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EFFECTIVENESS OF INTEGRATED FLIGHT SIMULATOR TRAINING IN PROMOTING B-52 CREW COORDINATION

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by Richard L. Krumm and Alfred J. Farina, Jr.
of the American Institute for Research, Pittsburgh, Pa.)

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FOREWORD

This report was prepared by the American Institute for Research under Contract No. AF 33(616)-7011 for the Behavioral Sciences Laboratory, 6570th Aerospace Medical Research Laboratories. Dr. Richard L. Krumm was the Principal Investigator for the program which was carried out during the period September 1958 to January 1961. Dr. Krumm and Mr. Alfred J. Farina, Jr., are the authors of the report.

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The contract was initiated and monitored by Major Richard T. Cave, USAF, Operator Training Section, Training Research Branch, Behavioral Sciences Laboratory. The nature of the work relied heavily on Air Force contractual work originated within the AFPTRC field unit located at Castle AFB, California. Mr. Irving Cohen and Dr. Paul Hood were responsible for the acquisition of the research environment. Major Cave actively participated in the design of this study and in the preparation of this report. Many other people, particularly the SAC personnel at Castle Air Force Base, provided invaluable support for the successful completion of this study.

ABSTRACT

This report represents the findings of a study designed to assess the value of a B-52 flight simulator electronically linked to a T-2a navigator trainer in promoting crew coordination. Seventy-five SAC aircrews undergoing B-52 transition training at Castle Air Force Base were used as subjects. Integrated and non-integrated simulator training of these crews was contrasted. The results as indicated by certain of the measures used enable a favorable recommendation to be made regarding the effectiveness of the B-52 integrated crew trainer. In the report, special attention is devoted to a discussion of two aspects of communication, pattern and volume, and the relation of these aspects to crew coordination.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

Walter F. Grether
WALTER F. GRETHER
Technical Director
Behavioral Sciences Laboratory

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I. INTRODUCTION

The past fifteen years have marked a progressively increasing sophistication in the design and use of devices for aircrew training. Initially, part-task trainers were built so that difficult portions of a job might be more conveniently and economically practiced in a training atmosphere. These devices gradually increased in complexity, culminating in equipment which provides complete simulation in a ground environment of all important displays and controls at the crew member's station. The chief advantage of this sort of device is that it permits the operator to practice coping with realistic problem situations that he may reasonably expect to encounter in the operational situation.

During this period weapons systems increased in complexity resulting in rapid advances in system performance with a corresponding increased level of operator skill. The concept of crew coordination was initially investigated in the environment of the World War II bomber and its crew. Studies were conducted using in-flight observations of interacting crew members. As the design of weapon systems advanced it became increasingly difficult to either train for or study crew coordination using in-flight observations. Consequently, this combination of the growing impossibility to depend upon in-flight training alone plus the desire for complete fidelity of simulation led naturally to the development of integrated training for the whole crew within a ground simulator complex.

The linkage device, which was employed in this study, is one of the first attempts to provide integrated training for more than one crew station. It is an electronic interconnection between the B-52 Flight Simulator and the T-2A Radar Trainer that enables the two pilots and two navigators to practice a fairly wide range of tasks requiring coordination among these four crew members. Turn rates, climb and dive rates, true airspeed, altitude and heading indications are transmitted from the B-52 Flight Simulator to the Radar Trainer. PDI signals (steering meter and time-to-go meter) from the bombing navigation system on the Radar Trainer and reference voltages are transmitted to the Flight Simulator. In addition, all four crew members are linked by a voice communication system similar to the actual aircraft intracrew communication system. The interconnection makes it possible to use the Flight Simulator and the Radar Trainer as separate trainers, as well as using them in the integrated mode.

The primary purpose of this study was to investigate the effects of training pilots and navigators together in the described integrated configuration as compared to individual training of these crew members. Emphasis was placed upon the training of student or transition crews as opposed to experienced or combat ready crews. It was conceived that crew coordination would be better developed if practiced in the integrated training environment than if the student crews were trained as individuals. A secondary purpose of the study was to develop new measurement techniques to reveal more precisely the nature of crew coordination activities.

II. METHOD

A. Selection of Subjects

In the training program at Castle Air Force Base classes of 14-16 transition crews are scheduled at 11-week overlapping intervals. Because of this stringent training schedule, the limited number of B-52 simulators, and the difficulty in converting from one simulator configuration to another, it was necessary to limit the size of the experimental group to five crews per class.

For each class, the entering crews were assigned to experimental and control groups on the basis of matching information from available records, and from questionnaires which they completed during their first day of academic training. Since the navigators reported nearly two weeks after the pilots, it was not possible to obtain all of the desired information before the student crews had to be assigned to their respective groups. Consequently, the matching of experimental and control groups was limited by this operational restriction (see Table 1).

Table 1

Experience Comparison of
Experimental and Control Crews

	Experimental (N = 38 crews)	Control (N = 37 crews)
Mean Total Flying Time (Hrs.)		
Pilots	4291	4253
(Jet time)	492	412
Co-Pilots	2844	2485
(Jet time)	317	407
Radar Navigators	3151	2622
Navigators	1965	1814
Mean Previous B-47 Experience (Hrs.)		
Pilots	345	389
Co-Pilots	239	217
Radar Navigators	215	305
Navigators	270	351
Mean Previous B-36 Experience (Hrs.)		
Pilots	1054	984
Co-Pilots	917	582
Radar Navigators	1143	889
Navigators	1162	963

There was a tendency for the control group to be more heavily endowed with navigators who were more experienced on the particular radar bomb sight used in the integrated simulator. This discrepancy might be expected to have some effect in reducing inter-group differences.

Entering crews which were not assigned to either an experimental or a control group received the simulator training program which was standard at Castle Air Force Base. No effort was made to match these crews with those comprising the test sample. However, follow-up criterion measures were secured for some of these crews, and were included in the analyses. This third group, since it received no integrated simulator experience, was subsequently designated as the standard group.

B. Development of Simulator Missions

During the flight training program at Castle Air Force Base, transition crews were scheduled to receive nine simulator training missions. Five of these were to be completed before the students reported to the flight line for aerial instruction. The remainder were interspersed among eight aerial missions as scheduling time permitted, but the final simulator mission was nearly always scheduled after the final aerial mission had been completed.

It was believed that maximum benefit could be obtained from the integrated simulator through judicious spacing of missions in an unlinked and in a linked configuration. This would presumably optimize utilization of training time since individual specialty training could be presented with the simulators disconnected, and then these individual skills could be coordinated during training missions in the linked configuration. Consequently, integrated missions were scheduled for simulator periods 5, 7, and 9.* During conduct of the experiment, however, it was not always possible to adhere to this schedule. After the first two classes had been trained, the simulator missions 5 and 7 were moved to positions 4 and 5, respectively, in the training program. Mission number 9 was accomplished after all aerial flight training had been completed. However, in some instances one or two aerial flights remained at the time the crews reported for the ninth simulator mission. These scheduling changes exerted an unpredictable influence upon the relevance of later analyses of relationships between flight line ratings and the amount and type of simulator instruction received.

The first two integrated simulator missions were accomplished with San Francisco area plates in the Navigation Trainer. The final mission was accomplished with Los Angeles area plates. It should be pointed out that control group crews were exposed to essentially the same mission profiles as the experimental group even though the trainers were disconnected. The missions generally involved operation of the B-52 under IFR and emergency conditions, and included a tanker rendezvous, RBS run, combat breakaway, and ECM run. For the

* These integrated missions are designated as Missions 1, 2, and 3, respectively, throughout later sections of this report.

most part, emergency conditions were programmed to include problem situations which would involve both pilots and navigators in their efforts to arrive at a solution to the problem. Additional emergencies were introduced during periods when certain crew members were not otherwise occupied in order to make the most efficient use of available simulator time. The complete mission profile and emergencies introduced for mission 3 may be found in Appendix A to this report.*

The control group pilots received instruction which was highly similar to that experienced by the experimental group pilots (since navigation directions may be as conveniently given by the instructor pilot as by the navigator himself). And the emergency situations, which form an important part of a pilot's normal training program, will be similar regardless of the trainer configuration. For the navigators, however, the situation was somewhat different. In order to duplicate in the individual trainer configuration all of the inputs that were possible in the integrated configuration, the instructor navigator would be required to follow a lengthy script of interphone communications for all other crew positions. This appeared to place an unreasonable burden upon the instructor navigators in addition to their normal instructional duties. Consequently, transition crew navigators in the control group did not receive practice in interacting with other crew members during simulated emergencies.

The three simulator missions designed for use in the integrated configuration were initially plotted by the instructor navigators involved in the study. These were tested by the instructor navigators, with instructor pilots "flying" the B-52 simulator. These tryouts permitted the investigators to obtain accurate time-required information for each leg of the missions, and to determine the optimum portions of the missions during which certain emergency situations could be programmed. It was intended that the missions should require approximately 2 1/2 hours of actual "flying" time. In order to attain this goal, it was necessary to begin the mission in a "cocked aircraft" (pre-flight completed and ready for start-engines). This procedure deprived the students of cockpit pre-flight practice. However, this can better be accomplished in a less expensive Cockpit Trainer with a consequent saving of relatively costly electronic simulator time.

In addition to the 2 1/2 hours of actual simulator training, time was allocated for crew mission planning activities and for a de-briefing session. Thus, roughly five hours were required for the accomplishment of each integrated mission.

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* Complete mission profiles for missions 1 and 2 may be found in Appendix A, AIR-327-61-FR-239, "Evaluation of a B-52 Integrated Flight Simulator for its Crew Coordination Training Potential as Measured by Crew Communications and Performance Measures", Krumm, Richard L. & Farina, Alfred J., 31 January 1961.

C. Development of Criterion Measures

Four criterion measures were employed to assess the value of the linkage device in promoting coordination activities among transition crews. The first was concerned with comparing the two groups in terms of their accomplishment of the final integrated mission requirements. The second consisted of flight line instructors' evaluations of crew proficiency and crew coordination. The third consisted of reports by the crew members themselves concerning their estimation of the value of the training they had received. The fourth criterion measure consisted of "objective" indexes of performance at the operational bases to which the crews were assigned upon completion of their transition training at Castle Air Force Base.

Each of these measures is discussed in more detail below.

1. Simulator "Flight Checks"

Simulator flight checks were constructed which were based upon more than 1,000 crew errors which had been recorded during the 93rd Bomb Wing Standardization Board flight checks. Review of StandBoard records for the previous 12-month period yielded more than 300 different ineffective actions on the part of various crew members during aerial missions. These were classified by the experimenters according to crew position and type of maneuver being performed, and were placed in a sequence which would be appropriate for their appearance during the performance of each of the maneuvers. These data were supplemented by information obtained during interviews with experienced instructor personnel. From these materials the simulator flight check items were prepared. It should be noted that the simulator checks were of the "objective" type. That is, the items referred to the appearance (or non-appearance) of specific behaviors. The instructor was to indicate merely by checking in the appropriate "yes" or "no" column whether the behavior was observed.

Development of the final form of the checks included review of each item by subject matter experts to insure (a) proper sequencing of the items and (b) their correct phraseology. The flight checks were then administered to a small sample of crews undergoing simulator instruction, and item analyses were conducted. Non-functioning items were deleted from the final forms of the checks.

The pilot check lists used during the study appear as Appendix B to this report.

2. Flight Line Ratings

It had been intended to employ flight checks during aerial training missions which would be similar to those employed during simulator instruction. However, because of the necessity for instructor pilots to function also as safety pilots, it was not possible for them to devote the close attention required for careful completion of the flight check items. Consequently, fairly general rating items were prepared for use on the flight line. These graphic scales consisted of four items, one of which dealt with proficiency and the remainder with various aspects of crew coordination as commonly defined. These forms were completed by each instructor at the conclusion of each aerial mission, except for missions concerned solely with touch-and-go landings.

The rating scales used are presented in Appendix C.

3. Crew Evaluation Questionnaire

It was believed that one of the potentially most useful sources of information would be reports of the students concerning the value of the training they had received. It was felt that a conventional rating system would be inappropriate for two major reasons. First, since a considerable amount of interest in the new equipment had been generated among the simulator instructor personnel, their enthusiasm might be expected to be communicated to the student. Second, the student, being exposed to an experimental situation and a new device, might evaluate the integrated training experience in terms of its associated "glamour."

For these reasons a disguised scale was developed. The scale consisted of 15 items which were common to all crew positions and an additional five items unique to each crew position. Each item concerned an aspect of a typical mission; e.g., performing a routine crew inspection and briefing, performing an airborne radar-directed letdown, etc. The task of the examinee was to rate his own proficiency in performing his job during each indicated mission activity. He was then requested to distribute 100 percentage points among five categories: B-52 academic training; B-52 synthetic training; B-52 flight training; previous training and flying experience; and any other training. It was believed that by masking the intent of the questionnaire through such an apportioning procedure, more valid scale responses could be obtained. However, as an additional safeguard, some items were selected for mission segments that could not be expected to be improved by simulator instruction; e.g., external pre-flight checks, crew line-up and briefing, etc.

As with the other measures cited above, this device was prepared in preliminary form and administered to a small sample of transition crews. Their comments were particularly helpful in eliminating certain wording difficulties and ambiguities from the final form of the scale (see Appendix D).

