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Study of Target Handoff Techniques

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The objectives of the research were (a) to determine how air-to-ground and ground-to-air target handoff (target designation) has been accomplished in the past; and (b) to develop techniques for low-cost experimental studies of target handoff in order to develop new procedures and specify requirements for new equipment.

An attempt was made to develop a battery of paper-and-pencil tests for selection or classification of individuals who will perform target handoff as

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part of their job. This effort did not produce a practically useful result. Analysis of recordings obtained of the verbal interchange between individuals performing simulated handoffs may provide useful cues as to the characteristics of effective verbal behavior during handoff. The simulator developed for the research appears useful as an inexpensive training device.

FOREWORD

The Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences (ARI) provides support to Headquarters, TCATA (TRADOC Combined Arms Test Activity; formerly called MASSTER--Modern Army Selected Systems Test Evaluation and Review). This support is provided by assessing human performance aspects in field evaluations of man/weapons systems.

This report presents the results of studies designed to investigate problems in handing off targets between elements of Army air. The studies specifically addressed the effectiveness of selection and training in improving the performance of personnel who must perform target handoff as part of their job.

ARI research in this area is conducted as an in-house effort, and as joint efforts with organizations possessing unique capabilities for human factors research. The research described in this report was done by personnel of the Human Resources Research Organization (HumRRO), under contract DAHC19-75-C-0025, monitored by personnel from the ARI Fort Hood Field Unit. This research is responsive to the special requirements of TCATA, the 6th US Cavalry Brigade (Air Combat), and the objectives of RDTE Project 2Q763743A775, "Human Performance in Field Assessment," FY 77 Work Program.

STUDY OF TARGET HANDOFF TECHNIQUES

BRIEF

Requirement:

The work carried out in this study is that referred to in paragraph 2.2.1 of the Statement of Work (revised) dated 3 February 1977 under the title "Study of Target Handoff Techniques." The following objectives guided the course of the study:

- To develop improved target handoff procedures.
- To recommend new target handoff procedures.
- To produce a statement of Required Operational Characteristics (ROC) for new or revised equipment/instrumentation.

Procedure:

A simple simulator employing static imagery was devised which would allow pairs of individuals to perform target handoffs. This simulator included appropriate instrumentation to record the verbal interchange between the subjects and to accurately time the duration of the handoff. This simple simulator served as a test bed for studies aimed at answering the following questions:

- What are the roles of verbal and spatial abilities in determining individual performance in handoff?
- What are the characteristics of an effective handoff message?

Following an initial small pilot study, a full-scale effort was mounted to provide answers to these questions.

As first steps in initiating the study, suitable imagery was obtained for the simulations, and a battery of verbal and spatial ability measures was compiled. Arrangements were then made for a suitable sample of experimental subjects. The subjects first received the test battery and then performed six simulated handoffs. One hundred and sixteen individuals participated in the study.

Principal Findings:

- The battery of spatial and verbal tests was relatively ineffective in identifying successful handoff performers.
- Successful utilization of the test battery would require selecting only the top scorers on the tests used.
- Faster handoffs use fewer words.
- Faster handoffs occur when the observer does most of the talking.
- A high ratio of adjectives relative to nouns is associated with rapid handoff.

- It is probably not possible to attempt to devise a specific set of rules which will apply to all possible handoffs. A more general set of rules is indicated.
- The ideas embodied in handoff simulation seems to form the basis for an effective program of the study of target handoff.

Utilization of Findings:

The primary utilization of the effort described in this report will be to direct the development of a systematic approach to the improvement of target handoff performance. Data acquired from detailed analyses of the recorded handoffs will form the basis for the development of training or job aids which will enhance target handoff performance.

A secondary utilization occured as a by-product of the main study. The simulator was, in effect, used to provide inexpensive, highly compressed practice in target handoff to the aviators and enlisted observers of the 6th Cavalry Brigade (Air Combat). The participants in the study were almost without exception pleased with their simulator experiences and felt it had a future as a training device.

CONTENTS

CHAPTER I

INTRODUCTION

It has been noted that it is relatively easy for ground observers to handoff (designate) ground targets to other ground elements. In this instance, both are viewing the target and surrounding terrain from a similar aerial perspective. The task becomes more difficult when a scout helicopter designates targets for Attack Helicopters (AHs) as the aerial perspective from which both are viewing the target differ, to an unknown extent. However, air-to-ground and ground-to-air handoffs are the most difficult. The common denominator in all of these situations is the difference in viewing perspective between the two individuals attempting a handoff. Because of this fundamental similarity, an improvement in handoff techniques for one situation should apply to all.

As an example, the ground observer may designate a target as being located among the tallest trees in a certain grid square, but the helicopter pilot will be unable to discern tree height from his viewing position. Conversely, a helicopter pilot may wish to have a ground unit fire on a group of enemy located on a trail bend. The bend will be obvious when viewed from above, but may not be visible from the ground view. Thus, differences in aerial perspective and the low likelihood that the ground and airborne observers will understand these differences contribute to difficulties in designating a target.

The handoff problem is complicated even further by the fact that the parties involved are likely to be viewing the target from different directions. For example, one observer may see the target as being 1000 meters directly behind a windmill. However, the second observer, not knowing the exact position of the first observer, is unlikely to know where "directly behind" is, even though he can see the windmill. Thus, the handoff problem is one of considerable magnitude.

The use of maps by both parties cooperating in a target handoff cannot be expected to improve target handoff performance. The usefulness of maps in target designation has proven to be limited. The 1:250,000 scale maps carried by aircraft are not adequate for use in target designation because of lack of detail. In addition, the accuracy of maps in many potential combat zones is an unknown factor.

Handoff procedures as they now exist generally have their origin in the recent experience in Southeast Asia (SEA). It is unlikely that this experience will be repeated, and therefore the techniques that were developed there will be inappropriate for future combat. The Asian experience was characterized by unquestioned air superiority and the lack of significant local air defense by enemy combat units. The conflict was also basically an infantry or guerilla action with few defined positions and very little armor involvement.

Therefore, it was determined that a more effective means of handing off targets while engaging a sophisticated enemy was badly needed.

For the purposes of further defining the problem, a number of limiting assumptions were proposed. These assumptions were as follows:

1. Handoff will occur in an environment with topography and climate typical of central Europe.

2. Handoff will occur in a mid-intense conflict with conventional weapons only.

3. The conflict will be with a sophisticated enemy with an Electronic Warfare (EW) capability.

4. Local air superiority will be doubtful and the enemy will possess strong air defense capability.

5. Handoff will be from a ground or airborne observer to an AH or gunship, or vice-versa.

6. Handoff to USAF or Navy air support units will not be considered.

7. Direction to the target and designation of the target will be by voice channel -- which must be used sparingly. This worst case approach is dictated by the realistic assumption that combat conditions will degrade or render inoperable more sophisticated systems. This assumption also focuses the emphasis of the research on the most variable element in the handoff -- the human.

8. The aptitude or general educational level of the individuals involved in the handoff will probably vary greatly. The helicopter pilots will probably be a relatively homogeneous group, well educated with high aptitudes. The ground observers or observers in observation aircraft will vary across the entire spectrum of aptitude and education.

With these limiting assumptions in mind, an approach was developed to further define the problem of target handoff. As conceptualized, this approach was a five-pronged effort consisting of:

- Review of Army Regulations, training, training materials, doctrine, and tactics.
- Review of the relevant technical literature.
- Conduct of interviews with aircraft pilots and gunners, and with combat arms personnel experienced in ground-to-air and air-to-ground target handoff.
- Survey of a larger group of individuals with target handoff experience.
- Observation of individuals actually performing handoff.

The primary goal of this approach was to develop a full understanding of the target handoff task and to develop a model of the behaviors and processes involved. Once the task was understood, then hypotheses could be proposed for improving its performance.

The first four of these activities were carried out as part of the first year's activity in the study, and the results are to be found in the final report authored by Ton, et al.[1]

The present report is largely concerned with the results of a study which involved the observation of individuals performing target handoff on a simple simulation. Questions of aptitudes and abilities that might be involved in handoff are addressed, and transcripts of taped simulated handoffs are analyzed for clues as to the content of an effective handoff message.

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[1] W. H. Ton, W. L. Warnick, A. L. Kubala, and J. L. Maxey. *Study of Air-to-Ground and Ground-to-Air Target Handoff*, ARI Research Problem Review 76-10, Human Resources Research Organization, Alexandria, Virginia, and US Army Research Institute for the Behavioral and Social Sciences, Arlington, Virginia, October 1976.

CHAPTER II

EXISTING ARMY DOCTRINE

Review of relevant Army documents reveals that procedures for handoff of targets to Army air elements are only grossly defined. Training Circular (TC) 17-17[1] states the approved target handoff message format consists of the following elements:

- Alert
- Acknowledgement
- Target Description
- Target Location
- Technique of Attack
- Method of Control
- Acknowledgement
- Execution

Many of these elements are simple in nature and could be accomplished without special training or improved procedures. However, description of the target and its location are not simple tasks in a combat situation. The individual handing off the target has the option of describing the target and its location by many methods; the final choice is determined by factors such as available resources, prevalent tactical situation, and of course the experience and training of the individual.

Among methods of target area description which may be used are:

- Grid Coordinates
- Range and Directions from a Known Point

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[1] TC 17-17. *Gunnery Training for Attack Helicopters* (Draft), US Army Armor School, Fort Knox, Kentucky, August 1975.

- Range and Directions from Observer's Position
- Range and Directions from Smoke or Other Markers

The use of any or all of these methods is dictated by local Standing Operating Procedure (SOP). Field Manual (FM) 100-26[2] points out that the ground commander and local SOP will determine the actual control of Army air elements in the target area. Further, FM 44-10[3] states that means for communication must be provided in SOP and plans. It further states that these SOPs and plans should be exercised in the field prior to hostilities. Thus, the Army places its reliance for effective target handoff on procedures developed by the individual unit, and as far as could be determined, no formal training exists for target handoff procedures. This view was confirmed by the results of a questionnaire administered to experienced individuals as part of the research carried out during the first year of this research.

A review of Army-sponsored research reveals no effort has been directly aimed at developing improved handoff procedures, although several references were made to problems in this area. In a particularly relevant piece of work, Warnick and Jones[4] administered a questionnaire to Army aeroscout pilots and observers who had served in combat with air cavalry units. The survey was aimed at the examination

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[2] FM 100-26. *The Air-to-Ground Operations System*, US Department of the Army, March 1973.

[3] FM 44-10. *Army Air Space Control Doctrine*, US Department of the Army, March 1973.

[4] W. L. Warnick and D. Jones. *Aeroscout Pilot and Aeroscout Observer Responses to the Air Cavalry Tactical Information Survey*, Research Product 72-37, Human Resources Research Organization, Alexandria, Virginia, September 1972.

of methods and techniques used in SEA with the objective of developing a basis for training development. In responding to the survey, pilots reported that communications with the Forward Air Controller (FAC) should be the subject of formal training. The respondents specifically noted that *brevity, exactness, and planning* were particularly important ingredients in effective airstrike control.

Subsequently, Warnick[5] asked a sample of Army helicopter pilots and observers to rate statements of skills or knowledges for a requirement in terms of their importance for combat job performance. The goal of Warnick's research was to identify skills and knowledges for an aeroscout training program. Warnick identified certain skills and knowledges, rated as important, that have application to the study of target handoff procedures. These were:

- Reporting information
- Briefing USAF forward air controllers
- Directing airstrikes
- Ability to relate terrain features to their representations by either map or photo

Researchers at the US Army Combat Developments Experimentation Command (USACDEC)[6] looked directly at the problem of unassisted ground-to-air target handoff. However, these studies suffered from a lack of

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[5] W. L. Warnick. *Combat Job Requirements for the Air Cavalry Aeroscout Pilot and Aeroscout Observer*, Technical Report 72-37, Human Resources Research Organization, Alexandria, Virginia, December 1972.

[6] US Department of the Army. *Attack Helicopter - Daylight Offense, Vol V, Final Report, Phase I and II (Air-to-Ground Target Acquisition and Hand-Off)*, Report No. FC 003, US Army Combat Development Experimentation Command, Fort Ord, California, May 1974.

combat realism; the observer was not required to direct the AH to the target area and target location was given in either grid coordinates or a known search area. It was noted, however, that ground observers were never sure of how their perspective differed from that of the pilot. Additionally, enlisted observers were seen to be far less skillful in handoff when compared to officers, their messages were longer, less precise, and tended to be "wordy." It was further noted that observers should give the pilot only general terrain features when designating the target; descriptions were often too "fine grained" for the AH pilot to use effectively.

RELATED COMMUNICATIONS RESEARCH

The problem of target handoff has received some attention in research sponsored by the United States Air Force (USAF). The impetus for this research was furnished by a study of target handoff between airborne FACs and high performance aircraft conducted in SEA by Simons.[7] Simons found that while a wide variety of techniques were used to designate target location, the use of terrain features as reference points was common. Simons' major emphasis, however, was on the critical role of effective communications between the individuals performing the handoff. Simons' findings are easily generalizable to any situation in which an individual must describe a target location to another who has a differing perspective of the terrain. Simons made the following recommendations for improving target location accuracy:

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[7] J. C. Simons. *Low-Altitude Reconnaissance Strike Techniques, Problems*, ASD-TR-67-17, Detachment 6, Aerosystems Division Liaison Office, South East Asia Air Force Systems Command, December 1967.

