NAVAL RESEARCH REVIEWS

JANUARY 1971

Portraits in Science

Dr. Clarence H. Graham is renowned in the field of sensory psychology, primarily for his work in human vision. Perception of movement and color vision are the areas in which he has concentrated. Dr. Graham's experiments with a person color blind in one eye and normal in the other were the first thorough investigations of one of these rare individuals, which proved that color perception is primarily a function of the eye rather than the central nervous system. Dr. Graham's work also includes research on figural after-effects, binocular summation, non-Euclidean models of visual space, stereoscopic vision, and visual illusions. A major accomplishment carried out under ONR contract is the book *Vision and Visual Perception,* edited by Graham, which is considered the best modern publication on vision. Over the years Dr. Graham has had close contact with ONR as a contractor, consultant to its Physiological Psychology Panel, and Scientific Liaison Officer, ONR London. Since 1945 Dr. Graham has been on the faculty of Columbia University.

Helping People Think

Robert C. Goldstein
Massachusetts Institute of Technology

Everyone, today, is familiar with the use of machines to ease physical burdens. Since the dawn of civilization, man's progress in gaining control over his environment has been largely determined by the power and sophistication of the machines that he has been able to command. Furthermore, since simple machines can be used to construct more complicated ones, this process, once begun, tends to advance at an accelerating rate.

When general purpose computers first came into existence in the years following World War II, many optimistic observers felt that they would soon do for man's mental capabilities what other machines had done for his physical ones. We have now passed through the first twenty years of the computer age, and regrettably, we do not seem to have made much progress in augmenting man's ability to think. Computers have given man more time to think by relieving him of many highly repetitive clerical tasks, and they have also made it easier by providing relatively quick access to large data bases. However, even these relatively meager benefits are usually available only to those willing to interact with the computer on its own terms. This paper discusses an on-going research program in interactive problem solving and decision making. The goal of this program is to develop a computer based facility for augmenting a man's intellectual ability. Such a system should provide powerful and well human-engineered interactive aids for attacking complex problems and should automatically handle routine ones.

The first requirement of such a system is for a very effective means of communication between the man and the computer. This might take the form shown in Figure 1. The chair provides a comfortable physical environment for the man and serves to minimize outside distractions. Within the chair complex, the man has a number of devices which can be used for communicating with the computer. Several devices are required because information inherently comes in several forms and different devices are best suited to each form. For example, ordinary text is entered through the use of a typewriter-like keyboard. A second, smaller keyboard is provided so that a selection of frequently used specific messages or requests can be entered with the push of a single button. At some point in the future, we should be able to replace both of these keyboards with some sort of speech recognition device which would be far more effective. A special pen and writing surface are provided so that the user can enter sketches, graphs, and other pictorial data conveniently. Finally, there is a device which can be used to point

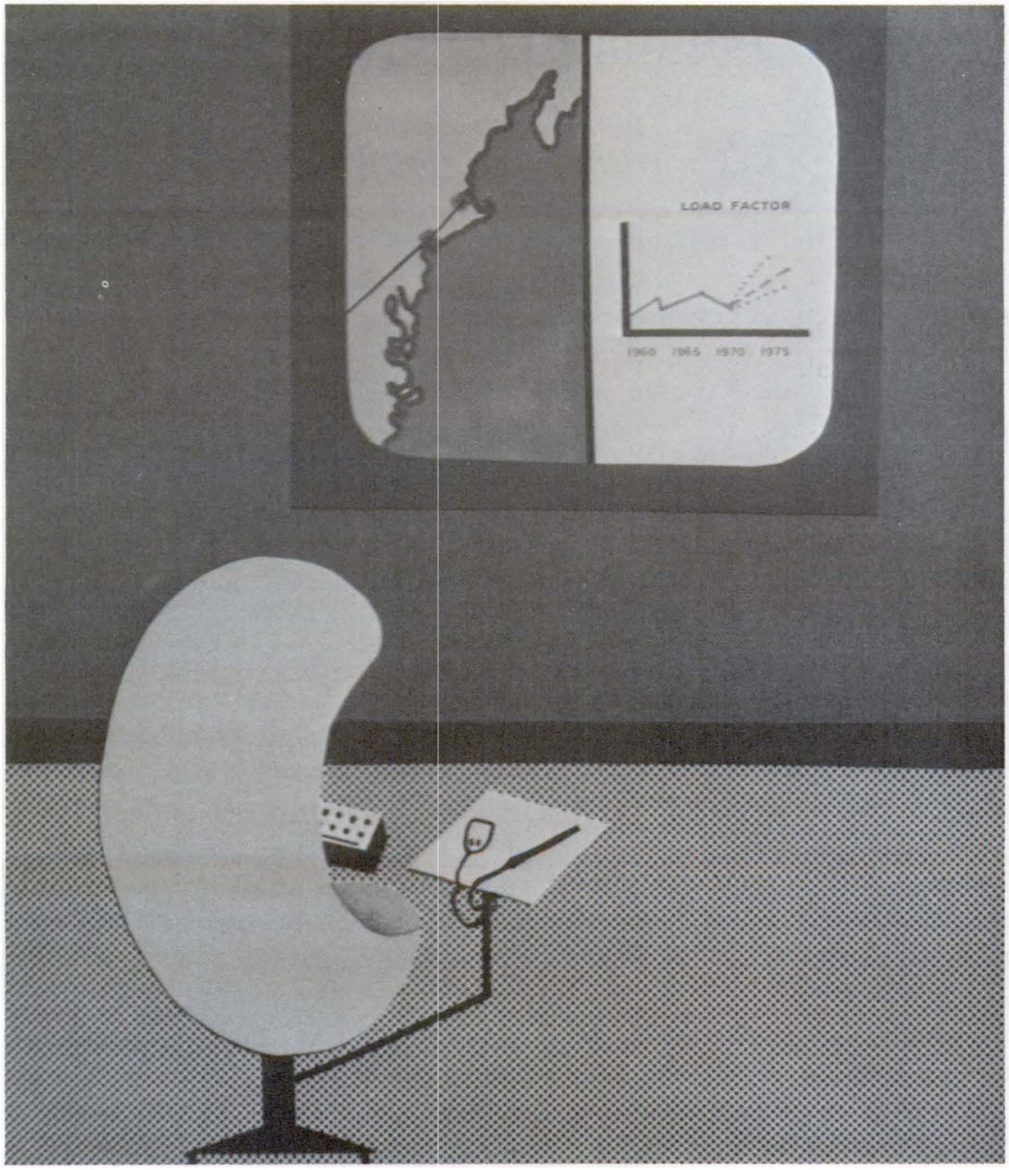

Figure 1 — Proposed user station configuration

at positions or objects on a display screen controlled by the computer. In our system, this device is a "mouse," a small hand-held object which can be moved about, causing corresponding motion of a spot of light, or cursor, on the screen. It would also be exceedingly valuable to have a means whereby complex pictorial data, such as photographs or three-dimensional objects could be perceived by the computer, but such facilities are not yet developed to the point where they can be included in an operational system.

Communication from the computer to the person is handled primarily through the medium of a display screen whose contents can be altered

dynamically by the computer. Both line drawings and text can be presented this way. Color and half-tone capability would be desirable, but will not be included initially. Additional display facilities will be added later for slides, microfilm, and other sources of relatively static information. Telephone and television capabilities will also be provided to facilitate communication with the outside world. Facilities are also provided to permit the user to make a permanent copy of information appearing on the screen. At some point, we would probably also want to consider the use of audio communication from the computer. This is not particularly difficult to provide. However, since the eye has a much higher bandwidth than the ear, it is appropriate that the initial emphasis be placed on visual presentations. The primary value of giving the computer a voice would result from its use as a signalling mechanism. It is possible not to notice a new message silently appearing on a screen, but very hard to miss an aural signal.

