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NOE NAVIGATION

AN OVERVIEW OF ARI EXPERIMENTS

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HUMAN FACTORS IN TACTICAL OPERATIONS TECHNICAL AREA

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NOE NAVIGATION
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ABSTRACT

Thirty-five Army rotary wing aviators with varying levels of flight experience were tested in a series of three field experiments during which they flew simulated operational missions in a UH-1H aircraft to determine their proficiency in Nap-of-the-Earth (NOE) navigation. The mission was to navigate a specified route starting from an initial point (IP) and identify all landing zones (LZ) while staying within 250 meters of the course line. Those pilots given additional terrain analysis training, as part of the study, performed their missions more effectively, than the group which did not receive this training. Pilots with greater flight experience performed slightly less effectively than pilots who were less experienced but were recent graduates of the Aviation School. Based on the results of this study, improvements in work methods and training are suggested.

BACKGROUND

Unlike those of past aggressors, the air defense weapons of a potential adversary in a mid-intensity conflict will be highly sophisticated and extremely mobile. As such, they are particularly threatening to helicopter operations.

In a response to this sophisticated air defense threat, the Army has chosen to implement tactics first developed and tested in the early 1960's. These tactics are subsumed under what we now call Nap-of-the-Earth (NOE) flight.

"NOE is to the aviator, what creeping and crawling is to the infantryman" (Maddox,1973). The aviator must now descend to altitudes previously considered unsafe and use the terrain and vegetation as cover in order to mask his aircraft from enemy radar or optical detection.

The introduction of NOE tactics presents special difficulties to Army rotary wing aviators, particularly in navigation. The extent of the terrain in the navigator's field of view is highly restricted because of his proximity to the ground and the terrain features depicted on his aerial map are viewed from a much different perspective. In an effort to alleviate these difficulties, preliminary NOE training has been introduced at the Army Aviation School and is also being put into effect at operational unit level. Therefore, this series of studies had four specific goals:

1. To develop and apply a quantified NOE navigation performance measure;

2. To determine the present level of NOE performance;

3. To measure the effects of additional terrain-analysis training;

4. To measure the effects of flight experience.

The achievement of the first goal is, of course, a necessary condition to the achievement of the others.

General tests of pilot performance in aircraft control have existed for over 50 years (Jenkins, 1941); however, specific measures of navigation performance in helicopters under NOE conditions are relatively new. Some of these measures were subjective in nature and relied on judgments by an instructor pilot or personnel on the ground (Martin, 1963). A somewhat more objective approach was developed to evaluate pilot performance during target acquisition and minigun firing under NOE conditions (Thomas, 1964). However, the most similar work to date has been done by Lewis (1961) in his attempts to evaluate navigation performance under low speed, low level conditions. Rallye-type measures such as these are quantitative, objective, and inherently valid (Farrell, 1973).

METHOD

SUBJECTS

The subjects in this study were 35 Army helicopter pilots who were currently proficient in the UH-1H helicopter and had some exposure to NOE flight, either at entry or unit level. The fourteen pilots in Experiment I were selected to represent the general population of Army UH-1H helicopter pilots and their experience ranged from 200 to 2700 flight hours.

The 14 subjects in Experiment II were selected to achieve a sample of the more proficient, instructor level UH-1H helicopter pilots and their flight experience ranged from 1000 to 3750 flight hours.

The 7 additional subjects in Experiment III were selected as representative of the recent graduates of Army Aviation School who had completed the new 15 hour course in NOE navigation. These pilots had each completed 200 flight hours.

LOGISTICS

The test range used in all experiments is near Troy Alabama. The range was divided into three areas of operation (AO) each containing four NOE routes. Each route was composed of an Initial Point (IP), 3 or 4 intermediate landing zones (LZ) and a release point (RP) which designated the end of the mission.

Two UH-1H aircraft were employed in the study. The "low ship" which flew NOE was used to transport the subject pilot, who acted as navigator, the instructor pilot, who actually flew the aircraft and the Army Research

Institute (ARI) test supervisor. The high ship flew "chase" for safety reasons, and it provided the high-altitude platform (approximately 800 feet altitude) from which a second instructor pilot observer could track the flight of the low ship.

EXPERIMENTAL DESIGN

Experiment I. The purpose of Experiment I was to determine the effect of terrain analysis training and flight experience.

Seven pairs of subjects were systematically matched for experience and then one member of each pair was randomly assigned to an experimental group and the other to a control group. The control group flew 12 flights in three phases, each over a different AO. The experimental group flew eight flights, standing down between Phase I and Phase III for a two day terrain analysis course, which consisted of 3 hours of instruction per day.

In order to control for differences in the terrain composition in each area of operation, the order in which the areas were overflown was systematically varied among subjects. For example, subject 1 flew areas I, II, III in that order, whereas subject 3 flew areas III, II, I.

Experiment II. The purpose of experiment II was to further investigate the effect of specific NOE navigation training. Since the 14 subjects in this experiment were all highly experienced NOE instructors, the variable of flight experience was deleted. The design of this experiment differed from the first in that the experimental group received its training in the form of mission specific, terrain analysis, briefings, rather than the 6 hour refresher course given in Experiment I.

Experiment III. The purpose of Experiment III was to measure the effectiveness of the new 15 hour NOE navigation course which had replaced the original 6 hour NOE familiarization sequence. The subjects used in this study were the most recent (Dec 1974) graduates of the Army Aviation School, Initial Entry Rotary Wing program. These pilots flew six flights, i.e., two over each of three AO's. The design was otherwise identical to Experiment II. Their data was compared with the data from the six graduates in Experiment I who had only been given the 6 hour NOE famiarization sequence.

