AD-767 377

ISOLATION OF RECURRING STUDENT PILOT ERRORS DURING PRIMARY FLIGHT TRAINING. I. SPIN MANEUVER

Richard H. Shannon, et al

Naval Aerospace Medical Research Laboratory
Pensacola, Florida

15 August 1973

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

1K

AD 767377

NAMRL - 1189

ISOLATION OF RECURRING STUDENT PILOT ERRORS DURING PRIMARY FLIGHT TRAINING. I. SPIN MANEUVER

Lieutenant Richard H. Shannon, MSC, USN,

Wayne L. Waag, Ph.D., and

Lieutenant Gerald M. Long, MSC, USNR

15 August 1973

NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY

PENSACOLA, FLORIDA

Approved for public release; distribution unlimited.

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Aerospace Medical Research Laboratory Naval Aerospace Medical Institute Naval Aerospace & Regional Medical Center Pensacola, Florida 32512	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

ISOLATION OF RECURRING STUDENT PILOT ERRORS DURING PRIMARY FLIGHT TRAINING. I. SPIN MANEUVER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

LT Richard H. Shannon, MSC, USN
Wayne L. Waag, Ph.D.
LT Gerald M. Long, MSC, USNR

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
15 August 1973	~~40~~ 43	1

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. MF51.524.002-5013DX5X	NAMRL-1180
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	13

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

The present investigation attempted to (1) develop a conceptual model for investigating student naval aviator (SNA) performance in Primary flight training; (2) isolate, with the use of the model, those behaviors within the Spin Maneuver which are judged to be recurring student pilot errors; (3) assess the criticality of those errors as they relate to the grades a student receives; and (4) provide behavioral definitions of the global skills, Basic Airwork, Headwork, and Procedures.

A procedural type of task analysis was performed on the Spin Maneuver. The necessary responses to each display and control both within and outside the aircraft were specified on a sequential continuum. Within each of these sequential components, a highly elemental approach (i.e., emphasis on the simultaneous individual responses to each display and control at each point in time) was taken so that it was possible to isolate the required simultaneous response configuration at any given point throughout the maneuver. An objectively structured questionnaire was developed using these individual task elements as the basic item pool, and administered to a sample of 97 flight instructors in Primary flight training.

The results of this investigation indicated that the recurring student errors within the Spin Maneuver could be isolated using this type of approach. Further, the definitions for the terms Basic Airwork, Headwork and Procedures and what constitutes a "critical" error were set forth.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

Unclassified
Security Classification

ia

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Pilot performance measurement						
Human errors						
Aviation training						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

Unclassified
Security Classification

Approved for public release; distribution unlimited

ISOLATION OF RECURRING STUDENT PILOT ERRORS DURING PRIMARY FLIGHT TRAINING. I. SPIN MANEUVER

Lieutenant Richard H. Shannon, MSC, USN,
Wayne L. Waag, Ph.D., and
Lieutenant Gerald M. Long, MSC, USNR

Bureau of Medicine and Surgery
MF51.524.002-5013DX5X.

Approved by

Ashton Graybiel, M. D.
Assistant for Scientific Program

Released by

Captain N. W. Allebach, MC, USN
Officer in Charge

15 August 1973

Naval Aerospace Medical Research Laboratory
Naval Aerospace Medical Institute
Naval Aerospace and Regional Medical Center
Pensacola, Florida 32512

SUMMARY PAGE

PROBLEM

The present investigation attempted to (1) develop a conceptual model for investigating student naval aviator (SNA) performance in Primary flight training; (2) isolate, with the use of the model, those behaviors within the Spin Maneuver which are judged to be recurring student pilot errors; (3) assess the criticality of these errors as they relate to the grades a student receives; and (4) provide behavioral definitions of the global skills, Basic Airwork, Headwork, and Procedures.

FINDINGS

A procedural type of task analysis was performed on the Spin Maneuver. The necessary responses to each display and control both within and outside the aircraft were specified on a sequential continuum. Within each of these sequential components, a highly elemental approach (i.e., emphasis on the simultaneous individual responses to each display and control at each point in time) was taken so that it was possible to isolate the required simultaneous response configuration at any given point throughout the maneuver. An objectively structured questionnaire was developed using these individual task elements as the basic item pool, and administered to a sample of 97 flight instructors in Primary flight training.

The results of this investigation indicated that the recurring student errors within the Spin Maneuver could be isolated using this type of approach. Further, the definitions for the terms Basic Airwork, Headwork and Procedures and what constitutes a "critical" error were set forth.

INTRODUCTION

In most cases Primary flight training is the student naval aviator's (SNA) first encounter with flying an aircraft. Basic skills acquired during this phase generalize to later stages of training. The vast potpourri of visual scanning and control movement responses which the SNA learns will provide the basis from which the highly refined skills required to successfully fly operational types of aircraft will emerge. Due to the importance of the development of these basic skills, one of the flight instructor's primary concerns is the detection of errors the student pilot makes, and the subsequent correction of these errors. The present research effort was directed toward the isolation of recurring problem areas in the development of these basic flying skills through the utilization of a combined task analysis - rating form and a conceptual model of pilot behavior.