In addition to elaborate facilities for man-machine communication, such a system must also be capable of storing and manipulating significant quantities of information. It is possible today to give a computer a better memory than a person, particularly if accuracy is considered as well

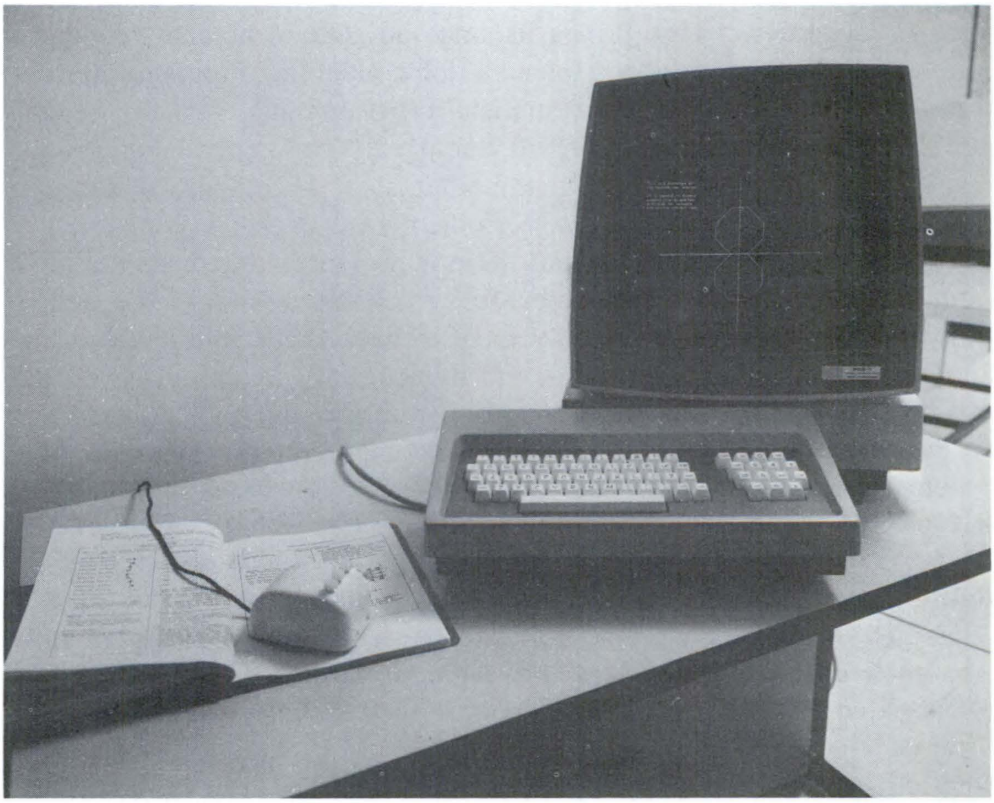

Figure 2 — The small typewriter-like keyboard, and display screen described in Figure 1

as size. However, people have a highly developed ability for screening the information that is constantly being presented to them, and remembering only that which is likely to be of future value. People are also good at using hierarchical memories. That is, they use some portion of their memory to hold a set of pointers to information which they do not choose to remember directly. These pointers refer to other people, or to books and articles, which can be considered as lower levels of an individual's hierarchical memory. Computers can probably not be taught to screen information on input as effectively as people do. Therefore, to achieve the same level of effectiveness, they probably have to retain more information. Fortunately, this does not pose any particular difficulty. However, if the computer is to engage in useful intellectual activities, it must also be given the same benefits as a person in the areas of external communication and library facilities. Probably the most important single reason why computers have been effective only in relatively routine tasks is that the information they are given is too little and too specialized. I would go so far as to suggest that, in lieu of being able to read a newspaper, the computer ought to have direct access to one of the national wire services.

Of course, it is not sufficient for the computer to merely pile up a massive amount of data. It must also be capable of finding patterns, drawing inferences, and evaluating implications with respect to given goals or objectives. This brings us into the general area of modeling. Our system must have at its disposal a rich collection of tools for simulation, statistical analysis, mathematical programming, *etc.* Such tools would offer the computer not only the ability to draw general conclusions from a mass of specific information, but also to compare alternative courses of action in terms of a set of objectives.

At this point, it might seem that there is no longer any reason to have a man in the system. However, before we can actually take the step of removing him, we would not only have to have great confidence in the computer's information gathering and interpreting capability, we would also have to be sure that its goals were the correct ones. Whatever steps we may take in the coming years toward computerized decision-making systems, it seems unlikely that man will, any time soon, be willing to delegate his goal-setting function. However, this should not cause us any particular concern, since our intent is not to replace man, but rather to utilize his unique capabilities most effectively.

Having seen where we would like to go, let us look at what we have been able to accomplish so far. The work reported here was performed by the MacAIMS (MAC Advanced Interactive Management System) Group at Project MAC under the sponsorship of the Office of Naval Research and the Advanced Research Projects Agency of the Department of Defense. The work of the MacAIMS Group began in June 1968 as an attempt to use the computer to improve the effectiveness of Project

MAC's own management. A study was undertaken to identify the most important problem areas. This led to a substantial programming effort that lasted approximately two years. All programs developed during this phase of the project were written in the AED (Algol Extended for Design) language and are used on a modified IBM 7094 computer operating under the Compatible Time Sharing System (CTSS) developed at Project MAC in the early 1960's. CTSS was one of the first large-scale, general purpose time sharing systems. As such, it lacks many features which exist in some newer systems, but is more capable than most time-sharing systems in use today. A number of programs developed as part of this research are in daily use by the MAC headquarters office. These include facilities for personnel administration, purchasing, inventory control, and budgeting. These programs have some excellent characteristics, particularly in the man-machine interface area and in their adaptability to changes in requirements. Examples of enquiries using the personnel and budgeting facilities are illustrated in Figures 3 and 4, respectively.

One should particularly note, in these two examples, how the system correctly interprets abbreviated or misspelled words. This capability, which was not difficult to implement, has proven to be extremely valuable. The programs also provide guidance at strategic points in the interaction if the user does not seem to know what to do. This guidance can also be requested at any point through use of the "help" request.

The major drawback of this system is that the limited memory capacity of the 7094 makes it impossible to combine information from the different application areas. For example, while the budgeting system will make a quick rough cut at a new budget by taking the previous one and making standard adjustments, *e.g.* for salary increases, it cannot actually look at the personnel data base to find out what current salaries really are. This capability for simultaneously considering information of different types or from different sources is something that people use constantly. Any computer system designed to offer intellectual rather than just clerical assistance must also be able to do this. CTSS also lacks adequate facilities for access control which has restricted our ability to open the system to wider use.

Late in 1969, a new computer system became available at M.I.T. offering substantial improvements in capability. This system is called Multics (for MULTiplexed Information and Computing Service) and runs on a GE 645 computer. It was developed as the result of a long cooperative effort by Project MAC, Bell Telephone Laboratories, and the General Electric Company. Multics was explicitly designed to overcome the limitations of CTSS in a number of areas, including processing power, data storage, and access control. Shortly after Multics became available, a decision was taken to begin a second phase of MacAIMS program development in order to take advantage of the new system's

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Personnel Record Updating Program   Thursday, October 22, 1970   10:27 AM

Good Morning!

Ready:  jones

Dorothy L. Jones
Malcolm M. Jones
Thomas L. Jones

    First name:  thomas l.

Thomas L. Jones
Last changed October 22, 1970


> change rank to res assist
    Effective date:  1 Sept 70

> p
    Research Assistant

> print assign
    A. I. - Vision/Robot                    76388      100%

> c percent ch to 80

> _
    Total percent charged for assignments is 80
    Do you wish to make an adjustment?   yes

> add assign
    Group: c s r
    Account number: 79457
    Percent charged: 20

> p
    A. I. - Vision/Robot                    76388      80%
    Computer Systems Research               79457      20%

> _

Ready:_

Program terminated at user request.
```

Figure 3 — Example of interaction with MacAIMS personnel system on CTSS

additional capabilities as well as the substantial recent progress in terminal device technology and the large amount of experience gained through the actual use of our CTSS facility. Observation of the system in use by the MAC headquarters staff provided much valuable insight into the relative importance of various capabilities. For example, the abbreviation and misspelling recognition facilities mentioned earlier are used very extensively and will be greatly expanded in the new system.

In terms of the general philosophy of interaction, we hope to orient the new system more toward commands than questions and answers. That is, we want the user to assume the active role, telling the system what to do, rather than merely responding to questions. This brings up

```
Good Afternoon!     October 23, 1970    14:53.0

Budget  Preparation  Program

GROUP : prog ling gen
Group not found in the Data File. Do you wish to add it? yes
SPONSOR : ARPA
SUPERVISIOR : Evans
STARTING DATE : 7/1/67
TERMINATION DATE : 30 jun 71
TOTAL FUNDS :  $ 575,000
ACCOUNT NUMBER : 79457

Enter  annual  Budgets
YEAR          AMOUNT
1969:      $ 50000
1968:      $ 35,000
1967:      $ 25,000