- When describing targets, start with large prominent landmarks and move down to smaller objects near the target.

- Never proceed with a target description until the recipient acknowledges a full understanding of the reference landmark.

- Use *relative* distance and bearing terms.

Each of these recommendations was properly interpreted as a hypothesis by the USAF and a considerable amount of research followed Simons' findings. The main thrust of the research concerned itself with the improvement of communications between the FAC and the attack aircraft.

As a direct followup of Simons' work, Morrissette[8] analyzed recordings of FAC/Tactical Aircraft (TAC) communications obtained under combat conditions in SEA. Morrissette began by ranking the missions on the basis of time from initial contact to strike to determine if differences in communications content existed between slow and fast missions. He then carried out a detailed content analysis of the ten fastest missions and the ten slowest missions. Morrissette termed the fast missions *effective* and the slow missions *ineffective*. Under similar mission conditions, the individuals involved in the effective missions were seen to communicate more effectively than the individuals involved in the ineffective missions. The FAC in the effective missions used fewer words in directing a strike than a FAC involved in the ineffective missions. (During the communications between FAC and TAC, 92.9 percent of all comments involved verbalizing the location of targets,

[8] J. O. Morrissette. *A Content Analysis of Communications Between Forward Air Controllers and Tactical Aircraft Pilots*, AMRL-TR-70-95, Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio (in process).

airplanes, people, and guns.) Morrissette felt that FACs should be well practiced in communicating their own location, describing target location, and recommending mode of ordnance delivery. Morrissette further recommended that emphasis should be placed on training FACs to identify terrain referents that are readily discernible by high-flying attack aircraft. Similarly, the FAC must be able to give direction information clearly, using relative units of measure. However, as was pointed out, it remains a question if the results obtained from his data would hold over different kinds of direct fire-support missions -- different terrain, day/night, etc.

In a study similar to Morrissette's, Siskel and Flexman[9] studied air crew coordination under simulated conditions. They noted that with increased training, communication transmission rates decreased (i.e., the communicators spoke less frequently), while the number of expressions of complete thought also declined. Siegel and Federman[10] followed up on Siskel and Flexman's work with a series of studies designed to take a close look at communications between and among crews of antisubmarine attack helicopters. The crews performed simulated exercises and their communications were recorded. The resultant recordings were then subjected to a communications content analysis. Factor analysis was performed on the results of the communications content analysis of two studies. Three factors which were common to both studies were identified:

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[9] M. Siskel and R. Flexman. *Study of Effectiveness of a Flight Simulator for Training Complex Aircrew Skills*, Bell Aeronautics Company, 1962.

[10] A. I. Siegel and P. J. Federman. "Communications Training as an Ingredient in Effective Team Performance," *Ergonomics*, 1973, 16(4), 403-416.

1. Leadership Control

2. Probabilistic Structure

3. Evaluation Interchange

Siegel and Federman (pp 407-408) define these factors as follows:

> Leadership control connotes the provision of an atmosphere in which opinions of other crew members are allowed to emerge. This atmosphere prevails up to the point at which the team leader makes a decision. Prior to the decision making point, the opinions of others are solicited and welcomed, divergent opinions are allowed expression, data are accepted from all sources for consideration, and the formulation of hypotheses is encouraged. After all data are collected, the leader comes to a decision and insists that his crew carry out this decision. After the decision point, the atmosphere changes to that of command and control, so oriented that the decision is carried out....
>
> The second factor denotes an active weighing of probabilities, a test of 'fair change', a questioning of assumptions and of the appearance of truth. The factor implies that better teams make tests of plausibility and likelihood. These are characterized by 'what if' type statements and by information and opinion supporting the alternatives brought about by these statements. In brief, units maintaining this structure think logically and reason rather than perform routinely. Behaviour is marked by the desire to obtain more information and opinion before coming to a decision and the attitude reflects this permutative thinking. The behaviour underlying this factor can be further described as reflecting cohesive and interlocked communications which seek active exploration of the data and of alternative courses of action.

The third factor, *evaluation interchange*, was described as follows:

> This factor identifies communications in which there is an interchange of ideas, proposals, and data. The interchange entails an evaluative reciprocity between team members. Here are communications in which 'requests for' and 'provides' information come into play. The content supports and enhances a probabilistic structure and provides a basis for the thinking within the structure.

These three factors were then used as the basis for constructing an experimental course of instruction. The course was then evaluated using a two group, posttest only design. The subjects were drawn from a pool of Navy helicopter crews at Ream Field, California. Sixteen crews composed each group. There were no differences in performance attributable to enhanced communication but the results were largely confounded by a difference in experience between the two groups. Inexplicably, no attempt was made prior to the experiment to determine if individuals assigned to the groups differed with respect to experience in the criterion task. Unfortunately, the group which did not receive the communications training was significantly more experienced than the experimental group.

Simons and Valverde[11] followed up on Simons'[12] earlier work and proposed a simple voice communications training program. They considered the task of verbalizing visual imagery as a critical FAC/TAC function. The criticality of this task in Army aerial observer performance was noted earlier by Whittenburg, et al.[13] Simons and Valverde describe a simple simulator/trainer which would provide visual/verbal experience to an FAC/TAC "team." This simulator presents identical scenes to both FAC and TAC players which differ in apparent altitude and occasionally in horizontal angle of regard. The images are on 35mm color slides which were shown to the subjects on back-projection screens. One observer (usually with the closer view) attempts to describe the

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[11] J. C. Simons and H. H. Valverde. *Voice Communications Training For Forward Air Controller/Strike Target Locators*, AFHRL(TR)-TRM-2, Advanced Systems Division, Wright-Patterson AFB, Ohio, January 1971.

[12] Simons, *op. cit.*

[13] J. A. Whittenburg, A. L. Schriber, J. D. Robinson, and P. B. Wordlie. *Research on Human Aerial Observation: Part I: Summary*, Research Memorandum, Human Resources Research Organization, Alexandria, Virginia, July 1960.

location, and thus "handoff" the target to the other observer. Preliminary assessment showed that the major portion of the time in a simulated strike mission was spent in verbalization of visual imagery. Experienced FACs could not discriminate between transcripts of communications obtained with the trainer and those obtained from actual combat missions. While observing individuals practicing on the simulator, Simons and Valverde proposed that certain skills may be important in determining effective target description. Briefly, these skills were seen to be:

- Accurate distance estimation.
- Ability to combine landmarks into a coherent description.
- A generalized ability to "decenter" perception and attend to the entire scene.

To the extent that target handoff as practiced by Army air elements resemble Air Force practice, possession of these skills may be important to an effective handoff between Army elements. A number of situational factors were also identified which served to define the difficulty of the handoff task:

- Observer's bearing from Aircraft (AC) location.
- Differences in altitude between observer and AC.
- Uniqueness of landmarks.
- Amount of scene structure.

In a followup effort, Valverde, Kearns, and Woods[14] formally evaluatedthe FAC/TAC trainer. The evaluation used a pretest, posttest

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[14] H. H. Valverde, N. H. Kearns, and W. J. Woods. *Evaluation of a Device to Train Forward Air Controllers to Communicate Target Location*, AFHRL-TR-72-12, Air Force Human Resources Laboratory, Air Force System Command, Wright-Patterson AFB, Ohio, May 1972.

two-group design with 17 subjects in an untrained group and 18 in a trained group. Transfer of training from the simulator to aircraft was assessed using eight subjects from each of the two groups. Unfortunately, this small number of subjects coupled with an inadequate plan for rating flight behavior contributed to a poor outcome. Valverde et al., realized these shortcomings, noting that the tested groups did not provide a sufficiently wide base for a realistic evaluation. They also noted that the performance rating instrument was sensitive only to gross differences in performance levels. USAF officers who had observed the FAC/TAC trainer in use were, however, sufficiently impressed with its usefulness to cause two duplicates to be built. One was sent to Eglin AFB, Florida, for use in training FACs. Unfortunately, no hard data were obtained showing that the use of these devices resulted in increased airstrike efficiency.

Laveson and DeVries[15] also looked at USAF FAC/TAC communications and decided that a lexicon of terrain descriptors based on natural language preference would be a significant contribution. The same combat tapes analyzed earlier by Morrissette[16] served as the starting point for this research. Laveson and DeVries' analysis showed that the *ineffective* slow missions had the following characteristics:

1. More information statements.
2. Lack of terrain feature lexical agreement.

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[15] J. L. Laveson and P. B. DeVries. *Forward Air Controller-Tactical Air Command Pilot Communications and Orientation*, McDonald-Douglas Astronautics Corporation-East, St. Louis, Missouri, August 1973.

[16] Morrissette, *op. cit.*

3. Inaccurate absolute distance estimates.

4. Use of clock headings in preference to compass headings.

Laveson and DeVries then set out to develop a structured lexicon of labels for terrain features and to determine if such a lexicon would be an effective aid in target location. The importance of developing a lexicon is supported by the general literature which shows the effectiveness of labels in such a usage.[17,18,19]

A group of experienced pilots was asked to view photos of 21 terrain features and give a name or label for each. This procedure generated 550 different labels. The photos were then grouped into six mutually exclusive categories by the judgment of the researchers. Subjects were given all pairs of photos within a category and asked to supply a single label for each one that would distinguish it from all others with which it was paired. The choice of this strategy may be disputed however as use of a single label may not be maximally effective.[20,21] Regardless, Laveson and DeVries performed a content analysis of the resulting unique labels which was then used to produce a lexicon of terrain descriptors. The resulting lexicon was then evaluated as to

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[17] C. W. Eriksen. "Location of Objects in a Visual Display as a Function of the Number of Dimensions on Which the Subjects Differ," *Journal of Experimental Psychology*, 1952, 44, 56-60.

[18] C. W. Eriksen. "Object Location in a Complex Perceptual Field," *Journal of Experimental Psychology*, 1953, 49, 126-132.

[19] P. A. Katz and E. Zigler. "Effects of Labels on Perceptual Transfer: Stimulus and Development Factors," *Journal of Experimental Psychology*, 1969, 80(1), 73-77.

[20] Eriksen, *op. cit.*, 1953.

[21] Eriksen found that targets which could be labeled according to several unique characteristics could be detected more effectively.

its effectiveness in improving the ability to locate target and terrain features. The results of the evaluation are unclear, as practice effects and individual differences in search strategies combined to swamp the effects of lexicon training. The possibility of combining a lexicon with training in search strategy was not explored. However, such a combination might prove effective in improving target location performance.

COMMUNICATIONS ANALYSIS METHODOLOGY

Because of the important role of voice communications in target description and location information, it is appropriate to examine some of the methodology of communications analysis. Chambers[22] considered methods for evaluation of speech communications with particular reference to high-speed, low-level strike aircraft. Chambers pointed out that even though mission planners and tacticians can conceive of elaborate attack systems, the inherent unreliability of the communications process will likely seriously degrade the probability of mission success. Chambers then proceeded to review the state-of-the-art in communications analysis and evaluation and concluded that most of the techniques are related to intelligibility, and are laborious and time consuming to apply. In the specific case of air-to-ground communications, Chambers recommended the Message Rate Efficiency Test (MRET). The MRET was developed by the British Telephone Administration and is described by Munson and Karlin.[23] The MRET was originally intended for

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[22] A. Chambers. *A Review of Tests for the Evaluation of Speech Communication With Particular Reference to High Speed Low Level Strike Aircraft*, Technical Memorandum ED-543, Royal Aircraft Establishment, May 1973.

[23] W. A. Munson and J. E. Karlin. "Isopreference Method for Evaluating Speech-Transmission Circuits," *Journal of the Acoustical Society of America*, June 1962, 34(6), 762-774.

use in measuring communications efficiency in two-way conversations in which the communicants seek to solve problems requiring an exchange of information. The communicants attempt to arrive at a solution by questions and answers in a minimum amount of time. The measure of message rate efficiency is the ratio of the average time to solve problems over the circuit to be evaluated to the time required when a high quality circuit is used. However, because the focus of this method is on hardware, it may not be of much use in studying the sort of problem posed by communications in target handoff. In addition, if enough time is spent communicating information about target location and the pilot has unlimited time to search, the probability that the target will eventually be located becomes nearly unity. The effectiveness of a real mission, however, is highly dependent on the expenditure of a minimum amount of time. A criterion for communications efficiency in this instance might be whether the target is identified within a time limit which is based on the maximum allowable for an effective mission.

A promising method of analyzing speech communications is described by Garvey and Baldwin[24] and Baldwin and Garvey.[25] This method was developed to analyze verbal interchange between two individuals mutually trying to solve a problem. Baldwin and Garvey term communications under such conditions as *convergent*. In a third effort, Baldwin and Garvey[26]

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[24]C. J. Garvey and T. L. Baldwin. "Structures in Convergent Communication. I. Analysis of Verbal Interaction," *JSAS Catalog of Selected Documents in Psychology*, Winter 1972, 2, 17, (MS 77).

[25]T. L. Baldwin and C. J. Garvey. "Studies in Convergent Communication: II: A Measure of Communication Accuracy," *JSAS Catalog of Selected Documents*, Winter 1972, 2, 18 (MS 78).