4. "Objective" Measures of Performance

There are certain traditional measures of crew performance which are routinely obtained at Strategic Air Command operational bases. Among these are records of crew navigational and bombing accuracy. Although these might be conceived of as indicators of navigator or radar-navigator proficiency, it is generally agreed that most crew members play some role in minimizing error scores. For example, on the B-52, the ECM operator takes sextant readings for the navigator and the pilots are responsible for maintaining a stable platform during the sightings. The pilots are also responsible for maintaining headings requested by the navigator. The radar navigator frequently works with the navigator in pre-computing celestial data. Consequently, navigational accuracy reflects credit upon the entire crew and, in this sense, may be regarded as an indicator of crew coordination (as well as crew proficiency, of course).

If substantial benefits could be achieved in transition training by crews experiencing integrated simulator training, then this improved crew coordination might well be reflected in operational performance. On the other hand, this sort of criterion measure is quite a remote one, and one that may be influenced by many variables. Consequently, a failure to reflect differences attributable to the training program would not necessarily indicate that the training was without value. The experimental design called for only three exposures to the integrated simulator and the measures of operational performance were obtained for the six-month period following transition training.

The operational bases to which the transition crews were assigned were requested, through Strategic Air Command Headquarters, to provide six-month follow-up information in the following areas:

a) the number of hours of instructional time required by the crew at its operational base before it was permitted to solo,

b) navigational average circular error scores (Nav CEA's), and

c) radar bombing average circular error scores (RBS CEA's).

Some of the difficulties in obtaining these data, and an indication of the degree of attrition in the experimental sample as a result of these difficulties, are presented in Appendix F.

5. <u>Additional Criterion Measures</u>

One purpose of the study was to derive additional measures that might be indicative of crew differences in coordination activities. One of these (crew evaluations) was described above. Another which was investigated on a preliminary level was concerned with types of communications. Interphone conversations during selected portions of the integrated missions were recorded and later analyzed in terms of pattern and volume. A detailed description of the procedures used and the results obtained appears as Chapter IV of this report. Implications of the results are discussed in Chapter V.

III. RESULTS

A. Simulator Flight Checks

During construction of the simulator flight checks, items were identified in terms of their relevance to individual proficiency or to crew coordination activities. This categorization permitted the derivation of several types of scores: the proficiency items totaled for the pilot team, the navigator team, or for both teams; the crew coordination items totaled in a similar manner; all items combined to yield total scores.

In scoring the flight checks, "the points-off" procedure was used. This is simply a procedure whereby the errors are subtracted from a constant value so that higher scores reflect more favorable performance. However, for the final simulator mission, the number of errors were interpreted in terms of the number of items which were applicable. This was necessary because, on this simulator mission, the crews were confronted with an emergency situation which was solved (preferably) by a controlled crew bailout, but was frequently "solved" by an inadvertent crash. Thus, some crews were exposed to more items than were others and had greater opportunities to commit errors.

Results of the comparisons that were made between experimental and control group performance on the third integrated simulator mission are presented in tabular form in Table 2. It will be noted that the experimental group navigators received significantly fewer "points off" for coordination scores and for total scores.

When the experimental group's performance was considered in terms of per cent of items correct, it was noted that in all instances there was a steady improvement from the first to the third integrated mission.

The relationship of the simulator "flight check" proficiency and coordination scores to the other criterion measures was studied. Simulator proficiency scores were found to be significantly related to "hours required to solo" ($r = .61$)*. Proficiency scores, however, bore no significant relationships with navigational or radar bombing accuracy. Simulator "flight check" coordination scores were significantly related to both "hours required to solo" and to the flight line coordination ratings ($r = .80$) and ($r = .50$). Finally, simulator "flight check" proficiency and coordination scores were significantly related to each other ($r = .63$). All other interrelationships between the "flight check" scores and other criterion measures were non-significant.

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* Spearman rank correlations were used throughout the report.

Table 2

Comparison of Experimental and Control Group Scores
on Simulator Flight Checks
(Final Simulator Mission)

	Experimental		Control				
PILOTS	Mean	Sigma	Mean	Sigma	DM	σDM	C.R.
Points-off Proficiency Items	16.29	10.8	13.86	8.61	2.43	2.25	1.08
Points-off Coordination Items	4.26	4.57	3.97	3.16	.29	.91	.32
Points-off Total Score	20.55	14.67	17.03	11.52	3.52	3.04	1.16
NAVIGATORS							
Points-off Proficiency Items	1.82	1.98	2.35	2.02	.53	.46	1.15
Points-off Coordination Items	.74	1.14	1.49	1.26	.75	.26	2.89**
Points-off Total Score	2.55	2.75	3.84	2.88	1.29	.65	1.99*

* Significant at the .05 level
** Significant at the .01 level

B. Flight Line Ratings

The flight line rating items were analyzed initially in terms of the crew average rating for proficiency and for coordination. These averages were obtained by combining the instructor pilot and instructor navigator ratings for all missions accomplished on the flight line. The experimental and control group averages were nearly identical.

A second analysis was concerned with the mean ratings (proficiency and coordination) obtained for each of the flight line missions considered individually. It was noted that within the pilot groups, the experimental pilots were rated lower than the control group pilots throughout the flight line missions. Conversely, the experimental group navigators were fairly consistently rated higher than the control group navigators on proficiency and coordination. None of the differences met accepted standards of statistical significance.

A third analysis was concerned with comparing experimental and control group ratings for the first flight line mission only. The rationale for considering only this first mission rating was that the experimental group had completed two missions in the integrated simulator configuration prior to their first flight line mission. If their work was noticeably improved as a result of these missions, it could be expected that this improvement would be reflected in their performance during their first flight line mission but that it might tend to "wash out" as the control group gained experience in flying together.

In this respect, it was noted that the experimental group navigators were rated appreciably higher than were the control group navigators on both proficiency and coordination. The experimental group pilots were rated slightly higher than the control group pilots on coordination, but slightly lower on proficiency. The differences in this latter case were of the magnitude of two or three tenths of a rating point and, again, were not statistically significant.

Regarding the relationships between the flight-line proficiency and coordination ratings and other criterion measures, only the coordination rating and "hours required to solo" were significantly related ($r = .86$). As was the case with the simulator scores, the flight-line proficiency and coordination ratings correlated significantly with each other.

C. Crew Evaluations

The first analysis of the crew questionnaire was concerned with discovering possible discrepancies between pilots' and navigators' assessments of the value of their simulator training program. Mean ratings were computed for the pilots and navigators within each of the two groups. It was noted that substantial differences existed between the pilots' and navigators' opinions with respect to certain items. Consequently, crew positions were considered separately in subsequent analyses.

The percentages assigned to the B-52 synthetic trainer category were tabulated, for each item for the experimental and control groups, and a median value was calculated for each item. Using the median as a cutting point, the frequency data were entered in 2 x 2 tables and Chi-square analyses were computed. These indicated significant differences between experimental and control groups for selected items. Interestingly, these differences were obtained only for the items which were included in the simulator training missions.

When the responses of the experimental and control group <u>pilots</u> were compared, significant differences were noted for the following:

	Item	Chi-Square	Prob.
3.	Complete your part in a before pre-IP bombing equipment check.	12.79	.001
4.	Accomplish your part in a radar bomb run.	8.33	.01
5.	Complete your part in a true heading check.	4.84	.05
9.	Accomplish your part in planning a maximum effort mission involving 40 hours of continuous flight.	5.42	.02
11.	Preform your part in a GCA approach and landing.	4.80	.05

When the responses of the experimental and control group navigators were compared, significant differences were noted for the following:

Item	Chi-Square	Prob.
2. Perform your part in an emergency airborne radar-directed approach.	14.51	.001
6. Accomplish your part of a routine crew report.	11.32	.001
7. Complete your part in an ECM Run against an ADC radar site.	14.84	.001
14. Accomplish your part of an air refueling rendezvous and fuel transfer under conditions of poor visibility.	18.27	.001
20. Accomplish your part in a bomb run check.	8.35	.01

These results yield only indirect evidence of improvements in crew coordination as a result of experience in an integrated simulator. There is no question that the experimental group felt they received a significant portion of their capability in accomplishing these tasks as a result of their simulator training. The questions were phrased ". . .your part. . ." which implies an improvement in individual proficiency. However, each of these 10 items involves several crew members working in unison. Hence, the significant differences noted may be assumed to indicate an improvement in crew-coordination activities.

Slightly more direct evidence of improvements, as a result of simulator experiences, lies in the relation of scores on certain of the crew evaluation items to later criterion measures. Three items were selected for study, numbers 2, 14, and 20 (see above). These may individually be considered as single-item predictors. Crews were ranked in terms of the number of points they allocated to the B-52 simulator in improving their accomplishment of each of these tasks. These ranks were then compared with the crews' rankings on navigational and bombing accuracy.

None of the percentage tabulations was related to the measure of navigational accuracy. However, all three were significantly related to bomb scores. Item 2 correlated .95, and items 14 and 20 each correlated .76 with this criterion.*

Each of these rank-order correlations is statistically significant for the sample size involved. However, they must be interpreted with considerable caution because of the small sample involved in this particular analysis. Bomb/nav criteria were available for only nine crews of the original sample (see Appendix F).

D. "Objective" Measures of Performance

The attrition factors mentioned in Appendix F resulted in performance measures of "hours required to solo", NAV CEA, and RBS CEA, being obtained for only 27 of the 75 study crews (15 experimental and 12 control crews). Data were also obtained for nine other crews who completed B-52 transition training during the study period, but were not part of the study sample. These we designated "standard" crews and their performance scores were entered into the analyses.

The standard crew scores enabled the investigation of training effectiveness to be extended from a comparison of two groups differing in amount of integrated training (experimental group--three missions, control group--one mission) to a three group comparison which included a "no-integrated mission" group. Table 3 presents the performance information about these groups.

Spearman rank order correlations among these measures ("hours required to solo", navigational accuracy, and radar bombing scores) revealed that, for the present sample, these measures were independent of each other. Correlation coefficients relating these three performance measures to other criterion measures employed during earlier phases of the study have been reported in previous sections. In brief, "hours required to solo" bore significant relationships to flight line coordination ratings and simulator check coordination scores. Radar bombing accuracy scores were significantly related to certain responses of the crew evaluation questionnaire. No other significant relationships were found between these performance measures and the remaining criterion measures.

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* To avoid confusion in discussing negative correlations with "error" scores (CEA's), we have adopted the procedure of subtracting all error scores from a constant value. Thus, positive relationships can be expressed directly.

Table 3*

Comparison of Experimental, Control, and Standard Groups on "Objective" Performance Indexes

	Hours to Solo	NAV CEA	RBS CEA
Experimental Group	136	109	112
Control Group	100	111	100
Standard Group	116	100	111

None of the differences among the above groups was statistically significant. However, the experimental--control groups difference in "hours required to solo" had an associated probability level between .10 and .05.

* The actual data are classified for security reasons and, hence, have been modified for inclusion into this unclassified report. The "best" average score for each of the three measures was converted to an index of 100, and the remaining averages were expressed in terms of their relations to it. For example, the control group took the least time to solo whereas the experimental and standard groups required 36% and 16% more time, respectively.

IV. THE DEVELOPMENT OF A COMMUNICATION CATEGORY INDEX OF CREW COORDINATION ACTIVITIES

A. Introduction

One aim of the present study was to explore the potential value of alternative indexes of coordination activities. Early phases of the research were devoted to the preparation of theoretical analyses of coordinative behaviors, exploring the nature of such activities in routine and in emergency situations. A more thorough presentation of the topics considered is to be included in a later report. However, in brief, a central hypothesis was that crew members could assist others in specified ways, one of the most important being in the area of voluntarily providing assistance to another during periods of overload.

Also, prior informal observations by the experimenters of various kinds of small military work teams seemed to indicate a change in pattern of communications as the team became experienced in working together. Over time, there appeared to be a decrease in the necessity for asking for directions or for directing activities, and a corresponding increase in non-work-directed remarks. For these reasons, it was believed that excerpts of intra-crew communications might provide source material for the calculation of indexes of crew coordination activities. Specifically, these indexes were to be concerned with two aspects of communication: volume and pattern. Volume is the measure of general "idea productivity" and pattern refers to the <u>type</u> of communication. Qualitative aspects of the content of the communications were not assessed in this pilot study, though they would form an integral part of a more comprehensive treatment of this issue.

B. Procedure

1. <u>Equipment</u>

Suitable evaluation of this sort of cooperative behavior during the study necessitated construction of special observation stations. This was possible at the pilot's position; however, the design of the navigation trainer precluded construction of an observation station at this position. Consequently, direct observation techniques were limited to assessment of pilots' side-by-side coordination. The observation station proved to be of primary value in the collection of transcripts of interphone communications.

The observation station was a light-proof box substituted for an access panel beside the co-pilot position of the simulator. A frosted window beside the co-pilot was replaced by a two-way mirror. A special jack box and power source were mounted within the observation station. The power source provided current for operation of a tape recorder; the jack box permitted the experimenter to monitor crew interphone conversations and also to communicate directly with the instructors and simulator operators via private interphone. Thus, the experimenter was provided with both visual and auditory cues to signal him to initiate recording of interphone communications.