Type  changes  Name  changes(+,-,$)
              >

Type Period : 7/70
Data for this Period and Group does not exist
Do you wish to add it ? yes

C a t e g o r y                          Budgeted Amount
FACULTY OFF            (dir. cost) $ 1200
RESEARCH STAFF OFF     (dir. cost) $ 0
SECRET. CLERICAL OFF   (dir. cost) $ 225.00
GRAD. STUD. STAFF OFF  (dir. cost) $ 992
MIT STUDENTS OFF       (dir. cost) $ 0
SPACE RENTAL                       $ 175.45
POWER                              $ 25
OFFICE SUPPLIES XEROX              $ 15
TELEPHONE                          $ 50
COMPUTER USE                       $ 1,350
TERMINAL EQPM                      $ 225.75
DATA COMM                          $ 54.37
Do you wish to add Additional Categories ? yes
Display list of Additional Categories? no

 C a t e g o r y  Budgeted Amount
 >travel              175.00
 >consult             500
 >
Should personnel cost be adjusted for
fringe benefits and overhead ? yes
T o t a l                                  $     5,794.17

Type  changes  Name  changes(+,-,$)
              >pow              +115
              >trav             $220
```

Figure 4 — Example of interaction with MacAIMS budgeting system on CTSS

```
Do you wish to display information after changes ? yes

C a t e g o r y                              Budgeted Amount
FACULTY OFF            (incl. F.B.+O.H.)        1,670.40
RESEARCH STAFF OFF     (incl. F.B.+O.H.)             .00
SECRET. CLERICAL OFF   (incl. F.B.+O.H.)          313.20
GRAD. STUD. STAFF OFF  (incl. F.B.+O.H.)        1,240.00
MIT STUDENTS OFF       (incl. F.B.+O.H.)             .00
SPACE RENTAL                                     175.45
POWER                                            140.00
OFFICE SUPPLIES XEROX                             15.00
TELEPHONE                                         50.00
COMPUTER USE                                   1,350.00
TERMINAL EQPM                                    225.75
DATA COMM                                         54.37
CONSULTANTS                                      500.00
TRAVEL                                           220.00
Do you wish to add Additional Categories ? no
T o t a l                                  $     5,954.17

Type  changes  Name  changes(+,-,$)
              >_

Type Period : Aug 1970
Data for this Period and Group does not exist
Do you wish to copy data from previous period ? yes
Do you wish to display it ? no
Do you wish to add Additional Categories ? yes
Display list of Additional Categories? no

C a t e g o r y  Budgeted Amount
>capital equip      115,000
>_
T o t a l                                  $   115,000.00

Type  changes  Name  changes(+,-,$)
              >_


C a t e g o r y                              Budgeted Amount
FACULTY OFF            (incl. F.B.+O.H.)        1,670.40
RESEARCH STAFF OFF     (incl. F.B.+O.H.)             .00
SECRET. CLERICAL OFF   (incl. F.B.+O.H.)          313.20
GRAD. STUD. STAFF OFF  (incl. F.B.+O.H.)        1,240.00
MIT STUDENTS OFF       (incl. F.B.+O.H.)             .00
SPACE RENTAL                                     175.45
POWER                                            140.00
OFFICE SUPPLIES XEROX                             15.00
TELEPHONE                                         50.00
COMPUTER USE                                   1,350.00
TERMINAL EQPM                                    225.75
DATA COMM                                         54.37
CAPITAL EQUIPMENT                            115,000.00
Do you wish to add Additional Categories ? no
T o t a l                                  $   120,234.17
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Figure 4 (Continued) — Example of interaction with MacAIMS budgeting system on CTSS

the interesting issue of what to do when the user fails to take the initiative. Under some circumstances, this may mean that he is not sure precisely what is going on, or what alternatives are open to him. At other times, he may merely mean that he wishes processing to proceed in a normal fashion. Thus, at every step, the system must be prepared to take some default action in the absence of specific instructions. Our actual operating experience has been very helpful in working out these default strategies.

Probably the most important lesson that we have learned from our past experience has been that the system designers must strive for the utmost flexibility. It is impossible to foresee all the ways in which the system will be used, and its very availability creates additional uses. We have therefore sought to make all aspects of the system alterable under operating conditions without requiring reprogramming. This applies to such system-wide features as the structure of the data base and to such personal issues as the particular style of interaction. This latter capability implies that the system may actually act quite differently when used by different individuals. This is merely a manifestation of the well-known differences between people and particularly, their different styles of management. We believe that our system, to be effective, must interact with each individual in a way which is comfortable for him. Thus, the system will constantly monitor the nature of each user's activitiy in order to adjust, as far as possible, to his individual style.

The data management system used in the Multics version of Mac-AIMS is substantially different from conventional information retrieval systems. This new design arises both out of our past experience and the additional capabilities made available to us by the Multics environment. It is based on a relational, or set theoretic, approach to data base organization. In essence, we take the view that all of the information we might wish to store consists of data elements and relations among them. Furthermore these data elements and relations fall naturally into sets. For example, we might have a set of persons' names, and a set of telephone numbers. We might then also have a set of relations associating telephone numbers with people. One obvious advantage of this approach compared to more rigid systems is the ease with which exceptional conditions can be handled. For example, the case of a person who has no telephone number or of one who has several requires no special treatment of any kind. A further advantage is that the substantial body of theory concerning sets and operations on them can all be brought to bear on the data management problem.

A relational approach to data management also has some attractive implications for the problem of information security. This comes from the fact that the data elements are stored separately from the relations among them. It would therefore be possible, for example, to give a

particular user access to the name set and the salary set without allowing him to associate specific salaries with individuals. In other words, we can protect that particular relation while still allowing the user access to both names and salaries in other relations, for example, a (name, telephone) relation and a (salary, account) relation. As a second example, a user could be given access to all sorts of relations about people for the purpose of some demographic research, while perfectly preserving individual anonymity by denying access to the name set or any other data element set that would permit identifying the individuals involved.

In recent years, a large number of so-called "Management Information Systems" have been programmed, all presumably aimed at meeting the manager's need for better information and purporting to help him make better decisions is much more complex than is commonly assumed. It is our hope that the rather elaborate hardware and software facilities discussed in this paper will finally provide a framework in which a computer may provide significant intellectual aid to a decision maker.

Radar Used to Detect Oil Pollution

Scientists at the Naval Research Laboratory, Washington, D.C. have discovered that radar can be used to detect and monitor oil spills in the oceans.

N. W. Guinard, Head of the Wave Propagation Branch, Electronics Division, revealed details of the technique at the Third Annual Earth Resources Survey Program Review in Houston, Texas. The surprising discovery was made in 1969 when a group from NRL was making studies of the characteristics of radar energy return from the ocean surface. NRL was using their Four-Frequency Radar, installed in a Navy Super Constellation aircraft, when this effect was first noted.

An oil film coating has a smoothing effect on the ocean waves. Consequently, the radar energy reflected from an oil is less than the energy returned from the surrounding ocean. It was found that when radar mapping oil contaminated areas, an oil slick appears as a dark area with the surrounding uncontaminated areas appearing lighter in contrast.

There are several advantages in using radar to monitor oil slicks over the present photographic techniques. Radar is able to penetrate clouds and fog, monitor in darkness, and monitor large areas. By flying the radar at high altitudes, a path one-hundred miles wide could be scanned for oil pollution. Daily surveillance of the entire United States coastline becomes a distinct possibility.

Mr. Guinard pointed out that radar could be used in an orbiting unmanned spacecraft to detect and monitor oil pollution over many parts of the world, regardless of weather conditions. Such a monitoring system would not have to be newly developed since most of the equipment needed is already in use.

Radar monitoring of oil slicks is not only of interest to the Navy, but is also of great interest to the U.S. Coast Guard for detecting and monitoring oil spills near the coast. Subsequent tests have been conducted at the request and support of the Coast Guard.

Additional experiments will be conducted to evaluate the sea state range over which oil slick mapping is possible, as well as to determine the ability of the radar to distinguish the type and thickness of the oil film.

Factors for More Efficient Communications

G. C. Tolhurst
Office of Naval Research

Let me say at the outset that most of what is written below will be based upon research concerning factors of speech reception and speaker intelligibility that have been known for some 20-30 years. Much of the research described was sponsored by the Office of Naval Research.

