updated (weekly as a minimum) and may be reviewed at any time. The real value is the opportunity for the subordinates to add comments, answer questions, or add items of general interest at any time. The file has become a supervisor's meeting in absentia, and is retained as a record of the continuing dialogue. This file seems to have become a highly efficient means of conducting the business of the organizational unit.

Imagination is the limit where open file usage is concerned. Another file is used to record for the manager any news items for potential inclusion in an administrative newsbrief. It is not clear why this channel is so attractive, however, its use in addition to the more formalized communication features provides a complete vertical communication tool.

To this point we have been discussing experiences based primarily upon the teletype terminal. It is most likely that a display terminal would not appreciably change communication usage, but it is certain that it does affect individual performance as borne out by the few that have become proficient.

The Display On-line System (DNLS) vs. the Teletype

DNLS constitutes a separate subsystem of AHI. It includes human engineered devices that result in the ultimate ease (within the state-of-the art) for man-computer communication.

A hand held, cursor control transducer, the "mouse," enables an AKW to point to any textual entity on the TV like display. He then can perform any of the operations that were available in the teletype version without further addressing. Any editing or other changes are immediately visable. To supplement the standard terminal keyboard, a "binary keyset" may be used to key in alphanumerics much as one would play chords on a piano.

The screen shows a number of feedback "windows" for commands, addresses, viewspecifications, literal inputs, etc., in addition to the display of an approximate page of a textual file. Commands that execute, delete, and point are actuated by buttons on the mouse. (see Engelbart, 1968)

This brief description of the highly interactive and optimized

interface will hopefully establish the setting for the particular effects of DNLS. It is through DNLS, it can safely be said, that the full potential for individual augmentation can be realized. Much of the foregoing discussion might be revised to show more positive ramifications if every user had a display terminal.

I hope to establish here the additional effect and capabilities we experienced beyond the teletype usage.

No one has tried to learn DNLS without first becoming reasonably capable with the teletype. The experience of those who have learned both indicates that it would be difficult to start with DNLS, although we have yet to show this. The present cost of the display terminal ($15,000 per IMLAC with mouse & keyset) has encouraged the emphasis of teletype access for the time being.

One subject, who has been using DNLS for about 6 months, describes the effect quite vividly as a "trip" that is addicting.

"When DNLS is flying so am I! This causes a noticeable change in my behavior. I am extremely reluctant to break for lunch, social conversation, coffee, the 5:00PM whistle or weekends. I smoke more (unconsciously). This is making me an emaciated, constipated, emphysematous, introvert; who is neglecting his family."

He offers the following analysis using some learning theory concepts.

He states that the use of DNLS is self-reinforcing because it is immediate, happens often, and happens at the level at which the behavior occurs.

Less frequent, but perhaps more powerful reinforcment is obtained from coworkers -- "Oh I didn't know you could do that!" -- which gives one a feeling of being on top of things, one-up-man-ship, superiority, etc.; and it is obtained from bosses in a similar way. In addition, the ability to respond quickly, often before the question is asked, engenders admiration.

My personal experience has been very similar to these perceptive responses from this member of the populaton (D. L. Stone).

The increased speed with which one can address, change text, and actually see the change, results in a dramatic

experience for the skilled user (there are three in our population). Pointing to a link address not only displays the addressed information at the push of a button, but also controls the viewspecification or "window" through which one looks at a body of information.

Link addresses are entered as any other text. Thus, the AKW typically enters links as he develops information units which are then linked together (cross referenced) including the specified views of the information. For example, the user may need to refer to an outline of the document he is massaging. By actuating the link he may display a toplevel view. The system stores up to five views at a time which may be quickly recalled as needed, thus facilitating return to the detail and location where the AKW was originally working.

In the same manner he can refer to any information unit for reference, which includes the vast journal documentation. Or, he can "split" the screen into up to four parts each representing a window -- textual units can be moved around between these. Searching for a topic area is easily done by sucessively showing more levels and detail in any particular file.

Displaying various windows into the information space is appropriate for briefing, etc., as visual aids: dynamic, computer generated "viewgraphs". The power is in moving quicky forward or back through the aids, and making changes at the request of the audience. Movement is done by imbedding a hidden link to the next viewgraph/display.