[26]T. L. Baldwin and C. J. Garvey. "Components of Accurate Problem-Solving Communications," *Journal of Educational Research*, Winter 1973, 10(1) 39-48.

reported considerable laboratory research which they describe as involving convergent communication. They define convergent communication as a communication in which two persons cooperatively exchange information in order to reach an explicitly defined goal. It was further specified that the two persons together have sufficient information to solve a given problem, but neither person is able to solve it alone. Therefore, a cooperation and convergence of information is necessary in order to reach a solution. Baldwin and Garvey further postulate a distinction between the functions of the two participants. One function is that of a *knower*, who is cognizant of the final form of the solution (e.g., the type and location of a target). The other function is that of a *doer*, who is aware of the problems which emerge in the course of the interaction and has the responsibility for executing the solution (e.g., firing at the target).

According to Baldwin and Garvey, there are five stages of problem solving under conditions of convergent communication:

1. Definition of the general problem.
2. Orientation of the doer to the knower's problem.
3. Identification of essential information.
4. Synthesis of the information and formulation of the solution.
5. Verification of the correctness of the solution.

Under this paradigm, success in reaching the common goal is largely determined by the ability of the individuals communicating to perform these cooperative components effectively.

The method of content analysis recommended by Baldwin and Garvey relies on trained judges and produces categories of content which are consistent across a variety of tasks. In addition, high inter-rater reliabilities are reported. This method appears to be very well suited to the sort of structured communication which must take place between air and ground. Analysis of target handoff messages using this technique may be quite revealing when *effective* and *ineffective* missions are compared.

Baldwin and Garvey's work was based, in part, on a review and synthesis of the literature by Mehrabian and Reed.[27] Mehrabian and Reed conceptualized communication accuracy as a dependent variable which is influenced by variation in five sets of factors. These factors are:

- Attributes of the communicator.
- Attributes of the addressee.
- Characteristics of the communication channel.
- Characteristics of the message.
- Characteristics of the referent (object being described).

According to these investigators, the important attributes of both addressee and communicator are:

- Level of cognitive development.
- Coding rules employed.
- Attitude toward referent.
- Rate of information processing.

Relevant channel characteristics are:

- Number of channels.
- Probability of modification in transmission.
- Availability of feedback.

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[27]A. Mehrabian and H. Reed. "Some Determinants of Communication Accuracy," *Psychological Bulletin*, 1968, 70, 365-381.

Relevant message factors include:

- Degree of simultaneous redundancy of communication.
- Degree to which a communication is defined independently of the situation or context in which it is presented.

Relevant attributes of referents are:

- Ambiguity.
- Complexity.

Consideration of these factors and their effects on communication accuracy led to the formulation of a number of hypotheses which will be valuable in guiding a study of communications in target handoff. In the case of any two individuals performing a handoff, there probably will be differences in the level of cognitive development of the participants. One typical index of cognitive development is age. However, differences in cognitive development are also apparent between adults of the same age. In adults, differences in the level of cognitive development appear as differences in personality, i.e., field-dependence/independence. According to research reviewed by Mehrabian and Reed, the accuracy of communication in a dyad appears fixed by the individual with the lowest level of cognitive development. The extent to which cognitive development could be modified to increase the probability of accurate communication is unknown. However, some encouragement is given by Brinkman[28] who reported success in developing instruction for enhancing perceptual discrimination. Mehrabian and Reed also quote limited data which show that communication accuracy was increased by the use of common coding rules by the two individuals communicating. They also note that coding rules, to be effective, must be well defined.

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[28] E. H. Brinkman. "Programmed Instruction as a Technique for Improving Spatial Visualization," *Journal of Applied Psychology*, 1966, 50, 197-184.

Johnson and Gross[29] came to a similar conclusion, stating that communication accuracy may be a function of the extent to which the communicators' tendencies to name and describe objects are similar. Unfortunately, it is likely that coding rules, attitudes and the rate of information processing will differ between any two unselected individuals, and therefore communication accuracy between them will be less than optimal.

On a more positive note, Mehrabian and Reed also hypothesized that communication accuracy could be increased by the degree to which the decoder could act to control the rate of information processing. Accuracy of communication may also be enhanced by structuring the message format to ensure serial and simultaneous redundancy. Additionally, if a message can be freed from a limiting context it is more likely to be perceived accurately, i.e., a message must contain enough generalizable elements to be understood on its own. Finally, Mehrabian and Reed hypothesized that communication accuracy decreases as the information content (or complexity) of a referent increases.

Each of the attributes or characteristics mentioned above suggests a hypothesis concerning communication in target handoff which could be readily tested in the laboratory. In fact, several of these notions were considered and formed the basis for hypotheses which were tested as part of the effort performed during the second year of the target handoff research. This body of information dealing with communication analysis was very useful in that it then provided considerable information for the future conduct of research in target handoff. The

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[29] R. L. Johnson and H. S. Gross. "Some Factors in Effective Communication," *Language and Speech*, 1968, 11, 259-263.

primary task then became one of finding out more about the conduct of the handoff task itself. Combat tapes were sought, but proved unavailable. Audio tapes were obtained of a test involving target handoff conducted recently at TCATA. However, the handoffs contained on these tapes were considered to lack combat realism and their overall technical quality was very poor.

It was clear then that some arrangement had to be made for observing the individuals performing a handoff task. Information based on these observations, coupled with the findings from the literature, should combine to form a solid basis for improving performance in handoff. The following chapter outlines the approach taken to obtain this needed information.

CHAPTER III

SIMULATION OF TARGET HANDOFF

As noted previously, the achievement of a detailed understanding of the target handoff task requires that the task be actively observed while it is being performed. Because of the great cost involved, it would not be feasible to stage a realistically simulated engagement with handoff. Additionally, it would not be possible to "stop" the action in such an engagement to question a particular action. Consequently, it was decided to develop a simple simulation which would allow access to the handoff task as it is being performed.

There are other reasons for developing simulation. Simulation provides an excellent environment for training personnel to function effectively in a system. Many of the variables in the learning environment may be controlled. In addition, the instructor has immediate access to the behavior under instruction and can provide adjustments in the experience and give feedback as required. Thus, the trainee can receive immediate knowledge of results without the detrimental effects of performing incorrect actions. Additional advantages of using simulation are:

a. Control over time. Simulation can be used to speed up the rate at which events unfold or slow them down. A rate can generally be selected which will be amenable for the particular methods of observation being used.

b. Precise control over situational and experimental factors. This advantage in control allows the experimental examination of factors which are important to the goal of an experiment without contamination from undesirable sources of variation.

c. Ability to repeat a situation a relatively unlimited number of times when it is desirable to do so.

d. Simplification of the complex environment within which the actions normally occur. Simulation will allow the isolation and extraction of only the most relevant variables for incorporation in the training.

It is intended that the observations made under simulated conditions transfer and apply to the real world. Since the ultimate goal of this research is to provide improved target handoff procedures that will be useful in combat, defining the conditions of transfer is very important. The degree of transfer appears to be directly related to *fidelity*, or the extent to which the simulation represents the real world situation.

The fidelity of simulation is composed of both physical and psychological dimensions. Physical fidelity refers to the extent to which the simulation represents the environment and equipment characteristics of the real situation. Conversely, psychological fidelity concerns the degree of similarity between the psychological demands of tasks in the simulation and in the real world. A number of researchers have concluded that psychological fidelity is more important for adequate transfer than physical fidelity.[1,2,3,4,5] In fact, there is some evi-

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[1] J. Cox, R. Wood, L. Boren, and H. Thorne. *Functional and Appearance Fidelity of Training Devices for Fixed-Procedure Tasks*, Technical Report 65-4, Human Resources Research Organization, Alexandria, Virginia, June 1965.

dence that too much physical similarity is possible and may lead to decreased transfer.[6] It is, however, possible to have fidelity in the simulation of psychological factors with limited simulation of physical factors. If successful, such a simulation would be very cost effective and it would allow close focus on the behavior under study while effectively excluding competing tasks. The actual tradeoff between cost and physical fidelity is affected by too many factors to allow the formulation of simple decision rules. The decision must be made on the basis of a systematic consideration of the behavior involved in the task at hand, and a careful appraisal of the resources required for a realistic level of physical fidelity.

A further aspect of simulation is that of abstraction. Harman[7] suggested that the varieties of simulation -- replication simulation, miniaturization, laboratory simulation, etc., could be ordered along a

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[2] D. L. Grimsley. *Acquisition, Retention, and Retraining: Effects of High and Low Fidelity in Training Devices*, Technical Report 69-1, Human Resources Research Organization, Alexandria, Virginia, February 1969.

[3] R. N. Isley. *Inflight Performance After Zero, Ten, or Twenty Hours of Synthetic Instrument Flight Training*, Professional Paper 23-68, Human Resources Research Organization, Alexandria, Virginia, June 1968.

[4] F. Muckler, J. Nygaard, L. O'Kelly, and A. Williams. *Psychological Variables in the Design of Flight Simulators for Training*, WADC Technical Report 56-369, Aeromedical Laboratory, Air Research and Development Command, Wright-Patterson AFB, Ohio, January 1959.

[5] W. W. Prophet and H. A. Boyd. *Device-Task Fidelity and Transfer of Training: Aircraft Cockpit Procedures Training*, Technical Report 70-10, Human Resources Research Organization, Alexandria, Virginia, July 1970.

[6] R. Ammons, C. Ammons, and R. Morgan. *Transfer of Training in a Simple Motor Skill Along the Speed Dimension*, WADC Technical Report 53-598, Wright Air Development Command, Wright-Patterson AFB, Ohio, 1954.

[7] H. Harman. *Simulation: A Survey*, System Development Corporation, Santa Monica, California, July 1961.

dimension of physical abstraction from the real world. One end of this continuum would be represented by a high-fidelity replication of the system and the other by a mathematical model. A good simulation would be designed at a level of abstraction which best represents the appropriate aspects of a system for cost-effective transfer of training. It was decided, therefore, in the waning days of the first year's contract effort to design a simple simulation which would be evaluated as a research tool in the study of target handoff.

The primary concern in the design of a target handoff simulator/trainer was the determination of the dimensions of the tasks to be trained. The literature cited in Chapter II of this report revealed some of the psychological aspects of target handoff. From this literature, it is apparent that the handoff task primarily consists of one individual verbalizing visual imagery to another. The purpose of the exchange is to solve a problem (locate a target) in the minimum amount of time. Each individual has only partial information to reach a solution. Initially, only the observer will know the target location and he must, by conveying a certain quantity of information, direct the AH pilot to it. The solution in the case of target handoff is the location and successful engagement of the target by an AH.

Therefore, the simulation must present visual stimuli to a pair of players, one of whom will act as the observer and the other as an AH pilot. The imagery presented to each player must duplicate as much as possible the view as it would be in real life. Differences in altitude, range, and angle must be incorporated into the images as appropriate. Whether or not the imagery presented to the individual playing the role of AH pilot should reflect the motion of the aircraft cannot be addressed at this point. A study which would compare both still and motion picture imagery of comparable target areas would be necessary to answer this question. It is clear, though, that motion picture imagery would be more expensive to obtain and project. An intermediate solution would be to use a series of still photographs taken from an aircraft as it moved toward the target location. Thus, the player in the pilot position would receive "updates" of the scene which might realistically relate to glimpses of the terrain seen by an AH "popping up" for orientation as it approaches a target area.

However, upon careful consideration, it seems that most of the basic aspects of the target handoff task can be contained in a minimum set of static imagery. As an example, two photographs of the same area with a target which differ only in camera position should provide the basic stimuli for a simulation of target handoff. Neither individual would be allowed to see the other's imagery, and some means of voice communication should be provided. Given a few rules and instructions, the players would then begin, one helping the other find the target. Intuitively, it appears that this simple-minded situation contains the essential elements of target handoff. A similar conclusion was reached by Simons and Valverde[8] in the USAF FAC/TAC target handoff research discussed earlier.

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[8] J. C. Simons and H. H. Valverde. *Voice Communications Training For Air Controller/Strike Target Locators*, AFHRL(TR)-TRM-2, Advanced Systems Division, Wright-Patterson AFB, Ohio, January 1971.

PILOT STUDIES

Initial research was aimed at evaluating a simple static simulation with regard to its general suitability as a vehicle with which to further study target handoff. The equipment used for this pilot work was minimal -- a pair of 15 x 20" 3M "polacoat" back-projection screens, a pair of 35mm slide projectors, a set of Army field telephones to tie the players and the experimenter together, and a tape recorder to acquire and store the players' interchanges. This equipment was felt to be adequate for initial small pilot investigations. The screen and projector furnish each player with bright, sharp imagery while the phones provide a convenient means to communicate. In addition, the experimenter can monitor the players' communication as he observes their actions.

The imagery required for the simulation should present views to the players which would differ realistically in perspective. The ideal method to obtain this imagery would be to take pictures from an aircraft of an area containing a target, while varying range, altitude and heading. This method would require detailed study of maps to select an area of terrain, followed by a fly-over to verify the nature of the terrain. Then a target(s) would be emplaced and photographs of the target area taken at several points along several preplanned flight paths.