While the facts about "improved" methods, training and circuit modifications have been known for a rather long time, the present state of voice communications, particularly in aircraft is only slightly better today than it was during, and immediately after, World War II. However, it is true that the communications industry has adopted solid state electronic components, intricate switching and control circuitry, highly reliable and linear transducers and a long list of other devices. These sophisticated components and techniques are integral to commercial broadcasting, television and data transmission systems. Few, if any, have been employed in aircraft communication or aircraft control systems. Where they have been used they have been employed as alternatives in circuits designed years ago when power supplies, amplifiers, transmitters, *etc.* required vacuum tubes and carbongranule microphones.

Many reasons are given to explain why communication system improvements lag technology so far, but the most frequent are, "the expense to make a total system change would be prohibitive," plus its corollary, "we have the components in our supply systems and the expense to include others would be excessive." It could be pointed out that the situation for change is not quite as bleak as indicated above and instances could be cited listing some improvements. However, in my opinion, the evolution has been inordinately slow with little selective breeding.

But let me stop the diatribe and begin to suggest some ways for enhancing voice communications efficiency. These will include methodology to improve listener reception and speaker intelligibility both with and without the individual being aware that anything has been modified. Some techniques include relatively short periods of training in listening and speaking. Each of the factors has been shown by laboratory experiment to improve speech communication. Rarely has there been a factorial experiment in which combinations of methods have been studied whose goal was to devise the best possible system for the widest application. Several experiments will be suggested to test the logic that if a single change can make a specific improvement some combination of several enhancement factors may yield optimum results.

The principal theme of this paper probably is, "we should take advantage of a fact of human design that man has two ears." Since most voice communication systems at the present time are essentially monaural or diotic *i.e.* the same signal, voice, *etc.* to both ears *via* earphones, let me indicate what has been found to help speech reception under these conditions.

Diotic Presentation Changes

Probably the single, most important factor which would aid diotic listening under almost every condition of noise interference is to increase the bandwidth of the system. Both laboratory and field experiments have shown that Shannon's theorem reciprocally equating bandwidth and time appears to be valid. That is, in order to transmit a fixed amount of information, as bandwidth is restricted the time must be extended, or conversely, information transfer can take place in a shorter period of time if bandwidth is increased. Mr. R. T. Camp, Jr. made this point in a paper presented at the London AGARD meeting in October 1968. His recorded demonstrations were impressively dramatic. As those who have flown aircraft can attest, it is a rare occasion when an unusually worded message does not have to be repeated over and over again, often spelled out letter by letter. A message that takes but 10-15 seconds to say may take two to three minutes before being understood.

As early as 1946, Egan and Wiener found that as bandwidth is restricted it is possible to compensate by increasing the intensity of the speech. They also report that in an experimental comparison of a military communication system *versus* a wideband system it required 15-25 dB intensity increase of the military system to achieve equal articulation scores as the wideband system. Licklider and Miller (1951) found that good speech reception scores required at least 6 dB signal-to-noise ratio (S/N), but if the speech is distorted (band-limited) higher S/N values are needed to get adequate speech reception.

Intelligible word-by-word transmission does not include the total content of a voice message. The whole message carries information about a speaker's mood, the parts of the message which are to be emphasized either by melodic pattern (pitch changes), intensity changes or by pauses preceding or following an important word. The same sequence of words can have many different meanings depending on how the words are said. Restricting the bandwidth can eliminate many, or all, of the nonverbal parts of a message.

Many arguments are advanced for restricting bandwidth: expense, channel crowding in each region of the radio spectrum, *etc.* If these are truly valid arguments, it is possible with known techniques to encode a wideband signal into digital form, transmit the code and reconstruct the wideband signal for the listener.

A second method to improve speech reception is a very simple one, and again, has been known for some time. It seems most strange that it has not been widely adopted. This "method" needs but a change in the earphone leads, or some other way, to put the phones 180 degrees out of phase. Licklider and Miller (1951) show that improvements of up to 25 percent can be affected over the in-phase condition. Other investigators have reported improvements of between 3-6 dB for similar comparisons (Pollack; Tolhurst). Why such a demonstrated improvement, requiring no additional circuits and almost no expense, has not been "standard" for a long time is hard to understand.

Much has been written concerning the advantages of peak clipping. This method of presenting an intensity equalized signal to a transmitter, as against the wide intensity differences occurring in "normal" speech, had some advantages in the era of vacuum-tube circuits, but few today. Regardless of the reasons why peak clipping was widely adopted, it should be pointed out that Licklider, the authority most often quoted by proponents of the need of peak clipping, stated in 1946 that 12 dB of peak clipping does not impair quality too much and does increase articulation scores (speech reception) but only under conditions in which the speech is generated in relative quiet and then mixed with noise. Licklider's statement (1946) concerning this latter point was, "clipping does little, if any, good if the speech is generated in a noise background." Most subsequent investigators have found similar results. When the speech plus noise of approximately 0 dB S/N are peak clipped the noise-like consonants become more like the clipped noise. Most of the intelligibility in the speech signal is carried by the consonants which with increased clipping tend to become more like noise and hence more easily masked. Probably the best way to improve most of the present aircraft circuits would be to eliminate peak clipping since few aviators, even in jet aircraft, initiate voice messages in quiet.

There is another technique to improve speech reception over voice communication networks. The general principle is to treat the usual diotic presentation in a way approaching a dichotic presentation (independent channels to each ear). Simply stated, the principle is to introduce distortion to the signal arriving over one earphone and keep the original signal to the other earphone as undistorted as possible. Somewhat regardless of the way in which the speech is distorted to the one ear, a significant and, in most instances, a practical improvement is achieved in speech reception (Tolhurst, 1959).

One of the simpler ways to distort speech is to add noise to the signal presented to one of the two ears. Egan (1949) reported an increase in the loudness of the speech to the contralateral ear. This effect of "relief from masking" is greater if the noise and the speech are kept separate, noise to one ear, speech to the other. These data were obtained with the speech in quiet and the listeners in relative quiet. I am unaware of

similar studies in which the speaker or the listeners were in a high ambient noise environment. However, the technique could be applied in an aircraft control center.

A further way of changing the speech signal to one ear, the other ear remaining undistorted, is to systematically change the intensity first to one ear and then to the other. Feldman (1965) has demonstrated positive changes in intelligibility if the range of the intensity changes was not too wide, *i.e.* did not become too loud or too quiet.

When the speech signal to the distorted earphone is frequency filtered, a significant increase in speech reception scores usually results. The types of filtering can be low-pass (below 1300 Hz), high-pass (above 1900 Hz) or band-pass. The band-pass filtering can be as narrow as 200 Hz and as broad as 1000 Hz but in the experiments the bandwidth was usually around 800 to 1000 Hz (Tolhurst, 1959). In all conditions of filtering the contralateral signal was kept as undistorted as a PDR-8 earphone would allow. Camp (1955) reported a study whose findings show that when the speech to one ear is filtered in a high-pass fashion and low-pass to the other ear (cross-over frequency was 1650 Hz) the speech reception scores were better than the condition of full bandwidth to both ears, a change of 45 percent to 61 percent or 16 percentage points improvement.

A very simple and inexpensive distortion method applied to one ear of a diotic circuit is to interrupt the signal. In a study by Tolhurst (1959), the findings were that on interruption of the signal on a 50 percent duty cycle schedule (on one-half the time and off one-half the time) and interruption rates of 20-40 times per second raised the speech reception scores by 10 to 15 percentage points. The interruption rates are somewhat above the fusion rate of the ear and were not perceptible to the listeners as being distorted.

The last distortion method to be discussed under diotic presentation is probably the most intricate and has the narrowest critical range. This is accomplished by introducing delay to the signal sent to one "distorted" earphone. Several investigations Tolhurst (1959), Feldman (1965), and Tolhurst & Peters (1956) have shown that when the signal to one ear of a diotic circuit is delayed by 0.06 to 0.09 second the speech reception is improved significantly over the condition of no delay. Feldman reports the delay condition yields higher articulation test scores than does changing the intensity of the signals between the two ears. Tolhurst found a practical increase in speech reception scores from 8-15 percent. However, it is not easy to achieve this range of delay except by utilizing the spacing between the record and playback heads of a tape recorder. The usual type of delay lines would be unwieldy in an aircraft due to both weight and size.

An extension of the delayed-message principle has been shown to aid the processing of rapid and overlapping messages, particularly in

aircraft control tower situations. The technique is to store each message on one channel of a multiple-track tape (or disc) recorder and then to play them back to the monitoring individual in sequence. If a listener can have such control of the incoming messages he is to monitor, Webster & Sharpe (1955) and Broadbent (1955) found that an individual could handle three messages about as well as he could handle one, if the criterion measure was the time in which he could give a satisfactory answer. The electronic circuitry to give such a capability is relatively simple.