Normally, a considerable amount of side-by-side communication occurs at the pilot and navigator stations through direct (non-interphone) conversation and through hand signals. It was, therefore, necessary to request crew members in the simulator to rely solely on the interphone for all their communications. To discourage them from direct communication, the engine-noise signal from the flight simulator was fed into a speaker mounted in the navigation trainer and the sound was introduced at full volume. During early try-outs of the integrated missions before the actual study began, it was found that the crews adapted to the increased noise level by shouting. Consequently, it was requested that student crews comprising the experimental sample wear their flight helmets during the integrated simulator missions. This stratagem resulted in all verbal communications being transmitted via interphone. (Interestingly, there were no objections by the students to this requirement. It may be that this totally unusual requirement merely added to the "realism" of their integrated simulator experiences.)

2. The Sample

During the course of the study, 32 integrated trainer missions, or portions of such missions, were recorded. Four crews were measured on all three integrated missions, three on two missions, and eleven on one of the three missions. Twelve experimental and six control crew missions were recorded. Typed transcripts were prepared from the recordings which indicated the crew member who was speaking and what was said. The tape was then re-played and elapsed-time information was entered on the margin of the transcript. The time information was included in order to (a) equate at a later time for unequal lengths of the segments, and (b) to permit computation of an index of communication volume (in terms of mean number of message units per minute).

Much of B-52 crew interphone activity normally consists of checklist reading. This sort of activity provides little to discriminate among crews. Consequently, the segments of communication which were to be recorded were those triggered by the several simulated emergencies programmed for each mission. The general procedure which was adopted was to record from the initiation of a simulated malfunction to the time that a satisfactory solution was achieved. This meant that unequal time samples of communications were obtained. However, equal time segments would have introduced a quantity of routine transmissions for the crews who had handled the "emergency" expeditiously. Since the relation between routine and emergency communication patterns is unknown, it is possible that proficient crews would evidence different communication patterns simply through this inadvertent inclusion of routine interphone interactions. This sort of bias appeared to be more serious than that introduced by variability in length of recorded segments.

3. The Category System

The transcripts were prepared for scoring by indicating the point at which a malfunction was introduced and the point at which the "emergency" was finally resolved. Within these mission segments, message units were indicated. A message unit was defined as a word, phrase, or sentence expressing no more than one complete thought. The message units were indicated directly on the transcripts so that these could later be independently categorized by several judges.

The first categorization of the message units involved use of a modified form of Bales' interaction category system (1). This system was employed to facilitate interpretation of the findings in the light of results obtained in analyzing communications in other contexts. The twelve Bales' categories involve six "emotionally toned" scalings which are difficult to assess reliably from transcript data. Therefore, for practical purposes we were limited to a six-category scheme. The great majority of message units were classified into two of these remaining categories and this limited spread did not provide sufficient information to permit differentiation among crews.

Although suited to discussion type groups, the Bales' system appeared to have certain limitations when applied to communications in operational contexts. Consequently, a new category system was constructed to fit the specific situation of B-52 crew emergency communications (see Appendix E). This system has three major categories and four subsidiary categories. The three major categories are further subdivided into subcategories. In brief, the system is as follows:

A. Requests Information

1. Factual data
2. Course of action
3. Opinion or evaluation

B. Provides Information (responses to specific requests)

1. Factual data
2. Course of action
3. Opinion or evaluation

C. Volunteers Assistance

1. Factual data
2. Course of action
3. Opinion or evaluation

D. Orders Course of Action (A/C commands)

E. Formal Indication of Compliance to Orders

F. Irrelevant Remarks

G. Acknowledgement of Receipt of Messages

It will be noted that category D (orders course of action) is a special case of the category C-2 type. This was introduced to represent specific inputs by the aircraft commander. As the designated leader of the aircrew, he alone can issue commands, and the frequency of message units in this category reflects the degree to which he exercised this prerogative. Category E is a counterpart to D in that it contains "formal replies signifying the order will be carried out". Category F contains "Irrelevant Remarks", and "Responses to Irrelevant Remarks". The last category, G, is used to record acknowledgements of receipt of messages other than those classified in category E.

A more detailed definition of the categories is as follows:

A. DIRECT QUESTION

1. Requests Information.

This subcategory is intended for messages seeking information which is readily available via the inspection of a display (dial, instrument, gauge), the reading of a check-list or through immediate recall on the part of the person being questioned. Such messages request factual information as opposed to judgmental information.

Examples: "Navigator from AC, what is our present position?"

"Pilot from AC, what is our flare speed?"

2. Requests Course of Action or Information Regarding Course of Action.

This subcategory includes all questions pertinent to the choice, initiation, continuation, modification, or cessation of a course of action.

Examples: "AC from CP, should I switch to alternate power supply when we reach 14,000?"

"AC from CP, do you want me to check that alternator again?"

3. Requests Opinion or Evaluation.

This category contains messages which request an opinion or evaluation of an action or situation. The evaluation might be in terms of possible outcome, effectiveness, desirability, soundness, or appropriateness of the action.

Example: "Gunner from CP, how did #4 engine look during the last restart?"

B. DIRECT RESPONSE

1. Provides Requested Information.

Example: "AC from navigator, present heading is 248 for Madera, sir."

2. Gives Course of Action or Information Regarding Course of Action as Requested.

Example: (AC to CP) "Switch to alternate power source at 14,000."

3. Gives Opinion or Evaluation.

Example: (Pilot from Gunner) "You had some black smoke sir, but it looks OK now."

C. VOLUNTARY INPUTS

1. Volunteers Information.

Example: (CP talking) "Oh oh, we've got a light on #2 tank."

2. Volunteers Course of Action (for self or others).

Examples: (CP talking) "I'll check my circuit breakers for that alternator failure on #1."

(CP to ECM) "Check your equipment is turned off."

3. Volunteers Opinion or Evaluation.

Example: "This is CP. Apparently we are having a malfunction. I think valve 29 failed in the closed position."

D. DIRECT COMMAND (Orders Course of Action)

This category is the equivalent of subcategory C-2 (volunteers course of action) except that it is reserved for use of the Aircraft Commander's messages of this type.

Example: "Crew from AC, shut down all unnecessary gear."

E. RESPONSE TO COMMAND (Formal Reply Signifying Action Will Be Carried Out)

Example: "Roger sir, Radar shutting down."

F. IRRELEVANT REMARKS

This category is intended for messages which have no direct relevance or value to the ongoing situation. In addition, any remark by the AC to the effect that he is uncertain or does not know what action to take is placed in this category.

Examples: (AC speaking) "What are you doing to the airplane?"

(RN) "I was turning with the slew button."

(AC) "You almost knocked Rocky's teeth out."

(RN) "As long as they're his own, its OK."

G. ACKNOWLEDGING RECEIPT OF MESSAGE

This category contains all acknowledgements of messages received.

Examples: "Roger", "I understand", "OK", etc.

It was hypothesized that categories C and D, considered in relation to the others, would provide meaningful information concerning the degree of "coordination" exhibited by a crew. That is, team members who were alert to the needs of other members of their crew would voluntarily provide assistance (category C), whereas crews less attentive to needs of their colleagues would wait to be asked (category A). Similarly, an authoritarian commander might take it upon himself to handle all emergencies and issue commands (category D) which would tend to stifle unsolicited inputs (category C). These, and other, hypotheses were investigated during the course of the analyses of this exploratory study in an effort to determine potentially useful indexes of coordination activities.

4. Stability of the Category System

The stability of the category system was assessed in terms of inter-judge agreement. A sample of mission segments was selected and message units were independently categorized by two experimenters. The raters then reviewed together each of the message units to determine possible areas of misinterpretation. The category definitions were refined to reduce ambiguities and a second sample of segments was independently classified. The category definitions were once again refined and a third categorization was accomplished. During this process, rater-rater agreements (rank-order correlations) increased from .86 to .98. The percentage agreement on the third effort approximated 100%, so the system was judged to be sufficiently well-defined for use in the analysis. Once the category definitions were stabilized, all mission segments (including those employed in the refining operations described above) were scored (or rescored) by a single experimenter.

Although the stability of the classification scheme seemed to have been established, other questions of stability appeared to be relevant. For example; does type of emergency affect the communication pattern? Does a crew change its communication pattern within a mission?

The integrated missions contained a variety of "emergencies" (engine fire, engine icing, hydraulic pack failure, oxygen pressurization failure, inoperative landing gear, electrical power failure, fuel leaks, low oil pressure, inoperative auto-pilot, runaway trim, etc.) which were programmed in a particular order. The sequence of appearance was initially selected to optimize the use of available training time. (Some pilot emergencies were programmed for times during which the pilots had no major duties. Others (involving pilots and navigators) were programmed to appear when crew members were already occupied with various tasks.) Theoretically, each crew under-going the same integrated mission should have experienced identical emergencies in an invariant order of presentation. However, such was not the case. (1) Simulator malfunctions occasionally prevented the presentation of some emergencies. (2) Some crews did not detect the programmed malfunction and, thus, no recorded interaction was possible. (3) In the third integrated mission, the sequence of events was structured to force the crew into a controlled bail-out situation. Thus, the crews differed with respect to the length of time that they stayed with the "aircraft" and consequently they experienced different number of emergencies.

As a result of these factors, the crews differed with respect to length of communication segments scored and with respect to numbers and types of emergencies experienced. It was apparent that crew differences in number of emergencies experienced (i.e., number of message units scored) could be controlled by studying the apportionment of the message units among categories, rather than the absolute number of message units. However, if type of emergency determined the nature of this apportionment, then comparisons among crews would have to be limited to those crews who had experienced identical emergencies.

The test of the influence of type of emergency upon apportionment was conducted in two phases: phase 1 considered single crew responses to different emergencies and phase 2 considered responses to single emergencies by different crews.

For the first phase, split-half comparisons were made of a crew's categorized responses. Message unit apportionments for half the emergencies during a mission were compared with apportionments for the remaining half. Both first half-second half and odd-even strategies were followed in dividing the emergencies into two groups. Chi-square analyses were conducted for eight crews in this manner, with uniformly negative results. It appeared that type of emergency did not significantly affect the communication pattern for single crews, so this testing was abandoned.

For the second phase, three major emergencies were selected: engine fire, alternator failure, and runaway trim. The responses of all crews experiencing these emergencies were summed, for each emergency, and the apportionments were compared for the emergencies taken two at a time. None of the three Chi-square tests approached statistical significance.

It appeared, therefore, that the classification scheme for communications was a stable one. Attention was next directed toward assessing its meaning.

C. Results

1. "Validation" of the Communication Pattern Index

It had been hypothesized that the pattern of communication exhibited by a crew might serve as an index of the degree of "coordination" which existed among the crew members. Specifically, it was believed that a relative preponderance of voluntary remarks (category C) might reveal an alertness to others' needs and a readiness to assist.

A number of reference variables were available to determine the relationship between patterns of communication and indexes of proficiency or "coordination." These included "coordination" ratings by flight line instructors, simulator "flight" checks, crew evaluations, and measures of operational performance on tasks which presumably require a high degree of crew coordination for their successful accomplishment (hours required to reach solo proficiency, RBS scores and navigational CEA's). Communication patterns were assessed in terms of each of these in an effort to reveal potentially fruitful areas for further investigation since the limited sample available appeared to preclude the discovery of definitive truths.

a. Flight line ratings. All crews were ranked in terms of coordination ratings received on the first flight line mission. This ranked group was then divided into thirds and a cumulative communication pattern was determined for each of the three subgroups. The differences among patterns of the high-ranked, mid, and low-ranked subgroups were subjected to a Chi-square test. The test results indicated that significant differences existed among the subgroups. Since groups which differed in terms of coordination also differed with respect to communication pattern, it was concluded that such patterns were potentially useful indexes of coordination. Further tests were, therefore, made to clarify the relationship.

b. Integrated training. The next logical step was to test whether the integrated training was related to communication pattern differences. If the training did influence a crew's communication pattern, then pattern differences should exist between the experimental and control groups. This analysis contrasted the third integrated mission of the experimental group with the sole integrated mission of the control group. Again it was discovered that the groups differed significantly in their communication patterns. It may be hypothesized, therefore, that the integrated training missions were instrumental in modifying the communication pattern of the experimental group crews. This hypothesis is tenable if it is discovered that (a) communication patterns of the control group on its first (#3) integrated mission are not dissimilar to those evidenced by the experimental group on its first (#1) integrated mission, and (b) communication patterns of the experimental group change significantly as they progress from the #1 to the #3 integrated simulator missions.

Results of the several tests generally supported the value of integrated simulator training in effecting changes in communication patterns. Insofar as such patterns are indicative of crew coordination, the training was effective. This conclusion is supported by (1) the lack of initial differences between patterns exhibited by the experimental and control groups on the first integrated mission experienced by each; (2) the significant differences between patterns of the groups on the third integrated mission; and (3) the significant differences among patterns exhibited by the experimental group as it progressed through the integrated simulator program. It was discovered that the first integrated mission apparently effects the bulk of any change in the communication pattern. The experimental group pattern changed significantly from the first to the second mission, but incremental improvements from the second to the third integrated mission were not sufficiently marked to reach statistical significance.

c. Simulator flight checks. The simulator flight checks consisted of items relevant to individual proficiency and to crew coordination activities. This categorization of items permitted separate "proficiency" and "coordination scores" to be derived for each crew. Present analyses are concerned solely with the relation of the "coordination" scores with communication patterns exhibited by the crews.

All of the crews (experimental and control crews) were ranked with respect to these flight simulator coordination scores and then divided in accordance with the design used earlier in relating pattern to flight line coordination ratings. The cumulative communication patterns were determined for the groups and tests of significance were conducted. It was found that the communication patterns of these "well coordinated" and "poorly coordinated" groups differed to an extent that would be expected, by chance, fewer than once in one hundred trials.