Unfortunately, it proved impossible to secure the required logistical support due to limitations on the use of fuel. Therefore, a substitute had to be found. A search revealed the existence of a possibly usable set of 35mm Ektachrome transparencies at the HumRRO Central Division in Pensacola, Florida. These transparencies were the basis of a set of training materials developed for low-altitude aerial observation and consist of view of terrain and target objects taken from a variety of altitudes and angles of view. The set at Pensacola was composed of approximately 5000 slides. A staff member was assigned to sort through the set and select those slides which seemed most useful for a study of target handoff. The slides selected (107) can be separated into two broad categories. The first set of six slides features military targets: a 105mm howitzer, low clutter; a 105mm howitzer, high clutter; a caliber .50 machinegun, high clutter; a 106mm recoilless rifle, high clutter; and an M48 tank, high clutter. Determination of the degree of clutter was by the subjective judgment of the researchers who originally compiled the entire set of transparencies. The second set of six slides consists of transparencies of differing terrain. Each piece of terrain was photographed from different angles and elevations. No military targets are present in these transparencies, but each shows a number of features, i.e., vehicles, buildings, etc., that could be arbitrarily designated as targets. The terrain in these photographs is rolling, moderately hilly, with deciduous forest. Streams are present as well as numerous cultural features, e.g., roads, bridges, train tracks, buildings, etc. Some of the transparencies were taken from a low elevation and could be employed to simulate the view ground observers would see from a moderately high vantage point.

Unfortunately, on closer inspection, the transparencies apparently vary greatly in density and color fidelity. In addition, since the transparencies are some 16-18 years old, time, in the form of scratches and smudges, has taken its toll. Thus, while these transparencies were useful for pilot studies, it was seen as important to obtain new stimulus materials for further work. The objective of the initial pilot study was to estimate the usefulness of the simple static simulation as a research vehicle in the study of target handoff. Four pairs of technically adequate transparencies were selected for this first study. The pairs of transparencies were presented in an approximate order of increasing difficulty.

The pilot study began on 26 April 1976 after having experienced several delays occasioned by difficulties in obtaining equipment, space, and subjects. A questionnaire previously circulated around HQ, TCATA served to identify individuals with target handoff experience. As a result, contact was made with a number of individuals who had reported considerable combat experience in target handoff. After considerable difficulty, a small pool of volunteer subjects was obtained and a schedule arranged to run them in pairs on the simulation.

As the subjects arrived they were briefed as to the objective of the study and details of its conduct. The roles of observer and pilot were then assigned randomly to the members of the pair. The pair was then seated, instructed in the communications protocol to be used, and after all questions were answered, they proceeded through the four pairs of transparencies "handing off" targets. The criterion of performance was time to detection for each pair of slides.

The experimenter was required to simultaneously cycle the slide projectors, turn on the tape recorder and begin timing. A common pocket stopwatch was used for this work as no other alternative was available.

The pilot study was terminated after seven pairs of subjects had been run. Difficulties with scheduling subjects, coupled with a growing appreciation of the inadequacy of the equipment caused the experimenter to cancel further study. Failure of the recording equipment prevented the preparation of usable transcripts of the simulated handoffs, while use of the stopwatch prevented accurate timing of performance. However, the experiment was valuable in that it pinpointed needed areas of improvement in the simulation equipment, i.e., better timing gear, reliable voice recording equipment, and clearer, more appropriate imagery.

The pilot study generally achieved its goals, in addition, the experimenter was able to observe 28 simulated handoffs. These observations led to the formulation of several hypotheses which could be fruitfully examined by future research. These hypotheses will be dealt with in depth in the following chapter. It was also apparent that considerable individual differences in the ability to perform handoff existed, and that much more data would be required before answers to the many questions surrounding the handoff problem could be answered.

CHAPTER IV

DESCRIPTION OF THE STUDY

As the shortcomings of the "first generation" target handoff simulator became apparent, plans were made to remedy the situation. First priority was given to improving the simulator hardware. Specifically, this meant providing a means of accurately timing the duration of the handoff as well as acquiring a capability of reliably recording the verbal interchange between the players.

Extensive inquiry revealed that HQ, TCATA did not possess any equipment that could meet the desired timing and recording requirements. An inquiry to ARI-Arlington did, however, result in the acquisition of a usable electric stopclock. Accurate timing of a handoff requires that the experimenter be able to start the stopclock simultaneously with the presentation of the visual stimuli to the players. This important experimental control could be optimally achieved by a relay box which, with a single switch action by the experimenter, would cycle the slide projectors and start the stopclock. Similarly, the relay box must allow the pilot player to press a switch when the target was acquired. This action would stop the clock, but not cycle the slide projectors. Thus, the stopclock would reflect time elapsed between presentation of the stimuli and location of the target. The HumRRO project staff at Fort Hood did not have the equipment or the experience to build the required relay box, nor did such a capability exist at either the ARI Field Unit or TCATA. Accordingly, it was decided to "farm out" the construction of the relay box to the HumRRO Field Unit/Fort Bliss, which at that time possessed the shop and engineering capability necessary to produce the desired equipment.

Acquisition of the needed voice communication and recording equipment locally proved to be impossible. However, a staff member unearthed most of the equipment desired in the inventory of the HumRRO unit at Fort Bliss. A trip was required to bring the equipment to Fort Hood. Briefly, the equipment consisted of:

- An Ampex F44 four channel reel-to-reel tape recorder with playback amplifier and monitoring capabilities.
- A pair of Altec condenser microphones.
- A four channel mixer.
- Headsets.

This equipment, supplemented by other items purchased locally, linked the two players together with a voice circuit and also provided the experimenter with a means of listening and speaking to the players.

The next order of business was the acquisition of suitable imagery for the simulation. After staff consultation, several methods were identified to obtain the required imagery. In the ideal case with the cooperation of Army units, target vehicles would be emplaced at predetermined sites and photos would then be taken from various preplanned aspects. However, the required resources and cooperation were not forthcoming, and the other alternatives were explored.

A second possibility involved photographing scale model threat vehicles emplaced either on a terrain board, or on a suitable piece of ground. This option was explored using both still and motion picture cameras and available "HO" scale models. When the results were viewed, it was judged that the shallow depth of field resulting from the small camera-to-subject distance rendered the resulting images unsuitable. In addition, the 16mm motion picture image as projected on the rear projection screen was judged as too "grainy" and generally lacking in resolution to be usable.

In an effort to explore yet another method, arrangements were made with an Army aviator assigned to TCATA to accompany him on a flight required to maintain his helicopter qualification. It was intended to overfly training areas on Fort Hood and seek out targets of opportunity and photograph them from tactically realistic positions. During a four-hour flight, some 180 35mm frames were exposed. These proved technically adequate when viewed later; however, the great majority of the targets were judged as being too difficult (too well hidden) or too easy (not concealed) to serve the needs of the simulation.

Faced with the pressures of time, yet another attempt was made to acquire the needed imagery. This effort involved the use of suitable terrain elevations (i.e., hills, ridges) to provide the aerial view required. "Targets of opportunity" would then be photographed from the vantage point of the hill or ridge, with an effort being made to vary the perspective between views. Staff members identified candidate areas from study of maps of the Fort Hood area, then made a reconnaissance trip to each area. Following site selection, additional trips were made to each of the sites as weather permitted, and some 200 35mm frames exposed. This effort produced a number of transparency pairs that were judged suitable for the simulation.

Six pairs of usable transparencies were selected from the totality of this effort. The six pairs of slides may be placed into two broad categories -- "area" and "target." In the area category, the task is to locate a particular terrain feature -- no military target is visible.

In the slides falling into the target catagory, a potential military target is visible. These categories were chosen to broadly represent the types of target likely to be encountered in the field during actual combat. In addition, on the basis of observations made during pilot work, the pilot's search task would likely differ as a function of the presence of a "real" military target. Table IV-1 describes the six pairs of targets in the order they were presented.

Table IV-1

Slide Description

Slide Pair No.	Type	Description
1	Area	Target is tree stand in an overall view of farm land.
2	Target	Convoy off road.
3	Target	Field piece in tree line.
4	Area	House at intersection of road.
5	Target	Truck mounted shelter in woods.
6	Area	Distant hilltop.

Each of the pairs described in the table contained one slide with the target or area marked with an inked circle. This slide was presented to the "observer" player who was also given a list describing the target or area on each slide. The "pilot" player's slide presented a view of the same terrain, but from a different perspective. The differences in perspective were due to differences in apparent range, viewing elevation, or heading. Unfortunately, due to a lack of adequate instrumentation, these specifications cannot be accurately given for each slide pair.

DESIGN OF THE EXPERIMENT

As noted previously, during the first year's activity, the experimenter was able to observe subjects performing a number of simulated handoffs using the first generation handoff simulator. During the course of these trials, a hypothesis was formed concerning the kinds of aptitudes and abilities each player required. In the effective (rapid) handoff, the observer player began with a brief, succinct target description (describing the distinctive visual aspects of the target) to the pilot player. Effective performance by the pilot player, on the other hand, was seen to depend on his ability to seek out and evaluate potential target candidates and then use the information from the observer to confirm his conclusions. Therefore, it seemed reasonable to hypothesize that while verbal skill might be important to the scout or observer, the pilot seemed to rely on perceptual/cognitive abilities to pick out and evaluate candidate targets. Further, the verbal abilities required of the "successful" observer were seen as involving a production of effective verbal information rather than passive verbal comprehension. The pilot, however, must be able to select candidate targets from a complex field, appreciate the spatial relationships between objects, and be able to imagine the shape of objects as viewed from different orientations.

Therefore, an attempt to test this hypothesis concerning the effects of ability mix on target handoff performance was designed as part of the effort aimed at gaining baseline information on handoff. Under the strategy envisioned, a large group of individuals would be given a battery of measures of verbal production and perceptual/cognitive ability followed by a period of practice on the simulator. The research design then was necessarily non-experimental and post-facto. This approach was dictated by the usual exigencies of field research which combine in this instance to preclude the use of an experimental design where subjects would be assigned to groups on the basis of ability level and then assigned randomly to some experimental treatment.

Under this non-experimental paradigm, appropriate correlational statistics would be used to determine the aptitude mix characteristic of pairs of individuals who perform successfully on the handoff simulator.

TEST SELECTION

As a first step, a search was made for usable tests of verbal behavior and spatial/perceptual ability. Standard sources such as Buros[1] and Conrey, Blacker, and Glaser,[2] were consulted and a list of candidate tests was compiled. This list was supplemented by a brief survey of related literature, which served to identify "research" instruments that might be useful. Therefore, the final list of test contained both published and unpublished instruments. Contacts were established wherever possible with the sources for these tests and

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[1]O. L. Buros. *The Seventh Mental Measurements Yearbook*, Highland Park, New Jersey: Gryphon Press, 1972.

[2]A. L. Conrey, T. E. Blacker, and E. M. Glaser. *A Sourcebook for Mental Health Measures*, Human Interaction Research Institute, Los Angeles, California, 1973.

statistical data bearing on questions of reliability and validity were solicited. Finally, the list of tests were narrowed down to the six paper-and-pencil instruments given in Table IV-2. Each of these six instruments will be described in turn below.

Table IV-2

Tests and Their Sources

Test	Source
• Word Fluency	Sheridan Supply
• Associational Fluency	Sheridan Supply
• Ideational Fluency	Sheridan Supply
• Hidden Figures	Educational Testing Service
• Spatial Orientation	Sheridan Supply
• Spatial Visualization	Sheridan Supply

Word Fluency. As defined by its developers, word fluency is the ability to rapidly produce a list of words, each of which must contain a given letter of the alphabet. In the Structures of Intellect (SI) model, the underlying factor is called *divergent production of symbolic units*. There is a substantial body of evidence for the existence of this ability which is best summarized by Guilford and Hoepfner.[3]

Associational Fluency is a test of the ability to rapidly produce words that bear a specified relation to a given word (similarity of meaning). In the SI model the underlying factor is called *divergent production of semantic relations*. Considerable support has been as-

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[3] J. P. Guilford and R. Hoepfner. *The Analysis of Intelligence*, New York: McGraw-Hill, 1971.

sembled for the existence of this factor and is summarized by Guilford and Hoepfner.[4]

Ideational Fluency. This test is designed to measure the ability to evoke a large number of ideas in a standardized situation. Specifically, the test requires the examinee to produce (name) things that belong in a particular class. In the SI model the ability is called *divergent production of semantic units*. Research into the existence of this factor is fairly conclusive and is summarized in Guilford and Hoepfner.[5]

All three of these fluency measures involve the generation of stored information, but in response to cues which differ from those they were connected with in learning. All three tests are of the open-ended or completion type. The examinee must write his responses in a booklet. This open-ended feature, however, is not a positive attribute when scoring the tests; considerable time and judgment is required. Norms are presented by the publisher together with other statistical information. Alternate form reliability estimates for word fluency range from .67 to .75; for ideational fluency from .68 to .77; and for associational fluency from .57 to .63. These reliabilities are not high in the absolute sense and it may be necessary in the current work to collapse the three test scores into a common "fluency" score. If supported by obtained relationships between the tests, this action will serve to considerably enhance the effective reliability of measurement.

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[4] *Ibid.*

[5] *Ibid.*

Hidden Figures Test. This test is an adaptation of the Gottschaldt Figures Test popularized by Thurstone. The examinee's task is to decide which of five geometric figures is hidden in a complex pattern. This test is very difficult, but was chosen from among similar tests on the basis that a wide range of this ability was likely to be encountered in the population of subjects to be sampled for this research. The form used was developed by the Educational Testing Service (ETS) in connection with a project designed to study field independence.[6] The underlying factor is identified as *flexibility of closure*,[7] which is the ability to keep one or more definite configurations in mind and to identify it in the face of perceptual dislocation. Flexibility of closure is believed to be related to field independency -- a dimension identified by Witkin[8] and Witkin, et al.[9] This ability may also have potential as a measure of cognitive complexity or level of cognitive development. Previous unpublished research by the senior author revealed the ETS Hidden Figures Test to have an odd-even reliability of .97. Reliability of homogeneity was .986, indicating the existence of a single underlying factor. This data was based on 137 Air Force enlisted trainees.