Several of the above-mentioned schemes known to improve speech reception, when utilized in the sidetone circuit of a talker will improve his intelligibility, often without his being aware his speech is being affected. Sidetone is defined as the voice of a talker reaching his own ears. When a speaker's sidetone is distorted he will tend to compensate in the direction to restore his speech to match his own "normal" airborne perception. One of the earlier exploitations of this phenomenon was by the Bell Telephone Company who reduced the sidetone level to the telephone receiver just enough that the talker exerted more effort to bring his sidetone back to his accustomed level. In this way Bell was able to eliminate two relay stations for every 700 miles of cable. Webster & Klump (1963), Black (1956), and others, have shown that a talker will increase his vocal output 5 dB for every 10 dB drop in his sidetone level. There are, of course, upper and lower limits. An increase in vocal effort will also accompany the condition in which whenever the ambient noise is increased by 10 dB a talker will exert an additional 5 dB of vocal effort in order to achieve a "constant" perceptual signal-to-masking-noise ratio.

If a delay of 0.06-0.09 second is introduced into one or both ears of a talker's sidetone circuit it will slow his normal speaking rate and increase his vocal effort enough that listeners will award him higher intelligibility scores than if he were to talk under a condition of no delay. A small, but significant improvement in speaker intelligibility is realized if the sidetone is filtered either high-pass, low-pass or band pass. The same is true if one sidetone earphone is interrupted at 20-30 times per second (Tolhurst, 1959). Other techniques to improve speaker intelligibility will be discussed later under the section on training.

Dichotic Presentation Methods

As stated earlier, one of the general hypotheses of this paper is that there has been a marked neglect of the singular advantage that man has a remarkable facility between and having two ears (pun intended). Aside from the well documented 3 to 6 dB advantage of binaural listening over monaural listening, man can, and does, adjust his attention between (or among) two separate messages arriving over separate channels to each ear so that he can handle both messages rather well. In 1956

Tolhurst & Peters published a paper which demonstrated that when listeners were presented with words from a multiple choice intelligibility test in one ear and rhyming words simultaneously to the contralateral ear, both channels of equal broad band-width and sound pressure level, they were able to receive both "messages" with 55 percent accuracy. The above condition would yield scores of 70-75 percent if both messages had been meaningful word groups. When one channel was progressively attenuated the scores on the messages received over that channel were reduced in a linear fashion. For the channel not attenuated the scores increased linearly. A study needs to be done to investigate if changing the levels between two independent channels could enhance the efficient reception of the "wanted" portions of both messages.

Delaying one channel of a dichotic circuit results in a significant improvement in the reception of both messages, especially when the delay is 0.09 second (Tolhurst, 1959). Two other investigators, Dirks and Wilson (1968), report that there appears to be no advantage to delaying both dichotic channels over the condition of delaying a single channel. Depending on the test materials used, scores were found to be 8-24 percent higher, or equal to 2-6 dB advantage over no delay in either channel.

Changing the frequency response characteristics of one message channel improves the reception of messages in a competing message situation. Spieth and Webster (1955) found increased speech reception scores for both messages when one channel was frequency filtered. This was true for both the "wanted" as well as the "unwanted" message. Perceptual advantages were found to occur to each message in a two channel circuit if one was filtered low-pass and the other high-pass. The crossover frequency was 1650 Hz.

One of the more impressive ways to increase the speech reception scores of both messages in a dual channel situation was found in an unpublished study by Tolhurst (1958). Each channel was interrupted at a rate of 30-40 times per second, but out of phase with each other. In other words, during the relatively short period that speech was heard in one ear the other ear heard no signal and the signal-no signal alternated first to one ear and then to the other. At the interruption rate in this experiment the listeners were unaware of the "picket fencing." The speech reception scores for both dichotically presented messages increased from the no interruption rate condition of 55 percent to 75-80 percent for both multiple choice word reception scores. The cost to modify a dichotic, or competing message, communication situation in this way would be negligible and simple to accomplish. The advantages are obvious.

A dichotic presentation is not only advantageous in a situation of two competing voice messages but is convenient when one channel is utilized for monitoring speech and the other for tonal signals. Such a situation is

not unusual in aircraft operations, particularly those having automatic glide slope position indicators or other auditory navigational beam-following systems. Lateral directionality can be displayed by switching the tonal signals from one ear to the other depending on the aircraft's position relative to the transmitted beam while the speech channel is shifted to the opposite ear. However, maximum intelligibility for both signals will be achieved if a finding of Kimura (1967) can be followed. His studies have shown that speech reception scores are higher when words are presented to the right ear, rather than the left ear. Non-verbal (tonal) signals are perceived with fewer errors when presented to the left ear. This fact of neural organization could be adopted by imaginative avionics circuit designers.

Almost all of the factors leading to improvements in speech reception or talker intelligibility have been explored in the laboratory, one variable at a time. Developmental studies are needed to determine whether certain combinations of circuit changes, each beneficial singly, would yield improvements reflecting some summation function of the multiple. For example, one can hypothesize changes to the present aircraft talkers voice communication systems which would include a wider band microphone, delayed sidetone, frequency filtered sidetone, increased noise attenuation by protective devices and some reduction of sidetone intensity. The listeners, if in noise, should have the most efficient noise attenuation devices possible to yield the greatest signal-to-noise ratio possible, earphones wired 180 degrees out of phase, earphones with extended bandwidth and with one of the earphones presenting as undistorted signal as possible while the contralateral phone is distorted by filtering, delay or interruptions. Other combinations are possible and should be tried experimentally and the most efficient system adopted with alacrity.

Until now, I have not mentioned factors of training or the construction of special vocabularies. There is enough data concerning the statistics of language, the relative intelligibility of the individual speech sounds and of digrams or trigrams to devise highly intelligible vocabularies. Of course, these may be artificial and perhaps cumbersome but could be useful under excessively difficult listening conditions.

Even a relatively small amount of training has been found to improve both speaking and listening. Black and Mason (1946), for example, found that providing training in the use of military communication equipment under noise environments usually resulted in greater improvement of voice message transmission than would engineering changes feasible at that time. A four-hour course in speaking and listening over military systems produced an increase of 12-24 percentage points over control group scores. Additionally, the training was found to last with no significant deterioration over a four year period.

In a multi-lingual world in which the accepted aircraft control language (at least in the Western world) is English, there are distinct advantages to providing listening training to individuals whose duties require them to monitor English-language broadcasts of people whose native language is other than English. A study was conducted by Black and Tolhurst (1955) in which two "foreign dialect" groups, speaking English, were listened to by a group of American listeners and also to themselves. They were awarded intelligibility scores from American listeners, listeners having the same dialect and listeners of another foreign dialect. Each listening group was then exposed to two hours of listening to prose passages read by members of each dialect group. Then all subjects were given intelligibility tests recorded by the "dialect" groups. The single two-hour listening exposure resulted in an increase of speech reception scores of 8-10 percentage points regardless of whether the listeners were of the same or a different dialectal group. It is also axiomatic that a novice pilot cannot "copy" a weather report or a tower clearance with any degree of accuracy or speed until he has had considerable listening experience. Some of this "training" could be done prior to his embarking in an aircraft.

Summary

It should be obvious from the above research findings there are many things which could be done to improve the efficiency of voice communication systems, both for military and civil aircraft as well as aircraft ground control. The principles by which these improvements could be affected have generally been known for some time. The theme of the present discussion is simply to apply the knowledge concerning these factors. The most efficient change would be to design and install a communications system that would have at least a frequency response of 12-15 kHz and be as distortion free as possible. If such a solution is too staggering at the present time, then certain circuit changes and training methods are possible, applicable both when the signal is the same message to the two ears (as in the present systems) or whether two separate message channels are employed, one to each ear. The fact that man has two ears should be exploited. In the diotic situation a general rule seems to be that for improved listening efficiency the message to one ear should be kept as undistorted as possible and to introduce some distortion to the other ear. For the dichotic, or dual message situation, any circuit change that enhances the "switching-of-an-attention-factor" between the two message channels yields increased message reception.

In addition to training, there are changes that can be made to a speaker's sidetone which will make him a more efficient talker. Optimum combinations of various listening improvement methods and increased speaker efficiency should be determined factorially and then instigated into aircraft and aircraft control voice communication systems.