Thus, as with the flight line "coordination" ratings, a significant relationship is established between communication patterns and flight simulator checklist scores of "coordination." It is noteworthy that the simulator checklist coordination scores were significantly related to the flight line coordination ratings ($r = .57$).

d. "Objective" proficiency measures. All crews were ranked in accordance with their performance on each of these measures: hours required before solo at operational base, and navigational and bombing scores obtained during the first six months at their operational bases. These groups were then divided at the median and identified as "best" and "worst."* In all three instances,

* These scores are classified for security reasons. Since tabular presentation in this report would require the report to be similarly classified, numerical data are with-held.

the patterns were quite similar, with the exception of "C category" responses (volunteers information). It appeared that crews scoring best on navigational and bombing criterion measures exhibited a preponderance of voluntary responses, consistent with initial hypotheses (see Table 4). Consequently, the patterns were re-grouped, isolating C category responses versus all others, in a 2 x 2 table. Chi-square values obtained were significant at the .02 level for navigational accuracy and approached significance ($p < .10$) for bombing accuracy.

Table 4

Percentage Distribution of Message Units Within
Communication Categories in Terms of Distal Criteria

Category	Hours to Solo		Navigation Accuracy		Bombing Accuracy	
	Best half	Worst half	Best half	Worst half	Best half	Worst half
A	13.4	10.0	10.7	13.0	12.2	12.8
B	12.7	10.6	11.1	12.4	11.6	12.6
C	44.8	46.6	49.6	41.7	48.7	42.7
D	15.2	16.3	14.3	17.1	13.8	16.6
E	6.2	6.5	6.4	6.2	5.6	6.4
F	1.9	.9	1.2	1.7	2.1	1.2
G	5.8	9.1	6.6	7.9	6.1	7.6
Total	100.0	100.0	99.9	100.0	100.1	99.9
Number of Message Units	567	461	512	516	378	499
Number of Crews	5	4	5	4	4	4

2. Analysis of the Communication Volume Index

The second index of communication coordination which was investigated was concerned with what might be termed "verbal productivity" of the crews. This was defined as the mean number of message units per minute produced by a crew in responding to the simulator "emergencies." (It should be understood that this is not a "words per minute" score, but an "ideas per minute" score. Subsequent research should investigate the relationship between the two types of measures since there would appear to be important theoretical distinctions between them.)

The index of communication volume proved to be of primary value in illuminating certain of the relationships described above. For example, this index bore a significant relationship with flight line instructors' ratings. Ratings of crew coordination and crew proficiency correlated .47 and .45, respectively, with the communication volume index. These Spearman-rank coefficients are both significant at the .05 level.

The index was not significantly related to any of the following reference variables: simulator "flight" checks, hours required to solo at operational base, navigational accuracy scores or bombing accuracy scores.

The investigation of a possible relationship between communication pattern and communication volume yielded interesting results. Significant pattern differences were noted between groups divided at the median communication value. These appeared to be limited to the category C Voluntary Inputs. Consequently, crews were ranked in terms of their "C" category percentages and a rank-order coefficient was computed. The rank correlation between these variables was -.70, which was significant at the .01 level. This inverse relationship indicated that crews who volunteered relatively more inputs provided fewer message units per minute.

To summarize these findings, crews who provided a high number of message units per minute were ranked high on "coordination" by their flight line instructors. Yet these crews provided relatively few voluntary responses, a type of response that had:

a) been hypothesized as indicative of crew coordination.

b) been found to increase as integrated simulator experiences increased, and

c) been found to relate significantly to objective indexes of coordination activities.

V. DISCUSSION AND CONCLUSIONS

The primary purpose of this study was to assess the value of an electronic linkage device in promoting crew coordination training among B-52 transition crews. To accomplish this purpose, various criterion measures of "crew coordination" were employed during the training situation and in later operational duty. Certain of these measures were structured in accordance with more or less "standard" techniques of assessment, e.g., flight checks and "objective" performance measures. These data, though easily obtained, are partially influenced by proficiency factors and thus provide only indirect evidence of coordination. Consequently, a secondary purpose of the study was to develop new techniques of measuring crew coordination, *per se*. The following sections will discuss the findings of the study in terms of these two purposes.

1. Assessment of the Linkage Device

Assessment of the linkage device was accomplished through use of several different criterion measures of "coordination." Four of these were directly relevant to the training situation, in that they were designed to assess intergroup differences in coordination during the course of the training program. Such measures were: the simulator flight checks, flight line ratings, crew evaluations, and analysis of interphone communication recordings.

It was also considered pertinent to the evaluation to determine whether any intergroup differences produced during the training period would remain stable during the months of operational duty that followed. An acceptable test of this stability would have required that the same "coordination" criterion measures employed during training be reapplied during the operational period. However, repeated evaluation of this type was not possible within the scope of the study. Consequently, a compromise was adopted by selecting certain "objective" (and readily available) performance measures which appeared to be influenced to some degree by crew coordination. These measures were: "the number of hours required to solo" at the operational base, navigational accuracy scores, and radar bombing accuracy scores.

During the data analysis phase of the study, the several sets of scores were interrelated and were individually related to the type of training the groups received during the experimental phase.

On the basis of the several analyses, the weight of evidence is substantially in favor of the integrated simulator as a device for promoting crew coordination training. This conclusion is based primarily on results obtained from the simulator flight checks, the communication analyses of pattern and volume, and the crew evaluation questionnaire.

The simulator flight checks indicated that the experimental group navigators performed significantly better with respect to "coordination" and total ("coordination" plus "proficiency") scores than did their counterparts. This small but statistically significant difference is "washed out" when navigators' and pilots' scores are combined and crews and intergroup differences are tested. Yet, if the integrated training was beneficial to the navigator team and was not detrimental to the performance of the pilot team, then it may still be considered a useful improvement over existing synthetic training methods.

The communication analyses indicated that significant pattern differences existed between the experimental and control groups on the No. 3 integrated mission. It also indicated that, within the experimental group, significant pattern differences were achieved as the group progressed from the first to the third integrated mission. Thus, the experimental training program may be assumed to have effected definite changes in the crews' communication behavior. Insofar as communications are indicative of coordination, the same conclusion applies to crew coordination behavior. This point will be discussed at length, below.

Indirect evidence of integrated training effectiveness is provided by the significantly greater recognition afforded by the experimental pilots and navigators with respect to benefits they felt they had derived from synthetic training. Thus, the crew evaluation data also support the conclusion that the integrated training program effected significant changes.

Although not all criterion measures directly supported the value of the integrated training device, none indicated it to be inferior in any respect to the standard training devices which served as control devices in the study. Both the flight line ratings and the three "objective" performance measures revealed that the experimental and control groups were essentially similar in terms of these comparators. It should be pointed out, however, that the "objective" measures represented crew performance during a period of at least six months following completion of the transition training program at Castle Air Force Base. The intergroup differences which had been found at the end of the training program could (during this period) have been vitiated by any of a host of intervening activities, including additional formal flight instruction and numerous operational flights. Moreover, acceptance of performance scores as criteria of coordination was a practical necessity. The exact degree of relevance of such measures to crew coordination has not yet been determined.

It would appear that, at the level of skill represented by B-52 transition crews, the amount of integrated simulator training that is required is relatively small. (In view of the advanced skill level of the crew members as presented in Table 1, it is remarkable that improvements in basic coordination behaviors are still possible.) The writers believe that the major benefits possible from this type of training device are still to be revealed. It seems likely that at later stages of training (combat crew training as opposed to transition training), the device will provide for training in coordinative actions during types of emergencies that may reasonably be met in combat situations, but with which transition crews are not prepared to cope.

It is recommended that for even further advanced training programs (such as for multi-man space vehicles) integrated crew training capabilities be routinely incorporated in the design of synthetic training devices. It is important, in this regard, to provide a quick-disconnect capability so that the trainers may be used in individual or crew configurations. The interaction between crew coordination and individual crew member proficiency has not yet been quantified. However, it is clear that individual proficiency is of primary importance. Until further study has determined the optimal programming schedule for the sequencing of individual and crew missions, it would appear desirable to spend the bulk of training time in raising individual proficiencies to a predetermined standard of excellence. Integrated crew training missions could be introduced with increasing frequency as crew members approached criteria of "combat-ready," "lead," or "select" proficiency. Eventually, all training missions of the crew would probably be scheduled for the integrated configuration.

2. <u>Newly Developed Coordination Measurements</u>

a. At the time the study was initiated, the American Institute for Research was engaged in a study of a "Crew Operating Procedures" (COP) test as a possible criterion measure of crew coordination (3). This was a replication of the work being conducted at the Ohio State University (2). It was initially intended that a "COP Test" might serve as a criterion measure in the present study to assess the integrated crew simulator. However, technical problems encountered in scoring and interpreting this type of test suggested that use of it in the present study would be premature. The method appears to have substantial promise, however, and additional research is recommended to reduce item ambiguity and to simplify scoring of the test.

b. Crew evaluations. The crew evaluation questionnaire used in this study provided data which enabled a differentiation to be made between the experimental and control groups with respect to their perceptions of the benefit of the integrated trainer. It would appear that the disguised nature of the rating scale and the intentional inclusion of non-relevant items were both successful techniques for acquiring, in a necessarily indirect manner, the reactions of the study crews.

Although these crew evaluations represented, in effect, criterion "ratings" of the integrated crew simulator, they functioned nicely as predictors of later performance. The navigators' evaluations of the integrated simulator in terms of benefits they derived from performing specific radar bombsight tasks correlated significantly with later bombing proficiency scores. This would appear to be a direct testimonial of the benefits of integrated crew training. However, some relevant questions remain. Why, for example, did points attributed to "prior flight training" not relate to bombing scores? It would appear that we face here a basic problem of the relative values of actual flight versus synthetic training with the benefits (in this instance) in favor of the simulator. Clearly, this area deserves some concentrated study. The implications for possible future use of simulators as a substitute for part, or all, of flight training are quite marked.

Another point worthy of consideration is the type of results obtained from comparisons of the pilot and navigator responses to the crew questionnaire. It was noted that the pilots in the experimental group differed significantly from those in the control group on five of the questionnaire items. The experimental navigators differed from the control navigators on a <u>different</u> five items. Hence, it must be concluded that the type of training received in the integrated simulator was differentially valuable as far as the crew members were concerned. Yet, the integrated simulator provided training values which were not available to crews trained as sub-teams. This would suggest that even though the pilots and navigators had different impressions of the value of their training, it was important that they receive this training <u>as a crew</u>. In other words, although the pilots might not feel they were learning something new by performing a certain maneuver, the navigators received definite benefits from the pilots' presence. A similar situation prevailed for maneuvers which were "old hat" for the navigators. It is possible that an elaboration of the ground environment training effort to include other crew positions might exert a proportionally greater effect upon crew proficiency, as an extension of this phenomenon.

c. Crew communications. Results obtained from analyses of recorded interphone communications indicate that this is probably one of the most sensitive means of assessing crew coordination activities.

Interest in recorded conversations as a possible source of coordination indexes was prompted by initial theoretical considerations regarding the general nature of coordination. It had been hypothesized that coordination activities might be of two primary types--"mechanical" or SOP coordination and "response improvisation." This latter type we regarded as the "true" measure since it appeared to reflect not only a crew member's ability to assist, but also his willingness. This is the sort of situation cited as critical by Hood and by Hemphill in that the crew members share in the consequences of an activity. Consequently, attention was directed toward determination of the possible promotion of this type of response by the integrated crew simulator training. This could be measured by observer tallies, but a more reliable method appeared to be recordings of the message units. It was believed that if integrated simulator training were effective in promoting crew coordination, such effects should be detectable through analyses of the communications of the experimental and control group, with particular attention devoted to incidence of voluntary inputs.

The recorded communications were analyzed in terms of two components: pattern and volume. Pattern is here defined as the distribution of message units among "type" categories. Volume represents the mean number of such message units produced per minute. The relationship of each of these components to other criterion measures of crew coordination was striking. The measure of communication pattern was related to both the simulator flight checks and to the flight line ratings. The communication pattern of the experimental group was found to have been modified over training missions, presumably because of experiences in the integrated crew trainer configuration. In addition, while total communication patterns were quite similar for "best" and "worst" crews on each of the three objective performance measures, the "voluntary inputs" category differentiated among these crews on the navigational accuracy scores, and approached significance for bombing accuracy, thus supporting initial theoretical analyses.

Volume, on the other hand, was significantly correlated with both the "proficiency" and the "coordination" components of the flight line ratings. This volume measure bore no relationship, however, to the simulator flight checks, nor to any of the three objective measures. The flight line coordination rating was correlated significantly with simulator check coordination scores, but not with any of the other criterion measures.

These relationships are illuminating, not only with respect to evaluation of the integrated crew simulator, but also with respect to revealing certain essentials concerning the nature of crew coordination and its measurement. We interpret these results as being indicative of at least two major dimensions of coordinative behavior. One is the concept that "coordinated crews" engage in a large amount of verbal interchanges (nature unspecified). This is reflected in the agreement between measures of communication volume and instructors ratings. The other dimension is the type of interaction as reflected in the communication patterns. When crews are divided at the median volume score, it is found that significant differences exist between communication patterns of the two groups. The low-volume group is typified by a relatively high proportion of voluntary inputs as contrasted with questions and answers. This group also evidences a relatively high proportion of irrelevant remarks. The high-volume group's pattern is the converse of the above.