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[6] Educational Testing Service (NIMH, Contract M-4186).

[7] J. W. French, R. B. Edstrom, and C. H. Price. *Manual for Kit of Reference Tests for Cognitive Factors* (revised 1963), Educational Testing Service, Princeton, New Jersey, June 1963.

[8] H. A. Witkin. "The Perception of the Upright," *Scientific American*, 1959, 200, 50-56.

[9] H. A. Witkin, et al. *Psychological Differentiation*, New York: Wiley, 1962.

Spatial Orientation. This test is Part V of the Guilford-Zimmerman Aptitude Survey, and was designed to measure the ability to appreciate spatial relations of things with reference to the body of the observer. Guilford[10] found this ability to be an important determiner of success in pilot training. Extensive statistics have been compiled concerning this test. Obtained alternate form reliability estimates quoted by the publishers range from .89 for a large sample of college males to .88 for a large sample of college women.

Spatial Visualization. This test is Part VI of the Guilford-Zimmerman Aptitude Survey. The factor underlying this test is described as involving the process of imagining the movement or transformation of visual objects. The factor is also measured by various paper-folding tests (e.g., Stanford-Binet, Minnesota Paper Form Board). Some researchers feel that spatial visualization and spatial orientation are two measures of a common Spatial (S) factor. However, the publishers of the Guilford-Zimmerman Aptitude Survey elected to administer and score them separately. They quote factor analytic data as the rationale for this decision. Alternate form reliabilities are stated by the publishers to be .94 and .93 for men and women, respectively.

In addition to the tests, limited personal history information was solicited from each individual before the testing session. Appendix A contains an example of this simple one-page questionnaire. It is intended to use this personal history primarily for the description of the sample of subjects. However, selected measures will be incorporated in

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[10] J. P. Guilford (ed.). *Printed Classification Tests*, Army Air Force Aviation Psychology Research Program Reports, No. 5, Washington, D.C., US Government Printing Office, 1947.

the analysis of determiners of success at target handoff, e.g., MOS or current job, together with other measures, such as experience, wherever appropriate. The research staff felt it was important to limit the number of variables analyzed to those which would either fit the model of performance under test, (i.e., the role of differential abilities) or those that might be useful in identifying subgroups within the sample of subjects. It was thereby intended to maintain parsimony in the number of predictor variables and also to avoid "muddying" the clarity of the proposed model of success. It was felt that any increase in prediction gained by "dumping in" all obtainable information into the analysis would be overwhelmed by the unavoidable obfuscation of the basic determinants of success. Many personal history factors are multi-dimensional in nature and while they may yield good correlations with criteria, their unknown but complex structures may preclude an understanding of why the relationship exists. In recognition of this likelihood, every effort was made to keep the number of variables under analysis to a minimum.

PROCEDURE

Subjects were obtained from the 6th ACCB [6th U.S. Cavalry (Air Combat)] at Fort Hood, Texas. It was requested that the subjects were to be as heterogeneous as possible to allow the sampling of a diversity of performance and aptitude. The study was carried out using facilities furnished by the 6th ACCB in an effort to minimize subject transport problems. The study was run from 3 December 1976 to 1 March 1977.

Even numbers of subjects were requested for each session and this generally proved to be the case. This request reflected the need to run the subjects as pairs on the simulator. As soon as the subject group was assembled, they were seated around a table and briefed concerning the objectives and nature of the study. It was emphasized that all data collected would be accorded the strictest privacy. Subjects were also assured that information gathered during the study would not become part of their personnel records. After questions concerning the study and its objectives were answered, testing began with the handing out of a brief personal history blank (see Appendix A). Following this, the tests were administered in a fixed order as follows:

- Hidden Figures
- Ideational Fluency
- Word Fluency
- Associational Fluency
- Spatial Visualization
- Spatial Orientation

The tests were administered with the test publishers' instructions used verbatim. Questions were answered as appropriate and the test publishers' guidance as to testing procedure was followed closely. The testing phase took approximately two hours to complete following which, the subjects were taken two at a time into an adjoining room which housed the simulator.

Each pair of subjects was then briefed on the intent of the simulator study and the procedures which would be used. Subjects were then seated and directed to read the detailed instructions provided at each position. (See Appendix B for these instructions.) Assignment of the subjects to pilot or observer position was done in a quasi random fashion. After the subjects had read their detailed instructions, questions were answered and additional reinforcement was given to adherence to critical aspects of procedure, i.e., use of callsign and signal button. The subjects were then instructed in the proper use and placement of the microphones. The experimenter then adjusted the tape deck recording level controls to prevent saturation of the tape and subsequent distortion of the signal. The headsets provided were not used. The close proximity of the subjects in this instance would cause "feedback" problems which would manifest itself as an unendurable "howl" in the headset. However, as the subjects were quite close (3-4 feet), it was felt if they spoke at an ordinary conversational level, they could hear each other. In practice, this proved satisfactory. The six handoffs were then performed without interruption. Following the completion of the handoffs, each pair of subjects was asked if they would like to stand back and examine the pairs of slides which served as stimuli for the handoffs. All subjects requested this opportunity and lively discussion usually accompanied the viewing of the pairs of slides. The pair was then thanked for their participation and excused.

CHAPTER V

RESULTS

Part I: Analysis of Tests and Performance Data*

Method

The personal history data, test results, and performance data were first coded on IBM general purpose data coding forms. A sequential numeric code was used to identify each individual. Names or SSANs were not used or coded in an effort to safeguard the anonymity of each subject. The data were then transferred to standard 80 column computer cards. Cardpunch was done by Automatic Data Processing (ADP) personnel at HQ, TCATA. The bulk of the analyses reported in this section was accomplished at ARI, Arlington, Virginia, between 15 March and 21 March 1977. The facilities used were a CDC 3300 located at Arlington and a Univac 1108 located at Edgewood Arsenal and accessed through a time-shared facility at Arlington. The majority of this work was done using the Univac 1108 and its Statistical Package for the Social Sciences (SPSS) programs.

Description of the Sample

Data were obtained on 116 individuals, all male personnel from the 6th ACCB, Fort Hood, Texas. Of these, 92 (75%) were aviators. Eighty (87%) of these individuals were warrant officers. The remaining 12 (13%) aviators were all officers (ten captains and two 1st lieutenants). Of the non-aviators, all were enlisted with the exception of one captain. The group of subjects reported a mean of 7.052 years of service

*NOTE: Readers who are not interested in the intimate details of the analysis or are unsophisticated in statistical procedures are advised to go to Chapter VI.

and a mean age of 26.83. The group also averaged 2.75 years in their present jobs. Fourteen (12%) individuals in the group reported having only a GED certificate or a high school diploma, while 74 (63%) reported some college. Twenty-eight (24%) of the group reported that they were college graduates. When questioned about handoff experience, most subjects reported difficulty in arriving at a reliable estimate. Therefore, the experience variable was collapsed into the categories of "some" and "none." Seventy-eight (67%) of the group reported some experience in handing off targets, while 15 (13%) had no experience. Twenty-three (20%) individuals did not respond to this item. The data for these individuals was not included in analyses of experience.

Test Scores

Means and standard deviations for the six instruments used are given in Table V-1.

Table V-1

Means and Standard Deviations for the Six Tests

Test	Correction Factor	$\bar{x}$	σ	N
Hidden Figures	R - W/4	11.56	6.00	113
Word Fluency	None	42.93	34.00	116
Associational Fluency	None	16.25	17.00	116
Ideational Fluency	None	60.69	59.00	116
Spatial Orientation	R - W/4	29.05	27.50	114
Spatial Visualization	R - W/4	21.00	16.25	116

Correction factors for guessing were calculated as recommended by the test publishers. This operation was carried out as a preliminary step by the computer before summary statistics were calculated.

No norm exists for the Hidden Figures Test; however, the mean scores obtained are slightly higher than those noted by the senior author for a sample of Air Force enlisted men. This difference is to be expected as the Army sample in the present study is generally older and more highly educated than the Air Force sample.

The scores obtained by the sample on the Word Fluency Test can be compared to norms furnished by the test publishers. The normative group consisted of a sample of Naval air cadets and Naval officer candidates. The typical member of this sample was a high school graduate with some college, and a general educational level substantially above the average. When compared to this group, the mean score for the Army sample fell into the 23-39 centile range in the table of norms.

In contrast to this rather poor showing, the mean score for Associational Fluency, when compared to the same normative group, fell into the 89-95 centile range. Similarly, the Ideational Fluency mean score fell into the 77-88 centile range. Thus, the general picture presented by the fluency tests is mixed with above average verbal production performance, coupled with an apparent deficiency in the ability to produce a large number of words containing a specific letters. This indicates a difficulty in appreciating similarity in the structure or symbolic aspect of words.

The mean Spatial Orientation score for the group compares favorably to a mean of 20.51 reported by the test publishers as being obtained from a large sample of college men. However, the obtained mean score for Spatial Visualization does not compare so favorably with a mean of 27.93 attained from the same college sample. According to data summarized by the publisher, a sample composed of successful aviators *should* yield scores above the norm on both orientation tests.[1] However, it is not clear how this deficiency in spatial visualization ability may manifest itself in performance.

Performance Scores

Times to the nearest second were obtained for each of the six simulated handoffs. These data are shown in Table V-2.

Table V-2

Times for the Handoffs

Handoff	1	2	3	4	5	6
$\bar{x}$	151.87	34.93	63.88	59.58	79.25	66.36
σ	71.54	12.28	65.25	44.51	110.47	69.95
N	101.00	102.00	105.00	104.00	105.00	103.00

As the experiment was being designed, it was hypothesized that handoff situations which differed as to the actual presence or absence of a military target would present different problems to the handoff team. Table V-3 presents the intercorrelations of the six pairs of slides used as stimuli in the handoffs. The picture of relationships presented by this table does not entirely support the existence of a

[1] J. P. Guilford and W. S. Zimmerman. *Guilford-Zimmerman Aptitude Survey. A Manual of Instruction and Interpretations* (2nd ed.), Sheridan Supply Company, Orange, California, 1956.

sharp distinction between sets of "area" (1, 4, and 6) and "target" (2, 3, and 5) slides. In fact, it is likely that a very large set of targets or area scenes would have to be examined before any existing commonality would become apparent. This effort may, in fact, have to be undertaken to establish a unique set of target labels. The pattern of intercorrelation does, however, indicate that there are slightly higher

Table V-3

Correlations Between Times for the Six Slides

N = 96

Slide No.	1	2	3	4	5	6
1	1.000					
2	.265	1.000				
3	.172	.261	1.000			
4	.546	.240	.409	1.000		
5	.278	.130	.426	.199	1.000	
6	.070	.025	.293	.228	.153	1.000

relationships among members of these "sets" than between those which are not members. Therefore, it was decided to keep the a priori dichotomy of area and military targets and sum the sets to derive two time scores. The sums were derived as follows: TS (Target Score) = Σ handoffs 2, 3, 5; AS (Area Score) = Σ handoffs 1, 4, 6. The resultant AS had a mean of 276.01 and a standard deviation of 131.12. The TS had a mean of 178.95 and a standard deviation of 156.67. A correlated measures t test was performed to determine if the mean differences obtained between the two sets of stimuli differed significantly from zero. This analysis yielded a t of 5.74 with 96 degrees of freedom. A t of this magnitude is significant at beyond the .001 level. Thus, it can be assumed that the two sets of slides differ with respect to the time required to successfully handoff the target.

Computation of Factor Scores

In an effort to limit the number of independent variables, a factor analysis was performed on the six test scores. A principle factors solution with varimax rotation was chosen for this purpose. In computing this solution, the main diagonal elements of the correlation matrix are replaced with communality estimates. Communalities are initially estimated by the squared multiple correlation between a given variable and the remaining variables in the matrix. An iterative process is then used in which new communalities are computed after each successive factor extraction and compared to the initial estimates. The process is continued until the differences between two successive communality estimates are negligible.

Table V-4

Correlations Between the Six Tests

Test	HF	WF	AF	IF	SO	SV
HF	1.000					
WF	.126	1.000				
AF	.139	.522	1.000			
IF	.205	.441	.480	1.000		
SO	.459	.200	.201	.170	1.000	
SV	.420	.196	.192	.319	.661	1.000

As a first step, product moment correlations were computed. The resultant correlations between the six tests are given in Table V-4. With an n of 111 for each correlation, a value which exceeds .195 is significant beyond the .05 level. However, a correlation of this magnitude, although statistically significant, is of little practical value as it explains only about four percent of the obtained variance.

This correlation matrix was then subjected to factor analysis. Two factors were obtained from the analysis and are presented in Table V-5. Examination of this factor matrix reveals that Factor I is composed primarily of the three perceptual tests. Accordingly, this factor has been named "Spatial." Factor II, however, is composed largely of the three verbal fluency tests and was named "Fluency." Based on the titles of the tests employed, this result was certainly not unexpected.