A complete description would continue, but it defies reasonable brevity. Overall, it is as if the AKW were traveling through information space comprised of the work of communities of AKWs. At any point he can stop and utilize the information at that location or move it to his own information space from others.

One of the few notable limitations we have encountered is display recreate speed, which is a function of our terminals, transmission line rate, and system load. Even under slow conditions, a "page" is written on the screen in a few seconds. Improvements in computer hardware will probably remove even these few seconds.

This description is offered despite the anticipated comments about over enthusiasm and starry eyes. How fast an AKW can "travel" through information space is surely a function of

the individual and the nature of the task. We have been extremely limited by our population size. However, these are in fact experiences we have had to date.

population characteristics and effects

The kind of work done by the population could have important bearing on the interpretation of these experiences and generalization from the results. Thus, the investigator established a framework which was used to categorize what kinds of work involved what percentage of the person's time.

The list of "job task types" was created by the experimenter intuitively from observations and discussions with members of the population (see below). A semi-structured interview was then given. The subjects were asked to determine the percent of time spent in each job task type.

A group profile was compiled from the job task type data. This graph (see figure) shows the respective job types for the organizational unit involved based on the mean percentages of time in each job task types.

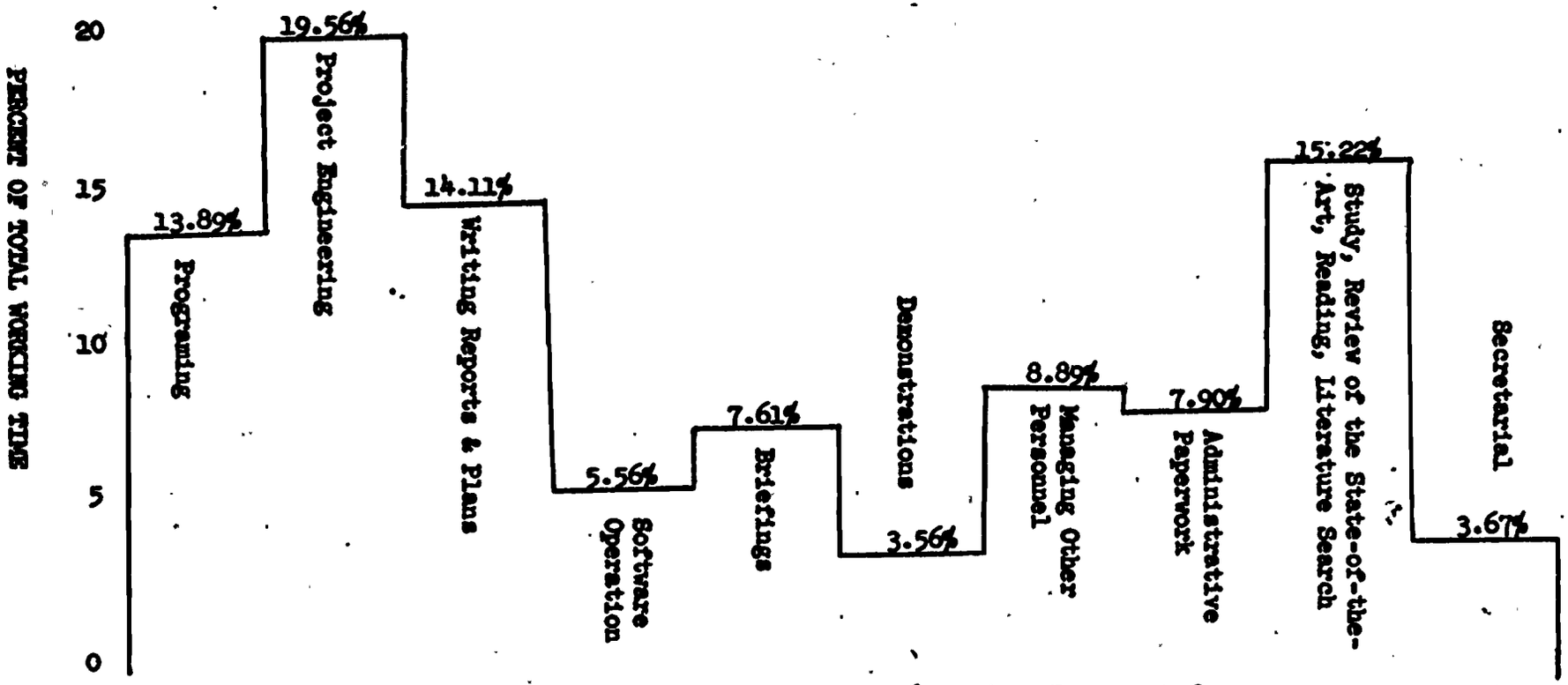
Job task types (general categories of job activities):