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Superconducting Magnetic Sensor Development

The low temperature group at Philco Ford has successfully completed a two year ONR/ARPA supported research program on superconducting magnetometers and gradiometers. They have developed a stable superconducting magnetometer which has operated reliably and reproducibly under repeated thermal cycling between room temperature and helium temperature (4 deg K).

Computer Aided Ship Design in the UK

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In a paper read before the Royal Institution of Naval Architects (RINA) last April, Dr. I. M. Yuille of the Admiralty Research Laboratory (ARL) in Teddington, described the work he and his group at ARL have accomplished in developing an interactive, man-machine system for on-line computer aided design of ships for the Ministry of Defense, Ship Department. ("A System for On-Line Computer Aided Design of Ships—Prototype System and Future Possibilities," RINA, April 23, 1970.) Physically, the main components of the system as they currently exist are a teletype in the Ship Design Offices at Bath connected by a telephone line to a KDF9 (32K word-core store and four million word-disc store) computer at ARL. Already purchased and shortly to be installed at Bath is an automatic drawing machine for outputting data, which is connected to the ARL computer by the same telephone line as the teletype. A cathode ray tube display with light pen for inputting data has also been purchased and some of the basic software for this is currently being developed.

An important feature of Yuille's system is that the backing store of the computer holds a representation of the ship design in such a form that it can be readily modified when the development of the design requires this. This representation not only includes a comprehensive description of each of the parts of the ship design but also an associative data structure that represents the association between the parts of the design. A ring processing package developed at ARL permits among other things expressing these associative relationships in a very simple manner. The various computer programs that are part of the system use this representation of the ship to prepare their own input data concerning the current state of the design, and the designer supplies additional data only when this is not already available or when he wishes to change the design.

Yuille has chosen to represent the ship hull surface (one of the "parts" of the ship design) by an array of Coons' parametric-cubic, patch equations. Thus, it is similar basically to the hull form representation program being developed at NPL. The program developed by Yuille is being used to assemble a library of data representing a whole family of ship forms, of known low drag characteristics, for a particular ship type (frigates in this case). When a designer chooses a form from this family as a "parent form" for his design, he is also selecting the proportions of that parent for his design. If he wishes his design to have a different set of proportions, the ARL system includes a program that changes the patch equations to define a geometrically similar ship of any chosen length, beam or depth. The system also includes a program for "swinging the sectional areas" to change the longitudinal position of the center of buoyancy of the ship to any location desired by the designer different from that of the parent form.

Yuille stated that, in practice, the preceding system of hull form representation has shown itself capable of great flexibility as a design tool. But it has also demanded that the designer learn new skills to manipulate properly and efficiently the representation of the ship's hull stored in the computer. Yuille expects the the acquisition of these skills will be eased by the increased adoption of user-oriented languages and will be further eased when the graphical input facility with light pen is operative.

The discussion of Yuille's paper at the RINA meeting and a later meeting in Yuille's office with the author and Prof. Louis J. Rydill, University College London who is also a member of the Royal Corps of Naval Constructors, brought out many interesting sidelights of the subject. Yuille clearly conceives of his system as having direct applicability not only to the preliminary design of ships but also, after further development, to contract design, final design, and the construction process itself. Rydill pointed out that the traditional break between each of these stages is a result of the necessity for a decision by management at the end of each stage, whereas Yuille feels that rationally there should be no break. Yuille excludes concept formulation and exploration (which precedes preliminary design) from his system and noted that at Bath, a non-interactive, closed, mathematical model of the design process was being developed for concept exploration.

Rydill, who has had considerable experience with preliminary ship design at Bath, raised one issue based on the following words in Yuille's paper, "... the problem of input data preparation is largely solved by letting the computer itself find most of the information it requires for running programs and the designer only supplies information that is not otherwise available ..." While Rydill agreed that this was an essential feature to make computer aided design attractive to the user, he also felt it represented a basic dichotomy because in his words, "it focuses the attention of the systems analyst on those calculations and operations which lend themselves to this approach and not necessarily on those (calculations and operations) which the ship designer considers most important." Rydill is clearly concerned that the mechanics of the computer aided design system may tend to impede a designer's freedom to concentrate on those steps which he considers most important and furthermore may tend to impair his inclination for creative design thought. Yuille countered with the statement that in his system all key steps and decisions are completely subject to the control of the designer.

The discussion of Yuille's paper by the British Ship Research Association (BSRA) representatives brought out the strong difference between BSRA's and the Navy's work on computer aids in ship design and construction. In the preliminary and contract design areas, BSRA has emphasized development of individual computer programs to aid in design but has not emphasized the development of computer aided design systems. In general, the bulk of BSRA's effort is in the ship production and final design stages rather than the earlier stages of design, because they feel the economic payoff to commercial shipbuilders is far greater in the former area than in the latter. Yuille agrees with this and also emphasizes that in the early stages of design, his system, rather than reduce the cost of the design process, will improve the effectiveness of the designer.

Rydill noted several powerful reasons for the Navy's need for a computer aided design system for both preliminary and contract design. First of all, he stated that contrary to some U.S. Navy practice in the past several years, these two stages of design were likely to remain in-house activities in the British Navy into the indefinite future. He further noted that competent design draftsmen, so necessary to the manual design process, particularly in contract design but also in preliminary design, are a scarce resource and are steadily growing more scarce. These factors taken in conjunction with the much greater complexity of warships compared to commercial ships are ample reason for the Navy to be deeply interested in a computer aided design system that encompasses both preliminary and contract design.

Those familiar with the development of computer aided design in the aircraft and auto industries will probably consider that Navy's ship design development timid and tardy. Yuille's paper makes it clear that his system utilizes large chunks of software developed by the British aircraft industry for aircraft design. It is perhaps proper that the technologically deprived ship industry should follow in the path of and derive technical support from her more lavishly endowed (at least until very recently) sister industry.

An Expendable Sonobuoy for the Arctic

The Delco Electronics Defense Research Laboratory (DEDRL), formerly the AC Electronics DRL and before that the General Motors DRL, has been conducting sound-propagation research under ONR sponsorship since 1962. All of the studies have involved Arctic problems and have been conducted from the Naval Arctic Research Laboratory, Pt. Barrow, Alaska, from T-3 and ARLIS-II, and from some pack-ice stations. One project has been the development of an expendable, ice-penetrating, search and detection sonobuoy. An instrument has been developed that responded quite well in tests made in the 1969-70 field season.

The main problem is to penetrate the pack-ice so that the listening gear is in the water while the radio transmitter remains on the surface; this to be done with an instrument that is dropped from an aircraft. The device must be capable of floating in the event the drop is into an open lead.

The sonobuoy developed is about 20 inches long, with a 1-1/2-inch diameter, 10-inch long steel cone that holds the geophone. (Hydrophones available are too delicate for the impact.) It has a six-inch diameter, finned tail piece that contains the radio transmitter and deployable antenna. Five-volt flashlight batteries operate the radio for two hours which is sufficiently long for the search and detection application.

Sonobuoys were dropped from the ARL Cessna-180 aircraft, flying at 2500 feet over the ice field north of Pt. Barrow. The two probes that fell vertically penetrated 48 inches of ice, deployed the geophone, and transmitted usable sound data. Those sonobuoys that fell at an angle greater than 45°C did not penetrate the ice, but transmitted suitable data although at a considerably lower decibel level. A striking angle of less than 45° resulted in damaged probes and no desirable results.

Another series of tests was made in October 1970, but it is now believed that the present sonobuoys are suitable for use in open water or when the ice is 4-6 feet thick. Thinner ice allows the entire package to penetrate the ice and the antenna is not, therefore, deployed. Thicker ice (more than 6 feet) will require the addition of an ice-melting mechanism to the probe.

Research Notes

Navy Studies Computer System to Aid Human Judgment

Contrary to the fears of some that computers will eventually make all our decisions for us, the Navy is taking the approach that computers can best be used as an aid to human judgment in making a complex decision. Toward that end, research has been initiated to improve the design and performance of man-computer interactive decision systems.

The research, which is underway at the University of Michigan under an Office of Naval Research contract, is based on the premise that many decisions should be based on human judgment in two areas—probable occurrences and estimated values.

Specifically, an individual receives information related to probable future events and makes a judgment or estimate on how likely they are to occur. That estimate may influence him to consider certain actions, and his final decision depends on his judgment or estimation of the gains and losses that will result from taking those various actions. In a combat situation, for example, a commander aboard ship trying to evaluate a sonar contact must estimate the chances that the contact is an enemy submarine and then judge the utility and risks of attacking it immediately or waiting for more information.