Table V-5

Rotated Factor Matrix For the Six Tests

Test	Factor I	Factor II	h^2
HF	.536	.119	.301
WF	.113	.680	.476
AF	.104	.743	.562
IF	.198	.622	.425
SO	.812	.200	.673
SV	.785	.182	.649

These data were then used to calculate factor score coefficents, which were then applied to the standardized test scores for each individual, yielding two composite factor scores for each subject. Thus, the desired reduction in the number of independent variables was obtained without loss of information and with a probable increase in reliability. These factor scores were used as independent variables in the next step of analysis.

Discriminant Analysis

The goal of this phase of the research was to describe the "mix" of ability which defined an effective target handoff team. To reach this goal, discriminant analyses were performed separately for the pilot players and observer players. As used in psychology, discriminant analysis is used to classify people into one or more mutually exclusive and exhaustive categories, by their scores on a set of independent variables, i.e., a battery of personality tests could be used to classify smokers or non-smokers with the aim of determining if smokers/non-smokers differed in personality. In the present work, the independent variables were: the spatial factor scores, the fluency factor scores, experience in handoff, and job (see Table V-6). The experience and job factors were added to allow some estimate of the relative contributions of

Table V-6

Independent Variables in the Discriminant Function Analysis

Variable Number	Name	Code	Description
1	Experience	XPR	Prior experience in target handoff
2	Job	JOB	Aviator or other
3	Spatial Factor	SF	Spatial factor score
4	Verbal Fluency Factor	VFF	Verbal fluency factor score

relevant experience. Four categories were identified for these analyses: effective/ineffective on area targets, and effective/ineffective on military targets. The effective/ineffective dichotomy was determined by splitting the sample at the median of the time distribution for each time score (AS and TS). Thus, each subject would be assigned to either the effective category or the ineffective category depending on the performance of the team of which he was a member. A discriminant analysis is termed successful if the independent variables correctly predict category membership. If the hypothesis of the differential effects of ability was correct, a significant classification would be obtained for both pilot and observer players, with spatial factors playing a large role in pilot classification and verbal fluency factors determining performance of the observer players. It can be further hypothesized that verbal factors will be even more heavily involved in predicting the performance of observers in handing off the more difficult area targets.

Table V-7 gives some of the initial output from SPSS subprogram "discriminant." A direct solution was specified in which all of the independent variables are entered into the analysis concurrently. The discriminant functions are then created directly from the entire set of independent variables, regardless of the discriminating power of each.

The direct solution was considered appropriate because the senior author had predicted an outcome concerning the relative importance of spatial and fluency factors as determiners of performance for the two positions.

The SPSS *discriminant* subprogram provides two measures for judging the importance of the obtained discriminant functions. One of these is

Table V-7

Discriminant Function Analysis of Time Data by Position and Target Type

Target Type*	Position**	R_c***	Wilks' Λ	χ^2	df	p
T	O	.418	.826	7.091	4	.131
T	P	.145	.979	.833	4	.934
A	O	.403	.838	6.370	4	.173
A	P	.387	.851	5.990	4	.200

*A = Area Target
T = Military Target
**P = Pilot Player
O = Observer Player
***R_c = Canonical Correlation

the canonical correlation (R_c) associated with each discriminant function. R_c is an index of association between each discriminant function and the set of variables defining category membership (fast or slow for each of the two target types). Just as with the Pearson product moment coefficient, we can interpret R^2_c as the proportion of variance in the discriminant function explained by the category. The obtained canonical correlations in Table V-7 are small, the largest accounting for about 18 percent of the variance in its associated discriminant function.

A second criteria for judging the importance of a discriminant function is Wilks' Lambda (Λ). Lambda is an *inverse* measure of the discriminating power remaining after a function has been extracted. The larger the Lambda is, the less information remaining. Each Lambda is presented with its associated chi-square (χ^2) value. In the instance of the first discriminant function, the Wilks' Lambda was .826, corresponding to a χ^2 of 7.091 with an associated probability level of .131. A

Lambda of this magnitude or smaller has a .131 probability of occurring due to sampling error. Thus, the overall picture presented by the data contained in Table V-7 is one of a low degree of separation for all four discriminant functions. This indicates that the independent variables selected were ineffective in predicting performance for the two types of targets.

Table V-8 gives the standardized discriminant function coefficients for all four analyses. Each coefficient represents the relative contribution of its associated variable to that function, sign indicates a positive or negative contribution.

Table V-8

Discriminant Function Coefficient Analysis

	Category*			
Variable	TO	TP	AO	AP
XPR	-.063	-.556	-.291	.605
JOB	-.725	1.126	.223	.100
SF	-.343	.517	.344	.452
VFF	.863	-.149	.800	.368

*TO = Target scores, Observer players
TP = Target scores, Pilot players
AO = Area scores, Observer players
AP = Area scores, Pilot players

The contribution of the four discriminant variables can be judged from this data. The function derived for TO (observer player and military targets) clearly indicates that job and verbal fluency are important. The factor involved in the AO analysis appears to be based mainly on verbal factors, indicating that these factors are important in determining observer performance, while experience is important when pilots attempt to find an area target. Tables V-9 through V-12 present the frequencies for the JOB and XPR variables for both player positions and both types of targets. Examination of these tables may help in clarifying the meaning of the obtained discriminant coefficients. As an example, Table V-9 presents the frequency counts for the Job and XPR variables for both the successful and unsuccessful observer players in handing off military targets. It can be seen that there is very little difference between the "successful" and "unsuccessful" groups in the number of individuals reporting experience in handoff (17 vs. 19). As regards the Job variable, twenty-one of the unsuccessful group were pilots as contrasted with only 16 of the successful group. Therefore, for the TO category, the discriminant coefficient (Table V-8) associated with Job (-.725) is larger than that for Experience (-.063). The high negative loading for Job indicates that pilots functioning as observers handing off military targets performed at a lower level than non-pilot observers.

Table V-13 gives the means and standard deviations for the two factor scores by category. Each category is further divided into successful and unsuccessful according to the time criteria for each type of target. This table will further aid in deciphering the meaning of the discriminant coefficients. As an example, the relatively large discriminant coefficient associated with the Verbal Fluency Factor (VFF) on several occasions can be clarified by examination of the differences between the means of the successful and unsuccessful categories. These differences are particularly marked in the case of the TO and AO categories.

Table V-9

Distributions of Job and Experience For Unsuccessful and Successful Observers and Target Scores

(Successful $\leq$ 129.25 Seconds - Unsuccessful $\geq$ 129.25 Seconds)

		Successful Observers		Unsuccessful Observers	
Category	Code	Freq.	%	Freq.	%
Pilot	0	16	61.5	21	80.8
Other	1	10	38.5	5	19.2
No Experience	0	4	19.0	4	17.4
Experience	1	17	81.0	19	82.6

Table V-10

Distributions of Job and Experience For Unsuccessful Pilots and Target Scores

(Successful $\leq$ 129.25 Seconds - Unsuccessful $\geq$ 129.25 Seconds)

		Successful Pilots		Unsuccessful Pilots	
Category	Code	Freq.	%	Freq.	%
Pilot	0	23	88.5	27	90.0
Other	1	3	11.5	3	10.0
No Experience	0	3	15.0	4	15.4
Experience	1	17	85.0	22	84.6

Table V-11

Distributions of Job and Experience For Unsuccessful and Successful Observers and Area Scores

(Successful $\leq$ 240.5 Seconds - Unsuccessful $\geq$ 240.5 Seconds)

		Successful Observers		Unsuccessful Observers	
Category	Code	Freq.	%	Freq.	%
Pilot	0	20	83.3	11	60.7
Other	1	4	16.7	17	39.3
No Experience	0	3	14.3	5	21.7
Experience	1	18	85.7	18	78.3

Table V-12

Distributions of Job and Experience for Unsuccessful and Successful Pilots and Area Scores

(Successful $\leq$ 240.5 Seconds - Unsuccessful $\geq$ 240.5 Seconds)

		Successful Pilots		Unsuccessful Pilots	
Category	Code	Freq.	%	Freq.	%
Pilot	0	23	92.5	27	87.1
Other	1	2	8.0	4	12.9
No Experience	0	1	4.8	6	24.0
Experience	1	20	95.2	19	76.0

Table V-13

Means and Standard Deviations for the Spatial and Fluency Factor Scores by Category

Category	$\bar{x}$ SF	σ SF	$\bar{x}$ VFF	σ VFF
TO (Successful)	-.236	.769	.186	1.008
TP (Unsuccessful)	-.119	.852	-.232	.666
TP (Successful)	.161	.921	-.065	.781
TP (Unsuccessful)	.164	.887	.082	.884
AO (Successful)	.042	.562	.227	.966
AO (Unsuccessful)	-.375	.939	-.237	.736
AP (Successful)	.348	.808	.060	.821
AP (Unsuccessful)	.016	.945	-.027	.851

In these two cases, the successful players had a higher VFF score than the unsuccessful players.

However, as previously noted, the ultimate usefulness of the discriminant analysis is in using information to classify individuals into categories. Therefore, it must first be determined if a successful classification has been obtained. Classification involves comparing *predicted* category membership with the actual category membership. In the present case, the categories were formed on the basis of handoff performance (time) for each of the two types of targets. This actual category membership was then predicted by the discriminant functions. Tables V-14 through V-17 present the classifications obtained by the discriminant function analysis for both pilot and observer players for the two types of targets. As an example, Table V-14 presents the prediction results for pilot players receiving handoffs of military targets. Their actual performance shows approximately an equal split between the unsuccessful and successful categories (i.e., 26 unsuccessful and 27 suc‹ ssful). However, based on the four independent variables, the discriminant analysis successfully classified only nine (34%) of the unsuccessful players. The results were better for the successful players with 63 percent being correctly classified.

Table V 3 summarizes the proportion of correct classification for both po itions and both target types. This data does not present a very encouraging picture of the probability of correct classification using the variables selected for the present study. In the best case, that of observer trying to hand off a military target (Table V-15), correct classification was only achieved in 64 percent of the cases. A validity

Table V-14

Prediction Results and Target Scores (Pilot Players)

Actual Category	No. Cases	Predicted Category Membership: Unsuccessful (Slow)	Predicted Category Membership: Successful (Fast)
Unsuccessful (Slow)	26	9 (34.6%)	17 (65.4%)
Successful (Fast)	27	10 (37.0%)	17 (63.0%)

Table V-15

Prediction Results and Target Scores (Observer Players)

Actual Category	No. Cases	Predicted Category Membership: Unsuccessful (Slow)	Predicted Category Membership: Successful (Fast)
Unsuccessful (Slow)	26	17 (65.4%)	9 (34.6%)
Successful (Fast)	24	9 (37.5%)	15 (62.5%)

Table V-16

Prediction Results and Area Scores (Observer Players)

Actual Category	No. Cases	Predicted Category Membership: Unsuccessful (Slow)	Predicted Category Membership: Successful (Fast)
Unsuccessful (Slow)	24	14 (58.3%)	10 (41.7%)
Successful (Fast)	24	10 (41.7%)	14 (58.3%)

Table V-17

Prediction Results and Area Scores (Pilot Players)

Actual Category	No. Cases	Predicted Category Membership: Unsuccessful (Slow)	Predicted Category Membership: Successful (Fast)
Unsuccessful (Slow)	25	17 (68.0%)	8 (32.0%)
Successful (Fast)	25	12 (48.0%)	13 (52.0%)

Table V-18

Proportion of Correct Classification

Condition	No. Cases	Percent Correct Classification*
Observer Player Target Score	50	64.00
Pilot Player Target Score	53	49.06
Observer Player Area Score	48	58.33
Pilot Player Area Score	50	60.00

*Based on original category membership.

of this magnitude (corresponding to .8) may be useful in classification if it were possible to choose a favorable *selection ratio*.[2] In this case, the selection ratio acts as a substitute for high validity, if the test has any validity. Thus, according to Taylor and Russell's tables, with an obtained validity of .8 in the best case, and estimating that 50 percent of current job incumbents are rated satisfactory, a selection factor of .30 would result in 90 percent successful performance on the part of those so chosen. This would mean administering the tests used in this study and accepting the best 30 performers out of each group of 100. It is doubtful that the Army, in the absence of the draft, could afford the luxury of this low selection ratio. In addition, replication of the present study, probably with a larger sample of subjects, would be required to establish the usefulness of the measures used in this study in selecting subjects who must perform target handoff as part of their job.

Part II: Analysis of Handoff Communications

Method

The verbal interchange between the players in the simulated handoffs was recorded on an Ampex Model 77 tape deck. Recording speed was 3 1/4 inches/second on standard quality 1/4 inch tape. Voice recordings obtained with this equipment were judged to have high quality.

A listing was then obtained of the times required by the pairs of subjects to perform each of the six handoffs. This list was inspected and a number of pairs were identified with times either above or

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[2] H. C. Taylor and J. T. Russell. "The Relationship of Validity Coefficients to the Practical Effectiveness of Tests in Selection: Discussion and Tables," *Journal of Applied Psychology*, 1939, 23, 565-578.

below the median of the time distributions for handoff of the two types of targets. The intention of this initial effort was to compare fast to slow handoffs for each target. It was hoped that this comparison would be useful in revealing gross differences in verbal behavior between fast and slow handoffs. As an initial pilot effort, eight pairs of subjects performing handoffs were selected for comparison. As can be seen in the far right-hand two columns of Table V-19, three of the pairs had scores above the median for Area Targets, while five were below. Similarly, three pairs had scores above the median for Military Targets, five were also below. Unfortunately, not all of the recordings of handoffs were complete; technical difficulties or experimenter error resulted in considerable missing information. The most probable cause for the gaps in the recordings is a faulty plug discovered late in the course of the study. However, it was felt that enough information survived to make preparation of typed transcripts possible. These transcripts were prepared without any editing or deletion, and even so, transcription proved to be a difficult and time-consuming task. Two examples of these transcripts are included as Appendix C.