1. Programming computer systems
2. Project engineering, including:
   Contract paperwork (forms memos, etc.)
   Reviewing proposals and reports
3. Writing plans and/or reports
4. Software operation (incl. evaluation, debugging of software packages)
5. Briefings
6. Demonstrations of equipment
7. Managing other personnel
8. Administrative paperwork (eg. working time sheets)
9. Study, review of the state-of-the-art, reading, literature search, etc.
10. Secretarial work.

It was difficult to separate the influence of the job task type variable from the personality variable but some interesting experiences were observed.

Those who spend the majority of their time programming might actually be impeded in the learning of AHI because of proactive interference. Expectations due to experiences with other systems interferred with at least one of the subjects as he tried to use AHI.

USER POPULATION (N-20)



The job task type profile is provided here to aid the reader in the assessment of the results. No other observations or conclusions have been drawn about the relationship of jobs of this particular population and the appropriateness or effect of AHI.

SUMMARY AND CONCLUSIONS

The Augmented Human Intellect System (AHI) was developed under the leadership of Dr. Douglas Engelbart at the Stanford Research Institute over the past ten years. The purpose is to increase the capability of man to accomplish "knowledge work" through the use of a set of powerful computer based tools that provide an extension to the capability of groups, organizations, and networks of organizations. This paper describes the experiences and effects of implementing this system on an organizational unit at the Rome Air Development Center.

Four methods were employed to gather and record data: a chronicle file maintained by the subjects, interviews, unstructured observations of the subjects at work, and personal account as the unit moved toward becoming an Augmented Knowledge Workshop. This was defined as an aggregate of knowledge workers successfully using AHI.

Knowledge work in this case consisted of research and development in computer technology for the Air Force. Individuals learning to use the system experienced certain problems before becoming Augmented Knowledge Workers.

There was a strong resistance to changing habitual work methods and communication patterns. There were psychological as well as hardware causes for the resistance which were mutually escalating. Weak training techniques, system failures, and hardware unavailability were some of the difficulties encountered. As the problems were overcome, thresholds were observed in the way the system was used and perceived.

AHI use tended to fall into two discrete kinds, use as an automatic typewriter and, with the more advanced users, use for on-line composition. With use on a regular basis, the skills were acquired that rendered the system "transparent", so that the individual was no longer concerned with system operation. This tended to free him for spontaneous, creative work while the rules of operation and syntax remained subliminal in much the same way as with the use of language in conversation.

Observations of the population subsequent to training noted three areas of effect, (1) on the individual, (2) on groups and teams, and (3) on the organization.

Hypothesized effects were not entirely realized, however, they may

be with additional time and system development. At present there are profound changes that point toward that realization. Individuals experienced an unprecedented flexibility and involvement with textual information through powerful features such as the link address, viewspecification system, and information structure.

This power facilitates the construction of an information space which may be easily and rapidly communicated and shared with other AKWs to promote dialogue among task teams. The communication facilities, Send Message, Linking, and the Journal System, were employed to create new patterns of communication that would not have been attained through alternate means. The resultant documented team collaboration extended to the organization.

Vertical communication improved, as new channels were opened and formal channels were modified from the traditional patterns. The system capabilities became a new management tool which increased openness without a loss of efficiency. A number of examples of this were discussed, including collaboration with geograpically distributed groups and the sharing of special dialogue files.

Display terminals were available to a few of the population promoting a fuller realization of the impact of AHI aided by human engineered interface devices. A dynamic information visibility was achieved by utilizing "windows" into the information space. The result was like traveling through the dynamically structured information space of a community of knowledge workers with such rapidity and ease that it was almost addictive to the user.

The dramatic changes in the work methods and communication of our population in the time span of six months indicates that Peter Drucker's "knowledge revolution" will arise from the use of systems such as AHI. At least for a population of scientific and engineering personnel in the government, AHI's potential is on the way to being that which it's designers at SRI intended: a revolution in communication in the broadest sense.

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