In a man-computer interactive system the man contributes certain key judgments about probabilities and utilities while the computer, performing rapidly and precisely, can compute and display the implied relative values or utilities that would result from various actions. In the research program experimental tasks are being conducted both to study the process of human judgment and how machine computation can aid it. One experimental task, for example, involves judgments about ship destinations based upon such variables as the amount of fuel taken aboard, tons of cargo carried, and ship characteristics.

According to Dr. Cameron Peterson, the principal investigator for the research program at Michigan, when humans estimate a situation, they tend to be imprecise and often reluctant to use numbers. Instead they use qualitative expressions as "very likely" or "low chances." Furthermore, when new information should cause them to revise their original estimate, they tend to be too conservative in applying the new data, resulting in a poor final decision.

By using numbers in estimating probabilities, such as a scale of odds, an estimate can be readily processed by the computer, which can also make use of previously stored data, invoke precise logical rules and add new data to previous results, thereby producing up-to-date and precise numerical probabilities.

In deciding the relative values of the outcomes of a number of possible actions, humans would perform the initial task of breaking down the anticipated value into separate components or dimensions and judging the utility or worth of each component. These numerous individually judged items could then be combined and integrated by the computer. Using any single criterion desired by the human, such as highest overall utility or minimum possible loss, the computer could then display a recommended decision.

Such a system assists human judgment by allowing a man to try out different bases for decision in advance and relying on the computer for rapid assessment of probable outcomes. It leaves the final decision in the hands of the man who must decide what end he wants to achieve the most.

Man-computer systems might be applicable to the improvement of many types of Navy decisions, such as those concerned with the analysis of intelligence information, diagnosis of equipment malfunctions, classification of targets, assignment of personnel, and management of resources.

Navy Studies Use of Yeast to Disperse Oil Spills

The Navy is studying the possibility that yeast may be useful in breaking down and dispersing an oil slick.

The study, underway at Georgia State College, Atlanta, under a contract with the Office of Naval Research, is part of a broad program aimed at better control of oil pollution of harbors and beaches by natural processes of biological degradation. The Navy is concerned with oil spillages that can occur during refueling or resulting from accidental discharges from shipboard installations.

Several strains of yeasts are known to occur naturally in oil-polluted waters, and the populations of these yeasts seem to increase with the extent of pollution. This indicates that they may thrive on oil and, along with bacteria and other microorganisms, contribute greatly to oil degradation. A parallel study, also sponsored by the Office of Naval Research, is concerned with marine bacteria that digest oil. Ways are being sought to seed oil slicks with oil-eating microbes together with nutrients to help the microbes multiply.

The action of bacteria, however, is often slowed down by environmental factors. Sunlight, for instance, kills the microbes, and osmotic pressure can cause their cell walls to rupture. The vegetative cells of most yeasts, on the other hand, are relatively resistant to the germicidal effect of sunlight, and to osmotic pressure.

Laboratory tests to date show that many yeasts readily attack and thrive on oil droplets. In certain cases the yeast colonies were able to break the "skin" of the droplet and develop within it. This means that in a marine environment the yeasts would be protected from the protozoans that are known to feed on yeast and bacterial cells.

The objective of the present study is to determine which strains of yeasts are most efficient in oil decomposition and to find feasible ways to utilize them, perhaps in conjunction with bacteria. To date more than 700 strains of yeasts have been collected from polluted beaches, estuaries and rivers, and screened for their ability to break down oil.

Development of Unmanned Under-Ice Submersible

An unmanned under-ice research submersible is being developed by the Applied Physics Laboratory (APL) of the University of Washington under an Office of Naval Research contract funded by the Advanced Research Projects Agency (ARPA). The vehicle would be used as a tool in a broad program to gain a better understanding of air, sea and ice in the polar regions. Naval operations in the Arctic pose special problems in weather prediction, under-ice navigation, ice penetration, ice breaking, underwater acoustics and communications through and under the ice cap.

The under-ice vehicle would be an adaptation of a torpedo-shaped, unmanned submersible presently operated by APL for deep ocean research. The under-ice version, which would operate literally just under the ice, would be lowered beneath the ice through a lead (an open patch of water) or a man-made hole. Remotely controlled and tracked from the surface, it would be programmed to follow a horizontal trajectory that would avoid the pressure ridges and hummocks that extend down from the undersurface of the ice.

A variety of instruments on the submersible would permit it to take basic oceanographic and ocean physics measurements needed to understand the behavior of ice in arctic waters. These measurements may include bathymetric data, magnetic fields, and analysis of the motion of the ice pack. Information on under-ice acoustic propagation and reverberations, very low frequency transmissions and the nature and origin of underwater sounds in the Arctic could also be collected. Homing devices would permit the submersible to return to the point of entry at the end of each mission or upon malfunction of some of the instruments.

New Underwater Camera

A Navy physicist and a technician, working as a team at the Naval Research Laboratory, have recently modified an inexpensive and simple in-air camera into a water-flooded camera that takes excellent photographs underwater.

Messrs. G. L. Stamm and A. G. Rockman of NRL's Optical Sciences Division report that the flooded-type camera has numerous advantages over watertight cameras presently in use. They expect it to become a valuable tool in underwater photography for Navy divers, scuba divers, aquanauts and others interested in underwater photography.

The advantages of the new development were listed by the inventors as the following:

- Small, and lightweight, easy for divers to handle.
- Inexpensive, can be disposed of without high costs.
- The camera is not subject to leakage or pressure problems.
- Possibility of changing film underwater by using film cartridges.
- Lens and window of camera not subject to fogging.

In exploring the development of the new camera, Messrs. Stamm and Rockman used an ordinary, plastic-cased in-air camera that uses 120 roll film and modified it into a water-flooded camera. They replaced its plastic lens, which was useless in water because of its excessively long in-water focal length, with a glass lens that has a shorter in-water focal length. The plastic camera, including film spools, held up well in water, but the metal shutter mechanism was subject to rusting. The developers corrected this deficiency by coating the shutter mechanism with teflon, which inhibits the rust adequately.

In the first tests of the new camera the inventors experienced difficulty in the use of wet film for the experiments but recently overcame this problem with the use of a hard-emulsion film.

In speaking of the research, Messrs. Stamm and Rockman believe that the success achieved with a hard-emulsion film in a flooded camera should be encouraging in terms of the development of a practical camera of the flooded type for use in the field. Heretofore, the special handling required of ordinary films would have made such development difficult and the field operation of the camera very cumbersome. With the use of a hard-emulsion film many of the difficulties of flooded camera operation are overcome.

The two enterprising researchers have applied for a patent on the new development, which is expected to be of great value to the Navy and a spin off to commercial photography.

Alvin to go Back into Operation

The Navy's underwater research submersible ALVIN, retrieved from a depth of 5,000 feet a little more than a year ago, is being reconstructed by the Woods Hole Oceanographic Institution. It is expected to be completed by late spring and resume its research dives for the Office of Naval Research.

ALVIN will return to operation with its original steel pressure sphere that will allow operations down to 6,000 feet. A new titanium sphere is now being fabricated and will be installed as a replacement for the steel sphere late in 1971. This is expected to give ALVIN a capability of reaching a depth of 12,000 feet.

The rebuilding of ALVIN together with budget restrictions limiting the funding of underwater research vehicle operations has led the Office of Naval Research to cancel its plans for supporting SEA CLIFF, which was to be assigned to Woods Hole.

SEA CLIFF, along with its twin TURTLE built at the same time, has been transferred to Submarine Development Group One, San Diego. The design of the two submersibles is a modified version of ALVIN, with a depth capability of 6,500 feet. Deep diving submersibles assigned to Submarine Development Group One are used to train Navy hydronauts, the men who operate such submersibles.

New Approach to Use of Polymer Additives for Drag Reduction

A completely new approach to the use of polymer additives in water as means of substantially reducing drag is being explored at the Massachusetts Institute of Technology under an Office of Naval Research contract. The use of polymer additives offers great potential for satisfying the Navy's requirements for increasing the speed of ships, submarines and underwater weapons and also reducing hydrodynamic noise associated with their motion through the sea. The most favored material for the polymer additive has been polyethylene oxide (Polyox). It has been generally assumed that the macromolecules of this polymer elongate in the boundary layer flow and that this is what contributed to the drag reduction effect. Work at MIT under the direction of Prof. E. W. Merrill, however, has indicated that there is no great extension of the macromolecule in the flow and that consequently drag reduction may not require elongation. Instead the MIT work appears to show that it is the high molecular weight which does the job. It has further been ascertained that the higher the molecular weight, the lower the concentration of the polymer additive that needs to be used in the boundary layer flow to achieve significant drag reduction. It is speculated that the concentration can even be reduced on the order of one part per ten million.