The major dependent measure for all three experiments was the objective mission success score (OMSS) which is a composite metric representative of the subject's scores on four individual measures. The component measures were: the ability to find the IP, (PIP), the ability to find intermediate LZ's (PLZ), the number of 250 meter excursions from the course line (#250EXC); and the number of 1000 meter excursions (#1000EXC) (Fineberg, 1974).

Each subject navigator received a pre-mission briefing conducted by the Senior instructor pilot. The briefing consisted of:

(1) a presentation and discussion of the day's mission;

(2) map analysis of the route to be followed;

(3) and, if necessary, a review of flight safety procedures.

The subject then received his NOE route to be navigated that day. The route was marked in yellow on the appropriate map sheet with the IP, LZ's and RP designated. An identical map was given to the observer who flew in the high ship.

The subject, with the instructor at the controls, then navigated at altitude (800 ft) to the IP of the NOE route, with the high ship flying chase. Identification of the IP by the subject was scored by the instructor pilot as correct or incorrect.

The subject then began navigating the route at NOE altitude, following the prescribed course on his map as accurately as possible. NOE altitude was maintained throughout the session by the highly experienced instructor pilot who controlled the aircraft. The actual course navigated by the subject was concurrently being drawn on the duplicate map by the high ship observer. The subject was required to identify and stop at each intermediate LZ. His selection of each LZ was scored by the instructor pilot as correct if he had landed within 100 meters of the correct landing zone.

RESULTS

The results of these studies are presented as individual experiments. The statistical test for significance was the Mann-Whitney U (Siegel, 1956) since many of the measures were ordinal rather than interval.

<u>Experiment I</u>. The data show that the group which received map training found the checkpoints (PIP and PLZ) more often and stayed within the 1000 meter corridor more accurately than the group without map training. This superior performance is reflected in the OMSS, which was .59 for the trained group and .51 for the untrained group. Although the differences are not significant according to the usual .05 level, there is preliminary indication of support for the hypothesized benefits of additional map training; however, more data are required for confirmation.

The differences were greatest when the ability to find checkpoints was compared. The trained group had a .86 PIP, while the untrained group scored .67. This difference is significant ($P<.01$). The benefits of map-training appear to be manifested in the ability to find checkpoints.

There was no significant difference between the navigation performance of the low-experience (214 mean flt hrs) and high experience (1387 mean flt hrs) groups.

Experiment II. The mean OMSS (.64) of the 14 highly trained NOE instructors was significantly higher ($P<.05$) than that of the 14 average aviators (.55) in Experiment I. The performance of the experimental group with additional training was not significantly different from that of the control group.

Experiment III. This experiment was designed to compare the navigation performance of two groups of recent IERW graduates uncontaminated by varying levels and types of operational experience. The first group (Sept 1973 graduates) received only the six hour NOE familiarization sequence while the other (Dec 1974 graduates) received a 15 hour navigation course. The results indicate an OMSS of .55 for the 6 hour graduates and an OMSS of .70 for the 15 hour graduates, ($P<.05$).

Combined Results. The scores of all 35 pilots were combined in Table 1 to provide a representative sample of Army aviator performance for diagnostic and predictive purposes.

TABLE 1

MEAN PERFORMANCE SCORES, STANDARD ERRORS AND ASSOCIATED CONFIDENCE INTERVALS FOR ALL PILOTS (N = 35) OVER ALL FLIGHTS (242)

Nav Measure	OMSS	PIP	PLZ	#250 EXC	#1000 EXC
Mean N = 35	.63	.85	.77	14.86	3.23
S. E.	.0361	.0295	.0281	1.0217	.4122
CI 95	.58- .68	.80- .90	.73- .81	12.86- 16.86	2.42- 4.04

DISCUSSION

The first and most obvious implication from the results of these experiments is that NOE navigation performance of the Army pilots tested leaves much room for improvement. Checkpoint identification (map/terrain association) appears to be the central and most critical error made in NOE navigation. This finding is based upon the fact that 15 operational combat pilots who rated the importance of the various NOE elements, weighted the two errors dealing with checkpoint identification as the most dangerous to successful mission completion. This is also reflected in the results of Experiment II where increases in checkpoint identification improved the OMSS even though there were decreases in course maintenance accuracy. Increased accuracy in checkpoint identification has another benefit, i.e., confidence. The combined results indicate as checkpoint accuracy scores increased, so did the number of 250 meter excursions. Those pilots with NOE specific navigation training tend to be more original in their route selection. They are not quite so concerned with getting lost.

Experience in flight at higher altitudes does not appear to have extensive transfer to navigation at NOE altitude. In Experiment I, the highly experienced pilots without specialized NOE training did not perform any better than the graduates who had only 200 flight hours.

It is also evident that flight experience per se does not necessarily improve identification of checkpoints. This suggests that the identification skill could be taught in a classroom or part-task simulation environment.

The hypothesis that specific NOE navigation training improves navigation performance has been supported in all experiments. This training appears to manifest its benefits in checkpoint identification which helps pinpoint areas of training emphasis. It is also apparent that this training should be given in the initial entry course, i.e., as early as possible, since the more experienced aviators in Experiment II did not benefit from additional training. The amount of NOE navigation training necessary to significantly improve NOE navigation is not overwhelming. The results of Experiment III indicate that an increase from 6 to 15 hours of instruction significantly improves the pilots' probability of successfully completing the mission.

Based on these findings, an experimental map interpretation and terrain analysis course (MITAC) was designed and is now under evaluation at the Army Aviation Center, Ft. Rucker, Alabama.

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