Thus, coordination measures which are sensitive to sheer volume will tend to correlate with impressionistic ratings of coordinative behavior. Measures that are based upon analytic considerations of the type of communication will tend to correlate with objective measures of behaviors which are partially, at least, dependent upon effective coordination. There is no assurance that either type of coordination measure or either type of criterion measure will correlate with its counterpart.

This should not imply that either measure of coordination is to be employed to the exclusion of the other. The present issue warrants an additional consideration, however, in terms of the interactive nature of these dimensions and their relative effects in terms of channel capacity.

Obviously, for coordination to occur among remotely located units, some communication volume is necessary. Other things being equal, volume measures should relate directly to effective coordination. It is in this respect that the nature of the communication pattern becomes important. If a deficiency is noted by a non-involved crew member and he voluntarily provides a necessary input, the deficiency can be remedied by a single message unit (plus a possible acknowledgement of receipt of the message). If the voluntary input is not made, however, at least two message units (a question and a response, plus a possible acknowledgement of receipt) will be required. Therefore, among crews trained to be alert to situations wherein they might be of coordinative assistance, the voluntary inputs should predominate and the communication volume should be correspondingly reduced. And this is precisely the situation that prevailed in the present experimental results.

It may be accepted so axiomatic that, when there is a limited channel capacity, the most efficient means of exchanging information is to reduce message unit frequency and length to an intelligible minimum. The B-52 intercommunication system represents just such a situation of limited channel capacity. Therefore, we may conclude (1) that the integrated crew training was effective in promoting efficient crew interaction and (2) that the flight line instructors were primarily attending to only a single aspect of coordination concerned with amount of interaction, not with efficiency.

It would be highly desirable to consider the interrelationships of the above dimensions in terms of a third dimension of coordinative behavior, communication content. In the above paragraphs we have spoken of communication efficiency in terms of use of channel capacity. Efficiency may also be considered in terms of relevance and completeness of the volunteered message unit. This consideration would require expert judgments of the value of each input in terms of whether the proffered information was at that moment required by the recipient and whether the information was sufficiently complete and accurate to be of use. It will be noted that accurate measurement of this dimension presents intriguing problems. However, we believe that such a measure will ultimately be required.

This third dimension of coordination is, itself, a complex issue. Entirely apart from the difficulty in drawing post hoc conclusions concerning the relevance of specific message units, the experimenter must deal with the effects upon these message units of individual proficiencies and cross-training and various leadership and attitudinal factors.

We have seen, for example, in a related study (3) the relation between navigators' ratings of each other and measures of navigational accuracy. Navigators on a single crew who do not like each other simply do not achieve very good navigational or bombing scores. In the present study, crews who do not communicate efficiently tend to have poor navigational and bombing scores. There seems to be at least a tenuous logical relationship here. Perhaps additional research directed specifically at this issue may clarify the picture.

Another example, derived from the present study, suggests the importance of the leader's role in the crews communication pattern. Considering only the D category inputs, definite commands by the aircraft commander, we find a significant negative relationship with C category voluntary inputs. As the commander exercises his command prerogatives, there is a decrease in the amount of assistance volunteered by other crew members. We do not suggest that the commander stifles crew interaction--perhaps his commands solve the problem and eliminate the need for further voluntary inputs from other crew members. Again, a study directed specifically toward clarifying such issues would appear to be indicated.

A final point of interest concerns the nature of the communication pattern as it may be determined by the environmental situation. In the present study, we selected for study communications occuring during simulator "emergencies," simply because so much of the normal B-52 interphone activity consists of checklist reading. During the data analysis phase we selected a few mission segments of a non-emergency, non-checklist-reading nature and compared these patterns with patterns evidenced during the emergencies. The absence of significant differences permitted us to generalize, in our discussion, with some confidence. However, if communication pattern is to be as valuable a coordination measure as we believe it is potentially capable of becoming, some additional information should be provided for other types of teams and in situations other than emergency situations. We believe that at any given level of training (or experience in working together) a crew's communication pattern will be a fairly stable index. (This assumes at least a 20-minute sample during "normal" work load.) We also believe that the pattern will undergo marked changes as crews continue to work together. But the specific nature of the pattern will probably be vastly different for different kinds of teams. For example, an effective surgical team may be expected to have a substantially different communication pattern than that exhibited by an effective guided missile team. Until additional research is conducted on this point, we should not assume that any specific type of communication pattern is highly desirable.

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APPENDIX A

Mission Flimsies

Mission #3 Flimsy

The mission flimsy included here contains the following information:

a. Instructor pilot's sequence sheet*
b. Instructor navigator's sequence sheet*
c. Radio aids and panel operator's guide*
d. Segment of jet navigational chart

The following information sheets were part of the original mission flimsies but are omitted from this Appendix:

Weight and Balance Clearance Form F
B-52 Take-Off Briefing Data
Local Departure Plan Information
Flight Log and Fuel Consumption Chart
Heavy Jet Bombardment Mission Flight Plan
Weather Information
Bombing Data Sheets
B-52/KC-135 Point Rendezvous Instructions
Flight Planning Format

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* These data were not supplied to the student crews during the study.

MB-41/T2A INTEGRATED TRAINER
MISSION #3 FLIMSY

1. Operations Briefing

a. Octane 98

b. Type of flight: This is a night training round-robin mission from Castle. This mission has high priority and will be completed, if possible, but under no circumstances will flying safety be jeopardized. The purpose of this mission is to provide additional crew coordination training in the operation of the B-52 under IFR and emergency conditions. One tanker rendezvous, refueling and one RBS run will be accomplished enroute.

c. Route and altitude: This mission will utilize departure plan Eagle to Madera, Taft, Merced, Bakersfield, Santa Maria, Los Angeles, Bakersfield, Madera, Castle VOR. Level-off will be at 34,000 feet, MACH .77; then descending for air refueling to 32,000 feet for a fixed point rendezvous. After refueling climb to 39,000 and maintain MACH .77.

d. Bombing: A RBS run will be made on Los Angeles Bomb Plot with a combat breakaway to the left.

RBS Call Sign and Channel	-	LA Bomb Plot #7
A/C Type and Radar Type	-	Golf Alpha
Crew Number	-	5 X-Ray
SAC Sub	-	Beagle Yankee
Run Type and Class	-	November 5
Target	-	LA # 'I'
IP	-	A/B Santa Barbara

e. Inflight refueling: Enroute to Bakersfield after passing Merced.

Tanker Call Sign	-	Tallman 18
Refueling Frequency	-	Duke Alpha (Channel 16)
Control Time	-	T/O + :54
Refuel Altitude	-	32M
Formating Speed	-	255 or 70 MACH
Rendezvous Point	-	Merced
Refueling Track	-	152 degrees
Off Load	-	10M

f. Danger areas: Crews Landing, Hunter, Liggett, and California Complex.

g. Emergency landing fields: Edwards, Beal, Mather, and Travis.
Primary alternate: Edwards.

h. Highest terrain enroute: Mt. Whitney 14,495 feet.

i. Pre-flight weather

(1) T.O. ceiling 300 feet, visibility 2 miles, temperature 59°, wind calm. Top of overcast 25,000 feet.

(2) Enroute 15 to 25,000 undercast.

(3) Landing ceiling 800 feet, visibility 2 miles, temperature 59°, wind calm.

j. Communications: Standard calls and position reports will be made. ARTC clearance approved VFR O/T Castle local area. Contact Castle approach control for altitude assignments when VFR O/T for local area separation, etc. Channel 15 and 19. Quadrantial altitudes will be maintained throughout the mission.

k. Forms to be completed:

(1) Form F (365F).

(2) Form 111 Navigators and Pilots Sections.

(3) T/O Data Form 302.

(4) 015 Camera Log Form 284.

(5) Bombing System Debriefing Form 316.

(6) Detail Map JN - Type.

(7) Mission Accomplishment Form.

l. Additional data that will be required for completion of forms:

(1) Form F.

(a) "F" model aircraft with 3,000 gallon drop tanks.

(b) Basic weight 164,761 lbs.

(c) Basic index 71.0.

(d) Crew 8 in compartment "A" and one "G" individual weight 270 lbs.

(e) Standard fuel load 188,000 lbs.

(2) T/O Data Form.

(a) -43 engines.

(b) No water.

(c) Runway temperature 58°, press alt. +40 feet.

(3) Monthly climatic outlook and planning data form (attached).

MB-41/T2A INTEGRATED TRAINER
MISSION #3 SEQUENCE SHEET

INSTRUCTOR PILOT'S GUIDE

1. Briefing

a. General.

(1) Objective of the Combat Crew Training Missions:

(a) Provide training in crew coordination.

(b) Increase proficiency in flight planning data.

b. Mission requirements.

(1) Mission is designed to give further practice in operations requiring more complete crew coordination involving:

(a) Flight planning of mission.

(b) Standard checklist procedures, starting with take-off checklist.

(c) Normal operation including take-off, climb, crew checks, and systems management.

(d) Radar controlled departure (Delta Departure).

(e) Increased proficiency in communication procedures.

(f) In-flight refueling coordination and procedures.

(g) Increase proficiency in emergency operation of the aircraft.

(h) Crew coordination on bomb-run and RBS procedures.

(i) Crew coordination on ECM runs.

(j) Airborne radar approach.

(k) GCA - ILS or wing fire and bailout procedure.

(l) Radar aids operator and IP will assume duties of TG and ECM.

c. Aircraft and flight conditions.

(1) Aircraft will be as shown in Mission Flimsy.

(a) Review Flight Flimsy for weather, route, aircraft loading, etc.

(b) Automatic parallel operation.

(c) Aircraft in take-off configuration.

d. Procedure discussion.

(1) Quiz crew on mission procedures. (Required position reports, etc.)

(2) Make certain correct procedures are understood.

(3) Stress the need for crew coordination during flight in making decisions and in accomplishing flying procedures. Crew should keep each other informed via interphone at all times. When one is accomplishing a procedure or dealing with an emergency, the other should accomplish the others' flight duties.

2. Take Positions in Simulators

Crew take normal positions in simulators and adjust controls. (Emphasize that maximum help will be given by the instructors on this mission. Decisions should be those most appropriate in an actual flight mission.)

3. Cockpit Pre-Flight

Complete before take-off checklist. (Or possibly before line-up and before take-off checklist, this will depend on crew, instructors, and time.)

4. Take-Off #1

a. Check crew procedures for take-off.

Engine fire prior to decision. Check crew procedure on abort take-off procedure.

5. Take-Off #2

Check crew procedures for take-off.

6. After Take-Off

a. Observe stabilizer trim procedure.

b. Observe instrument technique during take-off.

Split flap operation - check procedure, technique, and discussion.

c. Observe radio procedure and coordination.

7. Climb #1

a. Climb out will be as briefed. Observe instrument departure and anti-ice procedure. (WX to 25M)

Engine icing during climb, compressor stall and flameouts. Check crew procedure.

b. Check crew procedure in after take-off checklist.

(1) Current SFS and existing SOP's.

(2) Oxygen, station checks, and hook lanyard check.

(3) Radio calls.

(4) Climb A/S, MACH, and altimeter transition.

(5) Fuel management.

Fuel valve 29 failure - check recognition, discussion, and procedure.

8. Level-Off on Course

a. Check crew procedure in oxygen and station checks, radio calls, etc. (SFS)

b. Check altitude, heading, MACH and TAS, coordination.

#2 TR unit failure - check recognition and discussion.

c. Fuel management.

Observe transfer sequence.

9. Cruise #1

a. Observe normal procedures.

Left aft alternator failure light on - check recognition, discussion, and effect of alternator failure.

b. Observe GCI, flight following procedure.

10. Air Refueling Rendezvous and Refueling Procedure

a. Check crew procedures.

(1) A/R checklist.

(2) Communications.

(3) Descent, range, altitude, and speed schedule.

(4) Fuel management.

(5) Brute force breakaway and climbout.

b. Runaway time.

Procedure and technique (restore to NORMAL).

11. Climb #2

a. Check crew procedures.

(1) Climb power, A/S, MACH, and altitude.

(2) End A/R checklist.

(3) Fuel management.

Low oil pressure - recognition and procedures.

12. Level-Off on Course

a. Check altitude, heading MACH, and procedure.

b. Fuel management.

(1) TR unit #7 failed - excessive TR loads. Recognition and procedures.

(2) Fuel leak #2 main tank - recognition and procedure.

13. RBS Procedure

a. Check communications procedure.

b. Check crew coordination on Bomb Run.

c. Check altitude and speed coordination.

d. Observe combat breakaway procedure.

AC power failure during breakaway - recognition and recovering technique.

14. Cruise #2

a. Check communications procedure.

(1) Pneumatic leak #2 nacelle - check recognition, procedure, and decision.

(a) Cabin pressure failure.

(b) Hydraulic pack failure.

(c) Engine shutdown procedures.

(2) Engine backfire and fire procedure - check recognition and procedure.

b. Observe fuel management.

15. <u>WX Holding Pattern 20M</u>

a. Descent procedure.

Engine icing - recognition and procedure.

16. <u>Penetration</u>

a. Check normal checklist procedure.

b. Observe OMNI and radar procedures.

c. Check crew coordination on radar approach.

d. Check fuel management.

17. <u>Low Altitude Level-Off</u>

a. Observe normal checklist procedure.

Split flap procedure (continued).

18. <u>Missed Approach</u> (as GCA advise runway closed proceed to alternate Muroc).

a. Communications procedure.

b. Check normal procedure on missed approach.