This has led Prof. Merrill to start work on the synthesizing of giant branched macromolecules by the crosslinking of small linear macromolecules to a point just short of gel formation. The water soluble polymer to be used in polyvinyl alcohol, straightforwardly derived from polyvinyl acetate which is manufactured in great quantities in this country. Such a polymer additive could be much more efficient and lower in cost. One problem with the Polyox molecule is that it is relatively fragile and therefore cannot be used effectively in a recirculating system. If polyvinyl alcohol proves more durable, this would open up many practical applications of polymer additives.

In other research sponsored by ONR on polymer additives, Prof. A. T. Ellis at the University of California, San Diego, has discovered that very dilute polymer solutions, in addition to achieving drag reduction and suppressing hydrodynamic noise, have a large effect on inhibiting cavitation. In effect, the polymer solution delays the onset of cavitation. Prof. Ellis is making detailed studies on the dynamics of bubbles and how additives effect this.

Computer Simulation for Integrated Logistics Support

Mr. A. F. Feiler, University of California, Los Angeles, an ONR contractor, has prepared a technical report "Application of TRANSIM IV to ILS Problems—A Feasibility Study and Demonstration." The research discussed in the report is the adaptation of a general purpose computer simulation model, TRANSIM IV, to current naval problems associated with integrated logistic support (ILS). The basic intent of ILS is to provide a methodology which is composed of the elements necessary to assure the effective and economical support of a system, or equipment at all levels of maintenance, for its programmed life cycle. Mr. Feiler's work has shown that current computer and general purpose simulation technology can be used to build a family of submodels which can be applied to the ILS problem from system concept formulation through the operational phases of the hardware system. The basic model generated by Mr. Feiler is adaptable to the analysis of a single equipment or the analysis of the maintenance, supply support and associated manning for an entire ship.

The report includes an example of the model applied to the maintenance support of the AN-SQS-26-CX Sonar System. In particular, the example problem is concerned with

determining the effects on the Sonar Systems' operational availability of specific limitations in maintenance resources. This research was done in conjunction with NAVSHIPS Statistical Engineering Branch (0311) and NAVSHIPS ILS System Development and Review Branch (0631).

Stress Monitoring of Rotating Shafts

A new technique for stress monitoring rotating shafts was recently demonstrated. The technique, which is being developed as part of ONR's Mechanical Failure Program by the Naval Ship Research and Development Center, Carderock, provides a means of monitoring the stress levels in moving magnetic materials such as power transmitting shafts and running wire cables in a hands-off manner. The new technique measures the harmonic distortion of an applied magnetization signal as a function of stress level in a region ordinarily within the magnetic hysteresis loop by continually magnetizing and demagnetizing the material. Determination of stress level in a structural member without prior calibration seems feasible since the amplitude of the third harmonic of the magnetization signal doubles from its unstressed level, when the material reaches half its yield strength.

Naval Research Laboratory Scientists Save Money by Using Surplus Rockets in Research

The Naval Research Laboratory is saving thousands of dollars in the advancement of research by using surplus rockets and associated equipment to carry instrumented payloads into the upper atmosphere to conduct x-ray and ultraviolet astronomical experiments.

The first successful launch of the Super Chief, carrying a 1225 lb payload atop the two-stage rocket, was conducted from the Pacific Missile Range's San Nicolas Island last fall.

The 40-foot Super Chief, which is a combination of a Sergeant second stage and a Talos first stage, is designed to lift the payload to an altitude of 130 miles to obtain x-ray measurements of several galaxies.

NRL was able to obtain the Sergeant rocket from the Army and the Talos from the Navy. The Super Chief uses the Talos as a booster motor and the Sergeant motor the sustainer. A surplus Navy gun mount was used as the launcher for the Super Chief in its maiden high altitude diagnostic flight.

The Super Chief has evolved over the past few years from various preliminary vehicle concepts and was accepted after others proved to be of marginal performance, or have fairly high rehabilitation and manufacturing costs.

In the Blue Scout, Jr. program NRL scientists were able to obtain the rocket system from USAF as surplus. They also obtained transportation vehicles, launchers and support equipment.

One of the three-stage rockets was recently launched at night from Wallops Island by NASA carrying a payload developed by Dr. George Carruthers at NRL to measure radiation from certain stars. The experiment was considered very successful sending data back by telemetry from the vehicle which achieved a peak altitude of some 880 miles in its flight from Wallops Island, Virginia, eastward over the Atlantic.

Other experiments with the Blue Scout, Jr. rocket are planned using a modified two-stage rocket instead of three.

On the Naval Research Reserve

NRRC 12-2 Studies Commerical Neutron Radiography

NRRC 12-2, Livermore, California, took advantage of its proximity to General Electric Co. and Aerojet-General Corp.; the two companies arranged presentations for the group about their work in the field of neutron radiography. It is possible to obtain a neutron radiograph which shows an image of a rubber O-ring or a candle behind a lead brick. With X-radiography the lead brick would stop the X-rays, and the O-ring or candle would appear transparent to them. Relatively high neutron intensities are required for neutron radiography. The only effective method found to date for producing these intensities is from a nuclear reactor.

Science Cruisers in Twelfth Naval District

Members of Naval Reserve Research Companies 12-4, Fresno, and 12-9, Sacramento, California, recently participated in their local Central Valleys Science Fairs in conjunction with the Navy Science Cruiser Program. Both of the Navy award winners also claimed the boy's grand prize for their respective competitions.

New Theory on Prevention of Fouling

A new theory may dramatically solve the problem of how to prevent the attachment of fouling organisms, including barnacles, to a ships' bulk as well as the deterioration of wharves and piers by marine borers and similar organisms. The theory is that the entire process is started by a thin primary film of microbes or bacterial slime layer that first coats the surface of any material immersed in seawater. Certain chemicals in this film apparently attract free swimming fouling larvae which settle on the surface covered by the film. These breed and also attract larger organisms, such as barnacles, which come to feed on them.

Studies on the formation of this film as well as the chemicals contained in it are being conducted by Dr. Ralph Mitchell at Harvard University and Dr. J. S. Kittredge at the City of Hope Medical Center, Duarte, Calif., under contracts with the Office of Naval Research. It is hoped that this knowledge will lead to techniques for preventing the formation of the primary film that initiates the settling process. As an alternative, if chemical elements are found in the film which repel marine organisms, the entire surface immersed in seawater could be coated with repellent material that would keep the surface completely free of organisms. A clue to these possibilities is that while barnacles attach themselves to a number of marine animals, certain whales for some reason appear to be completely immune to them.

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Animated Sonar Displays Studied

A promising approach to easing this problem of identifying sonar targets is the use of electronic animation. Computer Image Corporation, Denver, Colorado, has developed a computer device and computer programs which work together to produce and display a variety of dynamic synthetic images in response to sound inputs. The company under a contract with the Office of Naval Research is investigating how certain visual patterns produced by such electronic animation might assist an operator in obtaining quick and positive classification of waterborne signals.

The research program has resulted in the development of new techniques for producing animated images which portray in real time the characteristics of the acoustic signals that are being received. Experiments conducted as part of the program have demonstrated that the combination of viewing the animated visual display while listening to the acoustic signal input significantly improves discrimination between underwater sounds that are only slightly different.

Electronic computer animation does not necessarily have to produce an exact image of the target. In fact, simpler patterns such as moving lines, circles or dots, may be suitable to reveal subtle differences between target signatures. As an added assistance to the operator, it is anticipated that patterns for a variety of ships would be stored previously in the computer memory. If the operator is in doubt about his contact, he would be able to flash on another screen the pattern for the type of ship be believes he has contacted and match the images.

Further research will be aimed at refining the techniques for presenting an acoustic signal simultaneously with its corresponding dynamic visual display. Experiments will determine the most easily discriminated type of visual display and the best arrangements for displaying the pattern.

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The two-stage rocket used in the Navy Environmental Background in Space Program (NEBIS) is known as "Super-Chief" vehicle. The Naval Research Laboratory sponsors the project. *See page 27.*

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