Table V-19 gives the times for the six handoffs for the eight pairs of selected subjects. The median of the distribution of times for each handoff is also given. It should be noted that performances are highly variable, both within pairs of subjects and between pairs. This great variability rendered the task of analysis very difficult. The missing data shown by the asterisks in Table V-19 indicate that while times were recorded for these handoffs, no tape record was obtained.

Table V-20 gives the word counts for the selected handoffs. Not surprisingly, there is a nearly perfect correspondence with the time to

Table V-19

Times for Eight Sets of Selected Handoffs

Pair No.	1	2	3	4	5	6	AS**	TS***
Median	140.37	32.25	42.13	41.13	40.06	41.04	240.50	129.25
1	96.00	18.00	300.00	87.00	300.00	300.00	483.00	618.10
2	48.00	11.00	14.00	34.00	12.00	12.00	94.00	37.00
3	144.00	07.00	17.00	24.00	24.00	22.00	190.00	46.00
4	140.00	*	*	*	36.00	34.00	406.00	244.00
5	300.00	*	*	*	*	*	493.00	274.00
6	*	*	52.00	130.00	.24	.44	204.00	119.00
7	*	*	*	21.00	24.00	32.00	87.00	62.00
8	*	*	*	38.00	14.00	45.00	182.00	52.00

* = No recording obtained.
** = Area Score
*** = Target Score

Table V-20

Word Counts for the Eight Sets of Selected Handoffs

Pair	Handoffs 1	2	3	4	5	6
1	211	13	207	168	177	262
2	41	4	6	51	12	10
3	285	16	30	59	45	57
4	238	*	*	*	41	32
5	370	*	*	*	*	*
6	*	*	75	257	31	46
7	*	*	*	44	46	42
8	*	*	*	66	9	52

* = No recording obtained.

handoff (Table V-19) and the number of words used. The slowest pairs use the most words.

Table V-21 shows the message rates in word/seconds for the selected handoffs. These data do not present a clear picture of the relationship between speaking rate and time to perform a handoff. The tabled data, however, are not sufficient to perform statistical analyses. As more transcripts are prepared, appropriate analyses will be carried out to gain further understanding of the role of message rate.

Table V-22 shows the number of messages interchanged between each pair of players in the selected sample. The tabled data again show great variability. It is obvious that the minimum number of messages to solve the problem presented the players is two — a target description by the observer player, and an announcement of target acquisition by the pilot player. However, there is variability in time between the pairs when only two messages are interchanged. This variability is likely due to either search time, or the length of the two messages. There is inadequate data available at this time to yield a reasonable estimate of search time. It is, of course, possible to estimate the time for each handoff that each player spent _talking_. However, subtracting talking time from the total will yield a remainder that might be filled with search time, but is most likely also occupied by other processes such as decision making and hypotheses generation. From the data shown in Table V-20 and V-22, it is possible to calculate average message length. These data appear in Table V-23. Unfortunately, this analysis does not seem to add much to our understanding of the handoff message. The message length data is probably compromised by the inclusion of short

Table V-21

Message Rates in Words/Seconds For the Selected Handoffs

	Handoffs					
Pairs	1	2	3	4	5	6
1	2.19	.72	.69	1.93	.59	.87
2	.85	.36	.42	1.50	1.00	.83
3	1.98	2.29	1.76	2.46	1.88	2.59
4	1.70	*	*	*	1.14	.94
5	1.81	*	*	*	*	*
6	*	*	1.44	1.98	1.29	1.05
7	*	*	*	2.10	1.92	1.31
8	*	*	*	1.74	.64	1.16

* = No recording obtained.

Table V-22

Number of Interchanges for the Selected Handoffs

Pairs	Handoffs 1	2	3	4	5	6
1	23	4	24	18	11	24
2	8	2	2	8	2	2
3	16	2	2	2	2	2
4	6	*	*	*	2	2
5	20	*	*	*	*	*
6	*	*	2	7	2	2
7	*	*	*	2	2	2
8	*	*	*	6	2	2

* = No recording obtained.

Table V-23

Average Number of Words/Message for the Selected Handoffs

Pairs	Handoffs 1	2	3	4	5	6
1	9.17	3.25	8.62	9.33	16.09	10.92
2	5.13	2.00	3.00	6.38	6.00	5.00
3	17.81	8.00	15.00	7.38	22.50	28.50
4	39.67	*	*	*	20.50	16.00
5	18.50	*	*	*	*	*
6	*	*	37.50	36.71	15.50	23.00
7	*	*	*	22.00	23.00	21.00
8	*	*	*	11.00	4.50	26.00

* = No recording obtained.

acknowledgements and does not reflect the relative contribution of either the player or observer.

Table V-24 presents the average message length for the handoffs for both players. From this table, it is obvious that the observer player does most of the talking. In fact, examination of the table reveals that a high ratio of observer's message length to pilot's message length seems to be associated with rapid handoff. However, the present sample of handoffs is too small to allow statistical analysis of this possibility.

As a next step, the sample of handoffs was examined for some cue to differences in language usage. It was felt that an examination of descriptive strategies might reveal some of the differences underlying handoff performance. As a last step, a count of nouns and adjectives was performed.

When the stimulus object controls the speech response, the speech response may be a noun or adjective. An important aspect of functional speech involves responses under the control of these types of stimuli. Without an adequate repertoire of nouns and adjectives with which to describe or label the object (in this case, the target), various communication difficulties occur.[3] If more and varied labels can be applied to a stimulus object it becomes more likely that true configuration of the object will be perceived by the listener. The observer in the present case must present the pilot with a "verbal representation" of the stimulus object (the target). It seems logical, therefore, to hypothesize that a good handoff might rely on the ability of the observer

[3] A. W. Staats and C. K. Staats. *Complex Human Behavior*, New York: Holt, Rinehart and Winston, Inc., 1963.

Table V-24

Mean Message Lengths For Observer and Pilot Players

Handoffs

Pair	1		2		3		4		5		6	
	O	P	O	P	O	P	O	P	O	P	O	P
1	12.82	5.18	10.00	3.00	12.18	6.64	8.00	11.56	15.80	19.60	11.00	10.00
2	6.25	4.50	8.25	4.75	11.00	2.00	8.25	4.72	11.00	2.00	9.00	1.00
3	32.38	4.05	13.00	3.00	27.00	3.00	58.00	1.00	43.00	3.00	55.00	2.00
4	74.33	4.67	*	*	*	*	*	*	*	*	*	*
5	24.40	14.50	*	*	*	*	*	*	39.00	2.00	32.00	2.00
6	*	*	*	*	65.00	10.00	50.50	13.75	19.00	12.00	40.00	6.00
7	*	*	*	*	*	*	41.00	3.00	34.00	5.00	38.00	4.00
8	*	*	*	*	*	*	16.67	6.00	7.00	2.00	51.00	1.00

* = No recordings obtained.

to provide an accurate set of descriptors for the target and for reference points. Accordingly, a simple count of adjectives and nouns was carried out for the sample handoffs. The results of this count are summarized in Table V-25. For each pair of players, the count for nouns is followed by that for adjectives. It could be hypothesized that a message that contained a relatively high proportion of adjectives relating to nouns would be "richer" in information. The use of a high preponderance of nouns would constitute merely naming features in the scene. The use of adjectives would add to this simple description by adding detail which should aid in discriminating the target. This hypothesis seems to be borne out by the counts of nouns and adjectives listed for handoff No. 1. The picture is not as clear for the other handoffs. It may be that the redundancy of information afforded by the use of many adjectives is mainly effective in solving difficult handoff problems. This hypothesis will be further examined when the bulk of the handoff recordings are analyzed.

Additional simple word-count analyses will also be carried out at [illegible] time with a search for uses of color and shape in target description heading the list.

The next step in the analyses would logically center around consideration of larger, more abstract units of meaning. Berelson,[4] in his excellent treatment of content analysis, lists five major units of analysis: words, themes, characters, items, and time and space measures. The word is the smallest unit, and to this point in the analysis,

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[4]B. Berelson. "Content Analysis," in G. Lindzey, ed., *Handbook of Social Psychology, Vol 1*, Cambridge, Massachusetts: Addison-Wesley, 1954, Chapter 13.

Table V-25

Counts of Nouns and Adjectives for the Sample Handoffs

	Handoff					
Pair	1	2	3	4	5	6
1	26/8	4/4	13/6	13/1	11/1	17/9
2	4/5	3/1	2/1	5/6	4/2	4/3
3	34/10	3/0	5/2	12/4	6/5	13/7
4	27/10	*	*	*	8/3	7/8
5	39/17	*	*	*	*	*
6	*	*	11/7	29/20	4/4	7/6
7	*	*	*	7/1	6/2	3/5
8	*	*	*	8/4	2/1	7/7

* = No recordings obtained.

word counts have served as the basis for discussion. The next step in the analysis will be the definition of prominent themes. In the parlance of content analysis, a theme is often a sentence, a proposition about something. The study of relevant themes within the handoff messages will probably be the final step in the content analysis. The theme is a very difficult unit of analysis, but often it is the only way to isolate larger units of meaning. Because theme analysis is very time-consuming, this effort will not begin until early in the third contract year.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The research effort presented in this report was concerned with two primary goals or objectives. These were:

- The exploration of the structure of abilities which underlie performance in handoff.
- The amassing of a data bank of baseline information concerning the behaviors involved in target handoff.

The first objective was approached by administering a battery of perceptual and verbal tests to a group of Army personnel and using the test results as predictors of success in simulated handoffs. The selection of tests for this effort was based on hypotheses derived from pilot work also using simulated handoffs. Briefly, it was hypothesized that verbal skills would be important to the observer describing the target, while perceptual and spatial orientation abilities would determine the performance of the AH pilot trying to find the target.

The results of the effort to determine the role of verbal and perceptual abilities in target handoff were disappointing. Only moderate relationships were obtained between the measures employed and target handoff performance. It was concluded that the battery of tests used in the current research would only be useful for selection and classification under conditions when the Army was able to select only those individuals scoring in the top 30 percent on the tests. However, in the absence of the draft, it is unlikely that the Army could afford to be so selective about its manpower.

The second objective was attained by tape recording the verbal interchanges between 68 pairs of individuals performing six simulated handoffs. This group of individuals was drawn from operational air combat units at Fort Hood, Texas, and featured a preponderance of handoff-experienced aviators.

The tape recordings were first transferred to cassettes from the original reel-to-reel medium. Selected handoffs were then reviewed and typed transcripts prepared. These transcripts were then submitted to content analysis. Unfortunately, due to the pressures of time, it was not possible to progress beyond some rather elementary word-count techniques. However, based on a limited sample of handoffs, the following conclusions were tentatively reached.

- The shorter message is most effective.
- High message rates (word/second) may be more effective.
- The ratio of observer speaking time to pilot speaking time seems important (observer talks more).
- The use of a relatively large number of adjectives yields a richer, more effective target description.

These analyses will be continued and the scope expanded to include all retrievable handoff recordings. Additional simple word-count analyses will be performed aimed at investigating the role of color and shape in target description. However, it is expected that these simple analyses will be supplanted with more complex techniques aiming at more abstract units of meaning, i.e., themes.

Finally, it was also tentatively concluded that each handoff situation is largely unique, and that the specification of a set of procedures to deal with each possible situation or even sets of situations is nearly impossible. The uniqueness of any handoff situation can be appreciated by considering that each of the elements that define the situation, i.e., terrain, target type, illumination, range, heading, etc., has many realistic levels. When these and other elements are combined, the universe of situations become a factorial with the number of possible combinations rapidly approaching infinity. Therefore, a number of more general approaches to the problem are under consideration. The bulk of these notions center around continued use of the target handoff simulator as a basic test-bed. Briefly, these general approaches can be regarded as alternate training strategies. The list of strategies which may be considered includes:

- The use of supplementary printed materials which give examples of "effective" procedures.
- The use of supplementary printed materials setting forth rules for effective handoff.
- The use of timing devices to teach the use of limited, condensed messages.
- The use of counting techniques to limit the number of words in any transmission.

Several other strategies may be considered which are even more general, and are not based on the results of the current study. These are:

- Free-play with summary feedback after each handoff.
- Prompting as required.
- Free-play with summary feedback after a series of handoffs.

These strategies will, of course, be supplemented by others and an effort will be made to identify several with the most potential for tryout.

These training approaches center around the simulator and may be supplemented by carefully designed field exercises which may feature simulated targets or the use of other measures designed to reduce impact on scarce resources. The final product of this research will be an integrated approach to target handoff training with emphasis on field and classroom exercises as appropriate. It is hoped that any approaches recommended can be validated in the field before implementation.