Heavy engine icing and flameouts.

(1) Recognition of engine icing.

(2) Attempted restarts.

(3) Alert crew for bailout.

c. Bailout procedure.

(1) Crew coordination.

(2) Bailout procedure.

19. Critique

a. Review general flight performance.

(1) Point out effective portions of flight.

(2) Point out general weaknesses.

b. Have crew analyze the mission.

(1) General performance.

(2) Decisions made on specific emergency conditions.

c. Go over performance check.

(1) Discuss errors and possible ways of doing the tasks more effectively.

(2) Question crew on weak procedures and reasoning behind some of the critical decisions made during flight.

(3) Discuss methods of improving procedures.

d. Crews evaluation of the mission.

Question crew on ways of improving training.

MB-41/T2A INTEGRATED TRAINER
MISSION #1 SEQUENCE SHEET

INSTRUCTOR NAVIGATOR'S GUIDE

1. Instructor Pre-Mission Responsibilities

   a. Determine status of T2A from trainer mechanic.

   b. Set up BNS using master mission flight plan (SAC Form 111).

   c. Check student flight plan for completeness and accuracy.

2. Take Positions in Trainer

Students will take assigned crew positions in trainer and perform "before take-off" checklist.

3. Take-Off

Monitor use of "take-off" checklist.

4. After Take-Off

   a. Monitor use of "after take-off" checklist.

   b. Navigator computation of 85% of total fuel flow.

   c. Monitor departure plan by use of GPI method and D2 Nav unit until useable picture is obtained.

5. Level-Off

   a. Level-off fix.

   b. Altitude measurement (adjustment of ballistic unit altitude to read flight level pressure altitude minus terrain elevation).

   c. Wind run.

   d. D2 Nav unit set.

6. Wind Shift at Take-Off Plus 34 Minutes (235°/40K)

   a. Time required to catch wind change.

   b. Alteration in course (if any).

7. Rendezvous and Refueling Procedures

   a. Simulated fixed point rendezvous with KC-135.

   b. Monitor RN procedures for distance calls.

   c. Determination of proper time to start descent.

8. <u>Level-Off After Refueling</u>

a. Fix.

b. Altitude measurement (adjustment of ballistic unit altitude to read flight level pressure altitude minus terrain elevation).

c. Wind run.

d. D2 Nav unit set.

e. Wind shift at take-off plus 01:19 (300°/75K).

9. <u>Before Pre-IP</u>

a. Monitor use of checklist.

b. Coordination between pilot and RN during equipment check.

c. Coordination between navigators on cross check of ballistics.

10. <u>Pre-IP</u>

Monitor use of checklist.

11. <u>Bomb Run</u>

a. Monitor use of checklist.

b. Technique, knowledge, and use of equipment.

c. Adequate number of accurate wind runs.

d. Coordination between navigators.

e. Post release check.

12. <u>Penetration</u>

a. BNS configuration properly set up.

b. ARDA procedures and technique.

c. Descent altitude calls.

13. <u>Critique</u>

a. General critique for all crew members on crew coordination and effectiveness as a team.

b. Specialized critique for navigators.

(1) Strong areas.

(2) Weak areas.

(3) Suggestions for improvement in coordination and effectiveness.

MB-41/T2A INTEGRATED TRAINER
MISSION #3 SEQUENCE SHEET

RADIO AIDS AND PANEL OPERATOR'S GUIDE

1. Simulator Set-Up

a. Standard 188,000 lbs. fuel load.

b. Total gross weight 359,000 lbs., C.G. 27.4%.

c. Wind calm, temperature 59°, altitude 187'.

d. Position, Castle AFB, ceiling 300', visibility 2 miles, top of overcast 25,000'.

e. Night take-off, cockpit and exterior light switches set for T.O.

f. Complete set-up in take-off configuration.

g. OMNI stations set for "Delta" departure.

h. Climb wind set after T/O for 250°/25 kts.

2. Acknowledge for the Following as Required

a. Tail gunner.

b. E.C.M.

c. Oakland Center.

d. Los Angeles Center.

e. Los Angeles RBS.

f. Refueling tanker, Tallman 18, and boom operator.

g. Castle tower, ground control, approach control, and control room.

3. Retune OMNI and Radios as Necessary Throughout the Mission

4. Take-Off #1

a. Fire in #4 engine prior to refusal. 90-100 kts.

b. Clear on IP's instruction.

5. Take-Off #2

a. Fail fuel valve #24.

b. Split flaps.

c. Engine icing 1, 2, 7, RPM's down; #2 and #7 flameout.

d. Wind 250/25.

6. Level-Off

a. #2 T.R. unit failed.

b. Left aft alternator KVAR to MIN. (Reduce voltage enough to require student to shut it down.)

c. Wind 260°/60 kt.

7. Cruise #1

a. Wind 260/60 kt.

b. Air refueling: Wind 260/40 kt. Acknowledge and direct as Tallman 18 boom. On load 10M lbs.

c. Brute force breakaway and runaway trim nose down.

8. Climb #2

a. Low oil pressure #3, 37 lbs.

b. Climb wind 260/40.

9. Level-Off #2

a. #7 T.R. unit failed.

b. Fuel leak #2 main; max. leak.

10. R.B.S.

a. During breakaway: AC power failure; both aft bus ties and right aft alternator failed.

b. Acknowledge as required as Los Angeles Bomb Plot.

11. Cruise #2

a. Pneumatic leak #2 nacelle.

b. Engine #8 backfire and fire.

12. Holding and Jet Penetration

a. No wind.

b. Landing weather ______________________.

c. GCA advises runway closed, proceed to alternate. (Edwards)

d. Heavy engine icing. Flameout #2, #4, and #7.

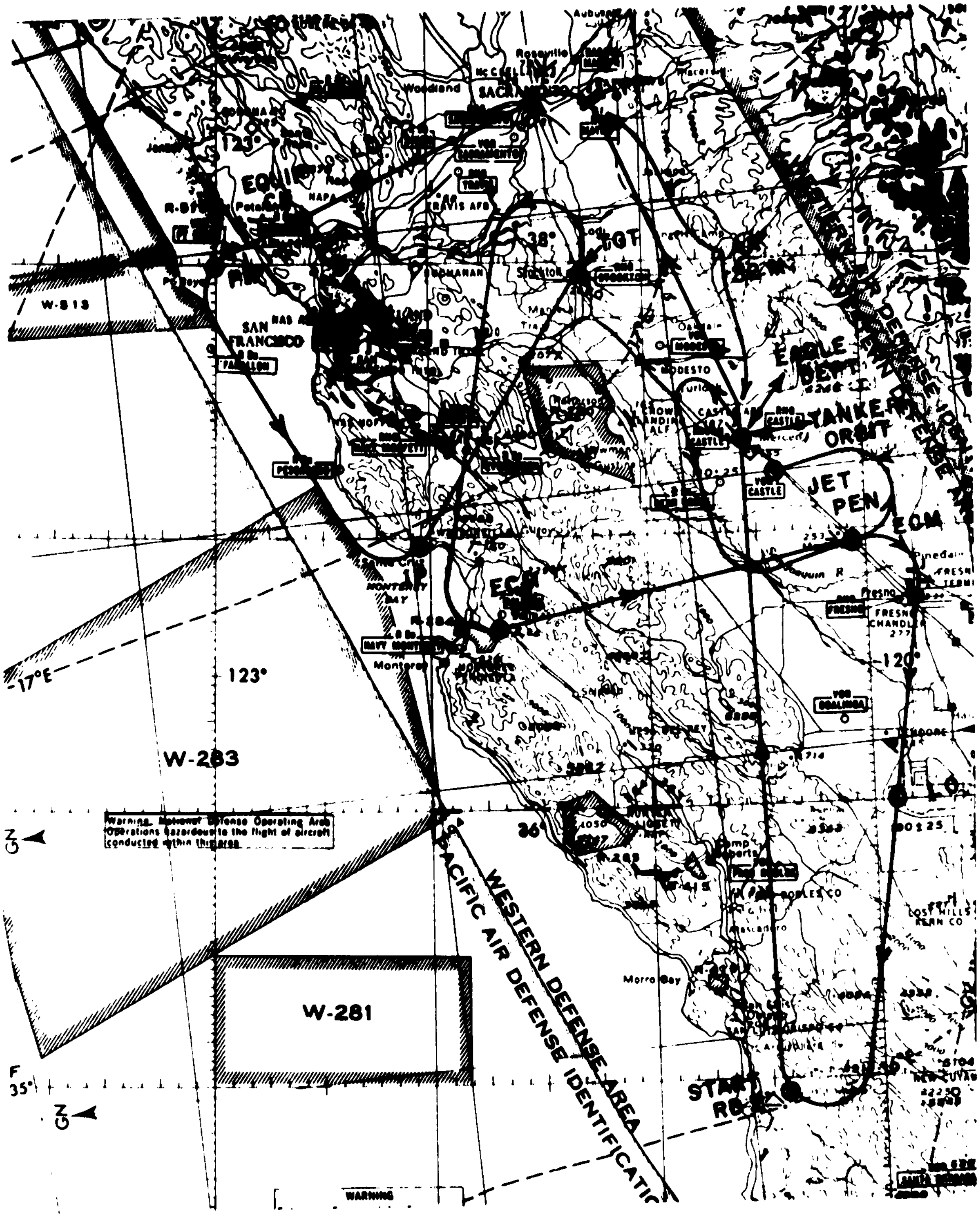
e. Bailout.

13. ATC Clearance

ATC clears Octane 98 to the Castle OMNI via Madera, Bakersfield, Los Angeles flight plan route, climb departure plan to VFR on top. Maintain VFR on top in control areas. Report to Oakland Center 379.9 when on top.

14. Tanker and RBS Information

RBS Call Sign and Channel	-	LA Bomb Plot #7
A/C Type and Radar Type	-	Golf Alpha
Crew Number	-	5 X-Ray
SAC Sub	-	Beagle Yankee
Run Type and Class	-	November 5
Target	-	LA # 'I'
IP	-	A/B Santa Barbara
Operator's Name	-	______________________
Tanker Call Sign	-	Tallman 18
Refueling Frequency	-	Duke Alpha (Channel 16)
Refuel Altitude	-	32M
Formating Speed	-	255 or 70 MACH
Rendezvous Point	-	Merced
Refueling Track	-	152 degrees
Off Load	-	10M



Mission #3 Navigational Chart

APPENDIX B

Integrated Crew Simulator Checks

Sample from PILOT team checklists

B-52/T2A SERVICE TEST

INTEGRATED SIMULATOR FLIGHT CHECK

PILOT TEAM

MISSION NO. 9

Crew Number: __________ AC _______________ CP _______________

Date: ____________________ Instructor: ________________________

P: 100 - $\boxed{}$ = ____

C: 100 - $\boxed{}$ = ____

INSTRUCTIONS

This flight check form has been developed for two purposes:

1. to provide SAC with an objective record so that quantitative information regarding the effects of integral crew training may be obtained, and

2. to provide you with a detailed behavior record that will be of value to you in debriefing the student crews.

An objective record is necessary since SAC requires information regarding specific aspects of training which will most benefit from use of the crew trainer. The sorts of comparisons made possible by this flight check format will provide SAC with the information it needs.

These check items will also be of help to you in debriefing your students. You will note that the items are phrased so that a "yes" or "no" answer is sufficient. In most cases, this should reduce the requirement for you to write comments, though space is still provided for this purpose.

It is important to emphasize that this format does not remove the necessity for making skilled judgments based on your experience and your knowledge of student's behaviors. The format should, however, make it easier for you to record these judgments.

The items included in these checks have come from two major sources:

1. 93rd Wing Standboard checks (in which specific write-ups have been made of common errors), and

2. 4017th simulator checks, plus your comments and suggestions for integrated training missions.

You will note that the present check does not include all the important behaviors that it is necessary to evaluate. This would make the check too long for you to use conveniently. We have attempted to include only those items which have the greatest likelihood of discriminating between student crews of differing abilities. All of you have contributed to this process of selecting these "critical" items by completing the item rating forms we distributed to you.

In this respect, the check is the product of your decisions regarding flight check item content.

The format of this check is somewhat different from that of your present checks. There are three important points to keep in mind as you complete these checks:

1. SCORE THE STUDENTS AS A TEAM. We have not differentiated between tasks to be performed by the AC and those to be accomplished by the CP. In most cases, this distinction will be obvious. Where it isn't, and you want to comment in the debriefing on some error, you may indicate "AC or CP" in the remarks column.

2. SCORE THE BEHAVIORS AS THEY OCCUR. The items are arranged in the sequence that they will be accomplished during the mission. Nearly all of the items are presented in terms of "Did they do this?" A check mark in the "Yes" or "No" columns is all that is required.

3. SCORE EACH ITEM. It is important that these be "canned" missions--each team must receive the same training and the same sorts of evaluation or the final results will not be comparable. Thus, there will be no "not applicable" items. Each crew must be scored on each item in order that sound conclusions may be presented to SAC.

One final point: since the two trainers will continue to drive together, it is important to keep interruptions at a minimum. It is, of course, good instructional technique to point out errors as they occur and to describe correct procedures. This will, however, disrupt the realism of the crew's mission and will result in "dead time" for the non-involved crew members.

Consequently, it is requested that you keep such interruptions at a minimum during missions 5 and 7, reserving detailed critique for the debriefing session. During mission 9, which is the nature of a final check-ride, it is requested that suggestions be given the student only if it is clear that completion of the mission will not otherwise be possible.