CONCLUDING REMARKS

During the contract year, contact was established between the handoff research staff and individuals from the Army Electronic Command, Fort Monmouth, New Jersey. These individuals were concerned with a concept which would exchange information between elements of Army air via a digital data link. This proposed system soon became known as the "Target Handoff Information System" (THIS). Briefly, this system would allow the rapid transferral of data concerning target type and location from a scout helicopter to an AH, or vice versa. The data would be digitized, compressed, and transmitted by radio in brief bursts and thus would be almost immune from enemy attempts at electronic interference. A staff member visited Fort Monmouth and discussed handoff and helicopter tactics with the THIS staff. The THIS system is currently only in the conceptual stage, although a request for proposal for three prototype systems is being firmed up. While it seems obvious that this system will solve a great many of the problems associated with target handoff, it should be pointed out that it is intended for use in advanced aircraft which will not reach the operational units until the 1980s. Even then, problems of reliability and maintainability may combine to render the system ineffective from time to time. Therefore, the current research should be continued, both as a means of providing an effective system until the THIS system is implemented, and also as a backup to this system, should it fail.

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APPENDIX A

Date ______________

Position P ____ O ____

Paired With ________________________

		Correct			Correct
Time 1	________	___	Time 4	________	___
Time 2	________	___	Time 5	________	___
Time 3	________	___	Time 6	________	___

DO NOT MARK ABOVE THIS LINE

PERSONAL HISTORY

Name: ______________________________ Rank: ______________
(Last) (First) (MI)

Primary MOS: ______________________ Years Service __________

Age: ____ Present Job Title: ___________ Time in Present Job _____

Present Military Unit ________________ SSAN __________

How far did you go in school?

a. High school or GED ____

b. Had some college work ____

c. Graduated from college ____

d. Completed some graduate training ____

e. Completed Masters ____

f. Completed PhD ____

g. Post Doctoral ____

Please estimate how many targets you have initiated/received. ________

APPENDIX B

INSTRUCTIONS TO PILOT PLAYER

A color transparency will be presented on the screen in front of you. Like the one now on the screen, the transparency will depict an area of terrain with a target or a target area. The target will be generally obscured and the target areas will not be obvious. Half of the presentations will be target area slides. In these you will be required to locate a small area of terrain that your observer is attempting to describe. The other half of the slides will contain military targets (vehicles, structures, etc.) that you must locate given your partner's instructions. It is important that you locate the target or area as quickly as possible, using the information given to you by your partner. Your partner will know the target location; however, his field of view, angle of regard, etc., will differ from yours. Your partner will begin by describing the target to you. After that, he will try and describe its location. You may ask whatever questions you want of him. In your communications, your callsign will be BLACKHAWK. Your partner's callsign will be BLUEBIRD. Please try and identify all of your communications by your callsign. This will aid in later analysis. Other than the callsign, any other communication format you may use is entirely your choice. If you have had experience as an attack helicopter pilot or observer, please attempt to make your communications realistic to a real combat target handoff. A trial will begin when the experimenter signals "begin," a scene appears on the screen, the other player will describe it to you. Continue until you acquire the target. Six trials with six different problems will be presented. When you are sure you have the target, acknowledge by saying, "I have the target." The experimenter will then verify your judgment. If you are correct, press the "pickle" switch; this will terminate timing. The next trial will begin with the appearance of the next slide. Remember, you must locate the target as quickly as possible. Please ask any questions now; it will not be possible to stop during a trial.

APPENDIX B

INSTRUCTIONS TO OBSERVER PLAYER

A transparency will be projected on the screen in front of you. This transparency will be of an area of terrain with a target or target area marked as in the example on the screen. There are six slides besides this example. Three will require you to describe the location of a military target emplaced in terrain, three will require that you describe a target area. In the area presentation no military target will be obvious. The sheet in front of you will name the target featured on each of the slides in order of their appearance. Your partner will be presented with the target area as it would appear from a greater distance and from a differing angle. The target location will not be obvious to him. Your task will be to help your partner locate the target by describing what you see. Always identify yourself at the beginning of a message with your callsign, BLUEBIRD. The callsign of your partner is BLACKHAWK. Other than the use of callsigns, you may use any message format you are comfortable with. However, the intent of this study is to look at target handoff. Therefore, if you have had experience in handoff, try and search as you would in a realistic combat situation. When the other individual has acquired the target, he will verify and the trial will be over.

The trials will begin when the slide projector cycles. Begin description as soon as you are able after the picture appears. Always begin your message with a description of the target (e.g., "T62 tank," etc.) from the list. The trial will end when the other player signals that he has identified the target. Each trial will proceed in the same fashion until all six have been shown. Please ask any questions now; it will not be possible to stop during a trial.

APPENDIX C

Examples of Handoffs

The following pages present two examples of handoff as transcribed verbatim from tape recordings obtained during the course of the main study. The two examples were chosen to illustrate some of the diversity of responses to the handoff task.

In the handoffs, the observer player used the callsign, BLUEBIRD, while the pilot player identified himself by BLACKHAWK. Except for the initial exchange, the transcripts use the abbreviation BB for BLUEBIRD and [illegible] for BLACKHAWK. Also, the reader may note that some of the transcripts end without a positive indication of target acquisition by the pilot player. In these cases, the pilot pointed out the target to the experimenter who verified his choice. The pilot then closed his switch, terminating timing. Thus, although the transcript does not indicate a successful acquisition, it was in fact achieved.

The players in example #1 generally perform at a less effective level than do the players in example #2. The differences between the two pairs of players are most marked in handoffs 3, 5, and 6. The players in the first example were not communicating effectively, and the pilot player became very exasperated with the quality of information being provided him. Yet, in both examples the players were experienced aviators who claimed extensive experience in target handoff.

EXAMPLE #1

Handoff #1: Time, 96 seconds

START

BLACKHAWK, this is BLUEBIRD.

(BH) Go ahead.

(BB) OK, do you have the bridge in sight?

(BH) Roger. I have the bridge.

(BB) OK, do you have the town on the opposite side of the bridge?

(BH) Roger. I have a group of houses.

(BB) OK. On the other side of the river, approximately 100 meters from the end of the river, is a tree and there's a bunker at the base of that tree. And it's approximately 10 meters off the road.

(BH) Understand 10 meters off the road.

(BB) On the same side as the village. It's on the opposite bank.

(BH) Roger. I'm looking.

(BB) OK. There's a tree there, a big tree all by itself.

(BH) Roger. Is it a dead tree or a live tree?

(BB) It looks like a live tree. It has some yellow foliage on it.

(BH) Roger. Understand it's on the other side of the group of houses.

(BB) It's on the opposite bank of the river from where the houses are.

(BH) I have negative contact.

(BB) OK. From the houses put yourself on the road.

(BH) Roger.

(BB) Near the houses cross the bridge.

(BH) Roger.

(BB) OK. You see a car?

(BH) Roger that. Got the car.

(BB) The car is pointing right at the tree, it's approximately 200 meters from the car.

(BH) Roger. I've got it.

END

Handoff #2: Time, 18 seconds

START

BLACKHAWK, this is BLUEBIRD.

(BH) Go ahead.

(BB) I have a group of vehicles on a dirt road.

(BH) I have contact.

END

Handoff #3: Time, 300 seconds

START

BLACKHAWK, this is BLUEBIRD.

(BH) Go ahead.

(BB) OK. To my front I have a dirt road.

(BH) Roger.

(BB) OK. To the left, correction, to the right of the dirt road about 10 meters in some trees is a 105.

(BH) Roger. Understand a 105 in the trees.

(BB) In the trees, just off the road.

(BH) Roger. Looking.

(BB) A small trail that goes off the road and it's just inside the trees.

(BH) Roger. Negative contact at this time. Still looking.

(BB) OK. From my position it's to the right, there's a very small trails that goes off to the ---------

(BH) Roger. I've got contact.

(BB) OK?

(BH) No, I don't have contact.

(BB) Do you have the dirt road?

(BH) I've got the dirt road. Dirt road is perpendicular to me at this time.

(BB) Perpendicular?

(BH) Roger.

(BB) OK. It should be near 12 o'clock, somewhere in that vicinity, there should be a small trail, just a vehicle track.

(BH) I have negative contact with ----- I've ----- vehicle tracks but they're on the open side of the field, not in the trees.

(BB) OK. Do they go into the trees?

(BH) Not that I can see at this time.

(BB) I've got no other references here. There's a road and some trees and that's all I've got in front of me. There's a trail that goes off of the road.

(BH) I can't find it.

END

Handoff #4: Time, 87 seconds.

START

BLACKHAWK, this is BLUEBIRD.

(BH) BLUEBIRD, go ahead.

(BB) Do you have the hardball in sight?

(BH) Got the hardball in sight.

(BB) Do you have buildings at an intersection.

(BH) Roger. I've got buildings at intersection at my 11 o'clock.

(BB) OK. Do you have the windmill?

(BH) Looking at this time. Negative tally on the windmill.

(BB) OK. Do you have any buildings at all? Describe the buildings.

(BH) Roger. I've got several farm buildings at my 11 o'clock.

(BB) OK.

(BH) Negative on that intersection. Those were farm buildings at 11 o'clock. I also have some buildings out at my 1 o'clock and I've got a dirt trail branching off the hardball.

(BB) The dirt trail branches off this hardball. Do you have one building in sight? Looks like a house or garage.

(BH) Roger. Out at the end of the dirt road.

(BB) That's it.

(BH) Roger. Got it in sight.

(Experimenter) That's not it.

(BH) OK. On the hardball you got the buildings. I've got my -- I got those buildings at 11 o'clock. There's a group of about six buildings. Where are they from your position?

(BB) That's the buildings that I thought I was looking at.

<u>END</u>

Handoff #5: Time, 300 seconds.

<u>START</u>

BLACKHAWK, this is BLUEBIRD.

(BH) BLUEBIRD, go ahead.

(BB) I have trucks concealed in trees to my front. Can you see a hill or a ---- can you see a hilltop?

(BH) I've got a hill mass approximately a click to a click and a half to my 12 and 1 o'clock

(BB) OK. Look to the base of the hills.

(BH) Roger. It's too far a distance to pick up. Looks like I'm on top of the hill looking down right now.

(BB) That's where I am. You must be further away. I can't give him anything. There's trees out there. OK, the target I have two, well, I have one truck that's circled and I've got two trucks in sight; they're 2 1/2s.

(BH) I'm looking at this time. I don't have much. I've got a dirt road at my 12 o'clock at the base of the hill and I have vehicle tracks branching out from there. And am approximately at 100 meters on the other side of the dirt road at the base I've got another dirt road.

(BB) OK. I don't have any dirt roads in sight.

(BH) OK.

(BB) Can't do it.

END

Handoff #6: Time, 300 seconds.

START

BLACKHAWK, this is BLUEBIRD.

(BH) BLUEBIRD, go ahead.

(BB) I've got a small mound at my 1 o'clock. There's a white portion that's small, it's covered with green and there should be a white portion in that small mound.

(BH) Roger.

(BB) That's it.

(BH) That is a double hill - observer.

(BB) It's a concealed observer.

(BH) No. I don't have it after all.

(BH) OK. I am looking at a hardball road at approximately 300 meters from my position and I also have a hill mass over here with a road on it.

(BB) OK. It's just a small mound. It's got green trees all around it and right in the middle of it is a white area.

(BH) It's got green all around it?

(BB) Looks like sand or dirt or smelting.

(BH) Negative contact at this time.

(BB) OK. Look to either side of the road. Are there wires on the road?

(BH) Yes, there's wires running to the road, there's no wires on the road.

(BB) Wires to the road -- hmm.

(BH) It's a double set of power lines running perpendicular to the road.

(BB) Yes, power lines. OK. Look to either side of the power lines for that small hill mass, small knole.

(BH) Roger. I've been looking. I think I have contact at this time. I'm not sure.

(BH) I have negative contact.

(BB) I'm unable to describe further.

(BH) I'm looking at hills and at my 11 and 1 o'clock, group of hills out there approximately 500 to 800 meters.

(BB) OK. These are closer, closer to my position. Just the small ones.

(BH) I don't know wh t your position is.

(BB) I don't know what your's is either.

(BB) OK. Out there to your 11 o'clock.

<u>END</u>

EXAMPLE #2

Handoff #1: Time, 48 seconds

START

BLACKHAWK, this is BLUEBIRD. Target area this side of trestled bridge.

(BB) Am I looking for an area, BLACKHAWK?

(BH) That's affirmative.

(BB) OK.

(BH) It's a road intersection, closest one, first on this side of trestled bridge.

(BB) OK. You say this side, BLACKHAWK? You got buildings on your side?

(BH) That's a negative.

(BB) OK. Target.

END

Handoff #2: Time, 11 seconds.

START

(BB) Target. 2 1/2 ton truck.

END

Handoff #3: Time, 14 seconds.

START

(BB) Target is a 105 field piece.

END

Handoff #4: Time, 34 seconds

START

(BB) Terrain area. Have numerous buildings in vicinity with windmill in center adjacent to road with power lines.

(BH) BLUEBIRD, you got a vehicle going down road in front of you?

(BB) That's a negative.

(BH) OK. Target.

(BB) OK. There's a small pond.

(BH) Small pond? That's the target?

(BB) A very small pond adjacent to the road.

(BH) OK.

END

Handoff #5: Time, 12 seconds.

START

(BB) Target is a shelter, possible enemy headquarters. It's a square block.

END

Handoff #6: Time, 12 seconds.

START

(BB) Terrain area, hilltop, bald spot near center of hill.

(BH) Target.

END