Much can be accomplished during the briefings preceding each "mission" with respect to the unique advantages of the integrated trainers. Students should be advised to be alert for situations in which they might assist a crew member who is temporarily overloaded. Maximum benefit can be obtained from these trainers only if the students anticipate other crew member' needs.

MB-41/T2A Pilot Check	YES	NO	REMARKS
BEFORE LINE-UP			
1. STAB TRIM set properly and checked............	[ ]	[ ]	
2. Both pilots check all trim settings...........	[ ]	[ ]	*
3. Pitot heat turned on.........................	[ ]	[ ]	
4. Fuel valves set properly.....................	[ ]	[ ]	
5. Landing lights ON............................	[ ]	[ ]	
6. Nav lights turn on and to STEADY..............	[ ]	[ ]	
7. Anti-collision light ON......................	[ ]	[ ]	
8. ARTC clearance obtained and read back correctly	[ ]	[ ]	
9. Expedite but complete checklist...............	[ ]	[ ]	
10. All instruments are checked..................	[ ]	[ ]	
11. Runway temperature taken into consideration in determining T/O data......................	[ ]	[ ]	
BEFORE TAKE-OFF			
1. Gyros and compass checked and set with Navs....	[ ]	[ ]	*
2. Fuel totalizer reading correctly taken........	[ ]	[ ]	*
3. Both pilots check all trim settings...........	[ ]	[ ]	*
4. Checklist completed without delay.............	[ ]	[ ]	*
5. Does the pilot lay down ground rules covering all situations both normal and emergency at take-off..................................	[ ]	[ ]	*
6. Is C/P briefed to cut the engines only on command of A/C..............................	[ ]	[ ]	*
7. On full power check are all instruments checked....................................	[ ]	[ ]	
8. Minimum EPR checked and read correctly.........	[ ]	[ ]	

P = _____, C = _____

MB-41/T2A Pilot Check	YES	NO	REMARKS
TAKE-OFF #1			
1. Notify crew prior to take-off.................			*
2. Alternator panel checked......................			
3. Stabilizer trim monitored by both pilots......			*
4. Co-pilot properly monitors engine instruments..			*
5. Were throttles guarded properly...............			*
6. CP call decision point........................			*
#4 ENGINE FIRE PRIOR TO DECISION (Smoke until all conditions are met.)			
1. Decision to abort made promptly...............			
2. Crew alerted to emergency.....................			*
3. All throttles are put to idle.................			
4. Did CP promptly deploy drag chute.............			
5. Was there any fumbling or confusion between pilots on the steps of this abort.............			*
6. Was air-brake lever put to position 6.........			
7. Wheel brakes were applied.....................			
8. Aft alternators were cut......................			
9. #4 Engine throttle cut-off....................			
10. #4 Fire button pulled........................			
11. Condition reported to tower..................			
12. #3 Engine cut (as smoke continues)............			
13. #14 Main fuel feed valve closed...............			
14. #9 Crossfeed valve closed....................			
15. Was the engine starter sw set to ground start..			
16. Did they re-cycle the starter sw..............			
17. Air-bleed manifold interconnect open..........			

P - ____, C - ____

APPENDIX C

Flight Line Checks of Crew Coordination/Proficiency

Contents

1. Pilots' flight line check
2. Navigators' flight line check

PILOTS

FLIGHT-LINE CHECK OF CREW COORDINATION/PROFICIENCY

SAC and the American Institute for Research are conducting a field test of an integrated trainer for B-52 pilots and navigators. In order to help evaluate the training value of this device, you are asked to complete the following scale for each crew of pilots at the end of each of their flights and return the completed form to your Squadron Operations Officer.

This scale is for research purposes only; the results will be used only by A.I.R. in evaluating the trainer. It will not, in any way, become a part of a crew's record or affect standing as regards training. You are asked to be completely objective and candid in your evaluation.

This form is to be used with PILOTS ONLY.

DIRECTIONS

Rate each crew on the basis of what could be expected of it in comparison with other crews of similar level of training. Think of each of the scales below as a thermometer ranging from 1 to 10. Within the framework of each, place an "X" along the line so that it best conforms to your answer to each of the questions.

Descriptive statements are placed along the line as a guide to gradations, but these do not refer to any one point on the "gauge." Score each crew only on the basis of a single flight, not a group of flights.

CREW NO. ________________ MISSION NO. ___________ DATE ______________

COMPARING THIS AC/CP WITH OTHERS OF A SIMILAR LEVEL OF TRAINING IN MARKING EACH ITEM BELOW:

A. THE PROFICIENCY IN ACCOMPLISHING JOB FUNCTIONS ON THIS FLIGHT IS IN:

1				10
Lowest 10%	Next 20%	Middle 40%	Next 20%	Upper 10%

B. HOW DID THE PILOTS DEMONSTRATE COORDINATION/TEAMWORK WITH EACH OTHER ON THIS FLIGHT DURING THE EVENTS THAT CONCERNED THEM: (This coordination may be demonstrated in such ways as: cross-checking, reading and following checklists, monitoring each other, taking over job functions in case of overload, etc.)

10				1
Upper 10%	Next 20%	Middle 40%	Next 20%	Lowest 10%

C. HOW DID THE PILOTS DEMONSTRATE COORDINATION OR TEAMWORK WITH OTHER CREW MEMBERS ON THIS FLIGHT. (This may be shown in: holding a steady platform for celestial, passing information to crew, briefing, performing functions when asked by N's during bomb runs, etc....)

1				10
Lowest 10%	Next 20%	Middle 40%	Next 20%	Upper 10%

D. HOW WELL DID THE PILOTS DEMONSTRATE COORDINATION IN THEIR INTERPHONE AND COMMAND COMMUNICATIONS ON THIS FLIGHT:

1				10
Lowest 10%	Next 20%	Middle 40%	Next 20%	Upper 10%

YOUR NAME ____________________

NAVIGATORS

FLIGHT-LINE CHECK OF CREW COORDINATION/PROFICIENCY

SAC and the American Institute for Research are conducting a service test of an integrated trainer for B-52 pilots and navigators. In order to help evaluate the training value of this device, you are asked to complete the following scale for each crew of navigators at the end of each of their flights and return the completed form to your Squadron Operations Officer.

This scale is for research purposes only; the results will be used only by A.I.R. in evaluating the trainer. It will not, in any way, become a part of a crew's record or affect standing as regards training. You are asked to be completely objective and candid in your evaluation.

This form is to be used with NAVIGATORS ONLY.

DIRECTIONS

Rate each crew on the basis of what could be expected of it in comparison with other crews of similar level of training. Think of each of the scales below as a thermometer ranging from 1 to 10. Within the framework of each, place an "X" along the line so that it best conforms to your answer to each of the questions.

Descriptive statements are placed along the line as a guide to gradations, but these do not refer to any one point on the "gauge." Score each crew only on the basis of a single flight, not a group of flights.

CREW NO. ________________ MISSION NO. ___________ DATE __________________

COMPARING THIS RN/N WITH OTHERS OF A SIMILAR LEVEL OF TRAINING IN EACH ITEM BELOW:

A. HOW DID THE RN AND N SHOW COORDINATION/TEAMWORK WITH EACH OTHER DURING THOSE FLIGHT EVENTS OF CONCERN TO THE PAIR. (This may be shown in such ways as: cross-checking, monitoring, following check-lists, taking over job functions in the case of overload, etc....)

10 ____ 1
Upper 10% — Next 20% — Middle 40% — Next 20% — Lowest 10%

B. THE PROFICIENCY IN JOB FUNCTIONS OF THIS RN/N IS IN:

1 ____ 10
Lowest 10% — Next 20% — Middle 40% — Next 20% — Upper 10%

C. HOW DID THE RN/N DEMONSTRATE COORDINATION/TEAMWORK WITH THE REST OF THE CREW. (This may be shown in: making good the rendezvous times, accurate, correct airborne directed approach, giving appropriate information on the work they are doing, its status, effect on crew, etc....)

10 ____ 1
Upper 10% — Next 20% — Middle 40% — Next 20% — Lowest 10%

D. HOW WELL DID THE RN/N SHOW COORDINATION IN INTERPHONE AND COMMAND COMMUNICATIONS.

1 ____ 10
Lowest 10% — Next 20% — Middle 40% — Next 20% — Upper 10%

YOUR NAME ______________________________

APPENDIX D

Crew Evaluation Questionnaire

Name ____________ Rank ____________ Crew Position ____________

Please list your previous experience (rough estimate of hours flying time) in other aircraft.

B-47 - Hours: ____________ Position: ____________

B-36 - Hours: ____________ Position: ____________

Other Aircraft:

Type: ________ Hours: ________ Position: ____________

Type: ________ Hours: ________ Position: ____________

Type: ________ Hours: ________ Position: ____________

Please estimate your total flying time: ____________

GENERAL DIRECTIONS

What is the purpose of this questionnaire?

Each member of a B-52 aircrew has had extensive training and experience within an aircrew specialty or specialties. He has also received special training in his duties as a B-52 aircrew member. This questionnaire is designed to determine what opinions you have regarding (1) the extent of skill you have attained in the performance of certain crew activities and (2) what types of training have contributed to your development of these skills.

What do we mean by an "aircrew activity?"

For the purpose of this questionnaire, an aircrew activity consists of a series of interrelated tasks or acts which are required of a crew member in order that they may accomplish a mission requirement or cope with an emergency. Such an "aircrew activity" may be large or small in terms of time required for its completion. The extent to which any given crew member will be involved in any specific aircrew activity will vary from his having a minor to a major part in its execution. In the case of some crew activities, all crew members have important duties to perform. In the case of many other activities, some crew members may do very little, such as not interfering with those performing the activity. In this case, the crew member may be expected only to remain alert, simply to be attentive to the possibility of an abnormal or emergency condition, or perhaps he may even be occupied with the performance of some other activity. In thinking about your part in a crew activity, consider only what you would normally be expected to do even if this is very little. Do not consider duties you might have under some unusual circumstance or duties that you do not normally perform, or duties that are not part of the activity. In rating both your ability level and the training, we are interested in all of your activities, including those where you have as little to do, perhaps, as not to interfere with others. (This can be important, too.) You are to rate each item as described below. Each item is to be completed, even if you have very little to do directly with the activity described.

How is the extent of your skill in an aircrew activity to be determined?

We are interested in your opinions about how well your skills have been developed to perform your part in the activity. You are to make your best estimate of your skill level in an activity by using the following rating categories:

5 = My skill level is very high and not likely to be much increased with reasonable amounts of instruction or practice.

4 = My skill level is more than adequate for satisfactorily accomplishing my part of the activity, but can be improved with further instructions and/or practice.

3 = My skill level is adequate for satisfactory performance. Instruction and/or practice would lead to improvement

2 = My skill level is such that I can do my part of the activity provided speed is not required or accuracy standards are not high. Instruction and/or practice are definitely needed.

1 = My skill level is such that I doubt that I could do my part of the activity adequately or safely without more instruction and/or practice.

With what types of training is this questionnaire concerned?

For the purpose of this questionnaire, training is classified according to the following five types:

Academic = B-52 Academic Training: This category includes individual study of T.O.'s or flight handbooks, lectures, and demonstrations presented by ground school instructors and MTD personnel.

Synthetic = B-52 Synthetic Training: This category includes training received involving any or all or any combination of the following synthetic trainers (pre-mission briefing for these trainers and post-mission critiques are to be included in the category).

S-9	B-52 Flight Simulator
C-11	Jet Instrument Trainer
T-2A	Ultrasonic Trainer (B-52 Configuration)
ECM	Synthetic Trainers
T-1A	Gunnery Trainer (MD-5 or A-3A Configuration)

Flight = B-52 Flight Training: This category includes training received during the five instructional missions which compose the Combat Crew Course.

Past = Previous Flying Training and/or Flying Experience: This category includes training or experience acquired with the operation of any type of aircraft other than the B-52.

Other = Any Other Training: This category includes any form of training, experience or indoctrination not specifically covered by the types of training shown above.

How is the questionnaire to be completed?

This questionnaire will be completed most efficiently by proceeding according to the following steps:

Step A - Read activity No. 1 carefully.

Step B - Think about your part in carrying out the activity as described. Think about the specific things you would be doing. Do you have any part to do in accomplishing the activity? Include duties specific to the activity, but as small as simply knowing that you must remain off the interphone (except for emergencies).

Step C - Judge to what extent you have developed skill in performance of your part of the activity. Judge your skill to perform <u>your</u> normal part of the activity even if it is a very small part and one which required little training in order to learn to do it perfectly. Make the judgment in terms of the five categories described above and record the number of the category which best describes your skill level in the blank in the left-hand margin corresponding with activity No. 1. (In the rare case, you may decide that you have absolutely nothing to do in the performance of the activity. In this case, write "<u>none</u>" in the blank before the item number and go on to the next item.)

Step D - Regardless of what you have judged your skill level to be, account for your skill level by referring to the five types of training described on the preceding page. You are to do this by recording a percentage figure in each of the five blanks which appear in the right-hand margin opposite the description of activity No. 1. The percentage you record in each blank is to represent your best estimate of the proportion of your present skill in your part of activity No. 1 which you consider to be a result of the five different types of training. The total of the five percentages you record must add to 100%.

Step E - Proceed to the next activity (#2) and repeat the steps as before, etc.

<u>EXAMPLE</u>:

Skill Level	Description of the Activity	Type of Training	
3	1. Accomplish an oxygen check.	Academic	20%
		Synthetic	20%
		Flight	10%
		Past	45%
		Other	5%
		(Total	100%)

The responses to this example indicate that the crew member has judged his skill in carrying out his part of an oxygen check to be "just adequate" (3 in the blank in the left-hand margin) and that he acquired this skill through past experience (45%), synthetic training (20%), academic training (20%), and to a minor degree (10%) from B-52 flight training and (5%) from some other kind of training.

PART I

ALL CREW MEMBERS

The following activities are to be considered by each crew member. Each crew member is to consider his part in the activity.

Skill Level	Description of the Activity	Type of Training
___	1. Perform your part in a power-off interior pre-flight check.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	2. Perform your part in an emergency airborne radar-directed approach.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	3. Complete your part in a before pre-IP bombing equipment check.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	4. Accomplish your part in a radar bomb run.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	5. Complete your part in a true heading check.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	6. Accomplish your part of a routine crew report.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)

PART I

Skill Level		Description of the Activity	Type of Training
___	7.	Complete your part in an ECM run against an ADC radar site.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	8.	Prepare for and accomplish your part of a controlled bailout at 15,000 ft. over water.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	9.	Accomplish your part in planning a maximum effort mission involving 40 hours continuous flight.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	10.	Cope with the failure of all four alternators during a climb through an overcast with 1500 ft. ceiling.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	11.	Perform your part in a GCA approach and landing.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	12.	Complete your part of an exterior preflight check.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	13.	Accomplish your part of an engine start, taxi and take-off under normal conditions.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)

PART I

Skill Level	Description of the Activity	Type of Training
___	14. Accomplish your part of an air refueling rendezvous and fuel transfer under conditions of poor visibility.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	15. Accomplish your part of a final crew line-up and briefing.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)

PART II

PILOT AND COPILOT

The following activities are to be considered by the pilot and copilot.

Skill Level	Description of the Activity	Type of Training	
___	16. Cope with the failure of the landing gear to extend due to loss of hydraulic pressure.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)
___	17. Perform your part of a descent, level-off	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)
___	18. Maintain a smooth stable platform for night celestial observations.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)
___	19. Accomplish touch-and-go landings.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)
___	20. Cope with a fuel leak involving main tank #3.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)

PART III

RADAR NAVIGATOR-NAVIGATOR

The following activities are to be considered by the radar navigator and navigator.

Skill Level	Description of the Activity	Type of Training	
___	16. Analyze and cope with computer malfunctions.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)
___	17. Accomplish your part in making a controlled ETA.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)
___	18. Navigate by means of pressure patterns.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)
___	19. Cope with the loss of VRM on both scopes at the IP.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)
___	20. Accomplish your part in a bomb run check.	Academic	___%
		Synthetic	___%
		Flight	___%
		Past	___%
		Other	___%
		(Total	100%)

PART IV

ECM OBSERVER

The following activities are to be considered by the ECM Observer.

Skill Level	Description of the Activity	Type of Training
___	16. Handle your part of a radio communication involving classified matter.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	17. Operate the ALE-1 chaff dispenser.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	18. Perform your part of obtaining a three-star fix.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	19. Search different frequency bands and locate transmitted signal.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	20. Jam radar signals by using the ALT-7 transmitter.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)

PART V

GUNNERS

The following activities are to be considered by the Gunner.

Skill Level		Description of the Activity	Type of Training
___	16.	Operate the A-3A system in all emergency modes operation.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	17.	Check deployment and jettison of drag chute on landing.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	18.	Perform preventative measures to decrease the likelihood of a malfunction of the M-3 gun.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	19.	Operate the APG-41-B radar set under conditions involving moderate jamming.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)
___	20.	Accomplish your part in coping with multiple attacks involving closing speeds of approximately 300 knots.	Academic ____% Synthetic ____% Flight ____% Past ____% Other ____% (Total 100%)

APPENDIX E

Communication Analysis Data

Contents

1. Category scoring format

2. Sample mission segment to illustrate scoring

Crew No. ________ Mission No. ________ Rater ________ Date ________

COMMUNICATION CATEGORIES	EMERGENCY NUMBER 1	2	3	4	5	6	7	Category Total	% of Total
A. Direct Question								ΣA	
1. requests information								A1	
2. requests course of action or information re course of action								A2	
3. requests opinion or evaluation								A3	
B. Direct Response								ΣB	
1. provides requested information								B1	
2. gives course of action as requested								B2	
3. gives opinion or evaluation								B3	
C. Voluntary Inputs								ΣC	
1. volunteers information								C1	
2. volunteers course of action (for self or others)								C2	
3. volunteers opinion, evaluation								C3	
D. Direct Command--orders course of action								D	
E. Response to Command--formal reply signifying action will be carried out								E	
F. Irrelevant Remarks								F	
G. Acknowledging Receipt of Message								G	
TIME (Nearest Half Minute)							Σ Time	Σ Message Units	100%

Two Scored Sample Emergency Segments

1. Transformer Regulator Failure

Speaker	Communication	Time
CP	It looks like #2 forward T.R. unit has no load on it (C1)/	00
AC	No load on that #2 forward? (A1)/	
CP	And 3, 4, 5 are overloaded (C1)/	
AC	Oh Hell, (F)/ #2 that's radar equipment, isn't it? (A1)/	
CP	Yeh (B1)/	
RN	15 miles (C1)/	
CP	We'll have to reduce some electrical load here, uh? (C2)/	01
AC	Right (C3)/	
AC	Pitot heat is off (C1)/ Will that help? (A3)/	
CP	No, it didn't (B3)/	
AC	Shut the OMNI off (D)/ How about that? (A3)/	
CP	Nope (B3)/	
RN	12 miles (C1)/	
CP	Autopilot? (C2)/	
RN	11 miles (C1)/	
AC	It's off (C1)/	
RN	10 miles (C1)/	
AC	ECM from Pilot, turn off radar equipment (D)/	
ECM	Roger (E)/	
AC	What are you reading now? (A1)/ Is it still overloaded? (A1)/	
CP	Roger, (B1)/ I've got 3, 4, and 5 overloaded (B1)/	02
RN	Pilot, this is Radar. I've lost the tanker in the refuel course (C1)/ Do you have him visually? (A1)/	
AC	Roger, Radar (B1)/	
CP	OK, it's within limits now (C1)/	

Number of Message Units by Category

A			B			C			D	E	F	G
A1	A2	A3	B1	B2	B3	C1	C2	C3				
5	0	2	4	0	2	10	2	1	2	1	1	0

Time: 2.5 minutes

2. #3 Engine Fire

Speaker	Communication	Time
AC	Crew, just lost #3 engine (C1)/ Have fire #3 (C1)/ Tail, how's it look? (A3)/	00
TG	Lots of black smoke, sir (B3)/	
AC	Roger (G)/ We pulled the fire bottle on it (C1)/ How's it look? (A3)/	
TG	Still smoking, sir (B3)/	
AC	Roger (G)/ Keep an eye on it (D)/ Shut fuel off #3 (D)/	
AC	Shut it off #3 (D)/	01
CP	That will be 3 engines out (C1)/	
AC	I can't help it (C3)/ I don't want the thing to go (C3)/ Just shut it off (D)/	
AC	How's it look Tail? (A3)/	
TG	Still smoking, sir (B3)/ It seems to be dying (B3)/	
AC	Crew, standby for bailout (D)/ We have 3 engines out (C1)/ If, ah, you hear the alarm you shall go (D)/	
CREW	Roger (E)/ (TG, N, ECM, RN)	
AC	OK, we just lost all our alternators, (C1)/ all our power (C1)/	02
CP	Let's get out of this damn thing (C2)/	
AC	Bailout, crew (D)/	

CREW EXECUTES BAILOUT

Number of Message Units by Category

A			B			C			D	E	F	G
A1	A2	A3	B1	B2	B3	C1	C2	C3				
0	0	3	0	0	4	7	1	2	7	1	0	2

Time: 2.5 minutes

APPENDIX F

A note regarding the influence of selected variables upon sample attrition.

A NOTE ON ATTRITION WITHIN THE SAMPLE

The reader will undoubtedly have noticed that throughout the report results of analyses were presented which indicated a considerable variability in the numbers of subjects. We believe a brief explanatory note is in order to indicate at least some of the reasons for "The Case of the Diminishing N."

We had initially planned for a sample of 100 crews. However, initiation of the experiment was successively delayed by a nine-month lag in delivery of the interconnecting device, a need to move the locations of the simulators to another building, construction of additional air conditioning capabilities for the new simulator building and various technical difficulties such as simulator equipment incompatibilities with the interconnect device. These incompatibilities included an inadvertant rotation of the X and Y coordinates so that when the pilot in the flight simulator assumed a north heading, the navigation trainer was "flying" to the east. This made it somewhat difficult for the navigators to interact meaningfully with the pilots, so time was lost while a fix was effected. Another interesting problem arose with the delivery of the incorrect model of the navigation trainer. The interconnect gear had not been designed for the equipment that was delivered to Castle. It is a tribute to the simulator personnel at Castle and to the manufacturers' technical representatives that local modifications could be made which finally surmounted this difficulty.

Just as the equipment set-up was nearing completion, the annual SAC bombing competition approached and Castle was selected as the host base. This placed a burden upon the wing in addition to their normal instructional duties and efforts to maintain their own combat proficiency.

As a direct result of these factors, it became necessary for the A.I.R. field unit to leave Castle before the full sample was obtained.

Of the 85 crews who participated in the experiment, ten were excluded from analysis because of incomplete records. Three of these had been lost to the study when a crew member departed the base on emergency leave. Others were lost because of equipment malfunctions during the integrated missions. Two were lost when scheduling difficulties prevented the third integrated mission's being scheduled before crew graduation.

Some attrition occurred in the collection of interphone communication recordings. This was not viewed as attrition at the time since the communication analysis was undertaken on a pilot-study basis. However, for later analyses of communication patterns the sample size was reduced to 32 mission recordings of communications among 18 crews.

Finally, the request for operational criteria was submitted, coordinated through Strategic Air Command Headquarters, and transmitted to the operational bases to which the crews had been assigned. The requests were for performance data collected during the first six-month period after transition training. However, by the time the requests reached the operational bases, records of some of the crews participating in the early phases of the experiment had been destroyed as being out-dated.

The major sources of attrition appeared to be due to changes in the crew complement and to crew assignments not requiring performance evaluation of the types requested. A sampling of illustrative paragraphs from some of the replies may serve to indicate the nature of these difficulties:

1. This crew was involved in a mid-air collision. . .The navigator and the co-pilot were killed in the fire and explosions which destroyed both aircraft. . .

2. The navigator on _____ crew has been transferred from this station and requested information is not available.

3. . . .a negative report is submitted. The three aircraft commanders listed for crews _____, _____, and _____ are staff officers and were with these crews at Castle Air Force Base only.

4. None of the crews at _______ AFB, _______ AFB, or _______ AFB are still flying as integrated crews who participated in the integrated trainer study at Castle AFB. Various changes to crew composition were made upon return from CCTS.

5. Only two crews of the ten (you listed) still fly together as crews. . .

6. All of the crews listed. . .your letter, are not presently assigned to this unit. . .

7. It is pointed out that in many instances crew composition will have been changed subsequent to completion of CCTS training at Castle AFB. . .

8. Captain ________ unknown at this station. . .Lt. Col. ________ never had a crew, but went through (CCTS) on a staff quota and has transferred PCS to ________ AFB. . . Col. ________, currently at this station, went through school at Castle as a staff pilot and has never flown with a crew as a regularly assigned combat crew member. . . Col. ________ also went through Castle as a staff pilot. He has never flown with or been assigned to a regular combat crew. He, therefore, has no history in regard to navigation CEA's or bombing CEA's. . .Each time either of these officers flies, he flies with a different crew. . .

These sorts of complexities resulted in a reduction of the sample to 27 crews, 15 of which were experimental crews. Further attrition occurred in matching crews for analyses of communication patterns in terms of operational proficiency measures. Of the 18 crews, whose communication patterns were analyzed, only half were included in the listing of crews for whom proficiency data were available.

Aerospace Medical Division, 6570th Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio
Rpt No. MRL-TDR-62-1. EFFECTIVENESS OF INTEGRATED FLIGHT SIMULATOR TRAINING IN PROMOTING B-52 CREW CO-ORDINATION. Final report, Feb. 1962. 87p. incl illus., tables, 3 refs.
Unclassified report

This report represents the findings of a study designed to assess the value of a B-52 flight simulator electronically linked to a T-2a navigator trainer in promoting crew coordination. Seventy-five SAC aircrews undergoing B-52 transition training at Castle Air

(over)

Force Base were used as subjects. Integrated and non-integrated simulator training of these crews was contrasted. The results as indicated by certain of the measures used enable a favorable recommendation to be made regarding the effectiveness of the B-52 integrated crew trainer. In the report, special attention is devoted to a discussion of two aspects of communication, pattern and volume, and the relation of these aspects to crew coordination.

UNCLASSIFIED

1. Military Training, training and training aids
2. B-52 Crews, flight simulators

I. AFSC Project 1710, Task 171003
II. Contract AF 33(616)-7011
III. American Institute for Research, Pittsburgh, Pa.
IV. Krumm, R. L., Farina, Jr., A. J.
V. In ASTIA collection

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