A Conceptual Model of Pilot Behavior

Pilot behavior during the execution of a flight maneuver can be characterized in numerous ways. At the most elemental level, it can be described as the execution of a fixed set of scanning and control movement responses in a prescribed sequence over time. Accordingly, three major dimensions of interest emerge; that of time, type, and time/type. Along the first dimension of time, the performance of any flight maneuver can be viewed as a set of procedural operations arranged in a sequential manner. The entire maneuver can be conceptualized as a sequential set of distinct procedural operations. For brevity, each procedural operation will be termed a <u>sequential step</u>.

Within the time dimension, the execution of a flight maneuver can also be categorized according to successive aircraft changes in airspeed, power setting, configuration or in one or more of the four fundamental flight attitudes that comprise the maneuver. Changes in aircraft configuration would include the raising and lowering of the flaps or landing gear. Aircraft alterations in flight attitude would include going from either straight and level flight, a turn, climb or descent to one of the other three attitudes. During straight and level flight, the aircraft remains in balanced flight on a constant heading and altitude with the wings level at any airspeed. In a turn, the flight heading is altered by applying coordinated aileron and rudder in the direction of the desired turn. During a climb, the aircraft gains altitude while maintaining a constant airspeed. During a descent, the aircraft loses altitude while maintaining a constant airspeed. In addition to these four fundamental flight attitudes, two combinations are possible, ascending and descending turns. These modifications in flight attitude, aircraft configuration and the increasing or decreasing in the power setting, affect the airspeed by causing the aircraft to go either faster or slower.

On the basis of these changes affecting the aircraft, it is possible to characterize a maneuver according to transitions from one aircraft modification to another. Thus, the sequential steps involved in the execution of a maneuver, along with their elemental scanning and control responses, can further be divided according to these aircraft modifications. Each successive aircraft modification during a maneuver will be termed sequential phase.

In summary, it is possible to categorize the elemental scanning and control responses of a flight maneuver along the temporal dimension as follows: (1) those comprising a conceptually distinct procedural operation are collectively referred to as a sequential step; and (2) those sequential steps involving the same aircraft changes in flight attitude, configuration, power setting and airspeed are collectively referred to as a sequential phase. It is apparent that such a taxonamy forms a hierarchy in which the elemental scanning and control responses form the base. Sequential steps form the first order level of analysis, while the sequential phases form the second order level.

The second major dimension of interest is a categorization of scanning and control movement responses according to a typology of behavior. Individual task elements are grouped according to similarity of function. For example, "scanning the horizon for proper nose attitude" is performed numerous times throughout most maneuvers. Consequently, these individual elements can be grouped according to their similarity of function. Such an arrangement of functionally equivalent task elements are collectively referred to as a task element group.

The flight path of an aircraft can be viewed as a function of control in the three major axes; pitch, roll, and yaw. Changes in the fundamental flight attitudes involve changes in one or more of these control axes. For the most part, control of the three flight axes is a continuous behavioral function. For example, proper control in the pitch axis involves continuous scanning for proper nose attitude and control of the elevator. In addition to these continuous functions which are performed simultaneously throughout flight, there are certain discrete activities which are performed only during certain steps of the maneuver. During the spin, for example, the pilot must close the throttle completely at one particular point. Such a behavior would be termed a discrete control response. In addition to control responses, there are discrete scanning responses which must also be executed at specific points throughout a maneuver.

Taken as a whole, five distinct task activities can be identified which categorize the various task element groupings. Accordingly, pilot behavior during the execution of any maneuver can be viewed as a series of discrete and continuous control and scanning responses. Continuous control in the pitch, roll, and yaw axes in conjunction with discrete visual scanning and discrete control movement responses form the basis of most pilot behavior.

Thus far, individual task elements have been categorized according to time and type of behavior. The execution of a maneuver may also be considered the synthesis of these two dimensions. In other words, the interaction of type of behavior with time of occurrence is of critical importance and forms the third dimension to the conceptual model, that of time/type. Although several alternatives were possible, two levels of analysis were believed to hold the greatest potential within the time/type dimension, that of task element by sequential step and task activity by sequential step. The three dimensions of time, type, and time/type and the six levels of analysis comprising these dimensions are summarized in Table 1 and Figure 1.

Development of a Probabilistic Approach to Error Isolation

As indicated earlier, the major emphasis of the present investigation was directed toward the isolation of the most recurrent student pilot errors. It seemed that the most meaningful approach would be to define the importance of an error in terms of its probability of occurrence. In other words, for a given error category, what is the probability that it will be committed by the average student during primary flight training?

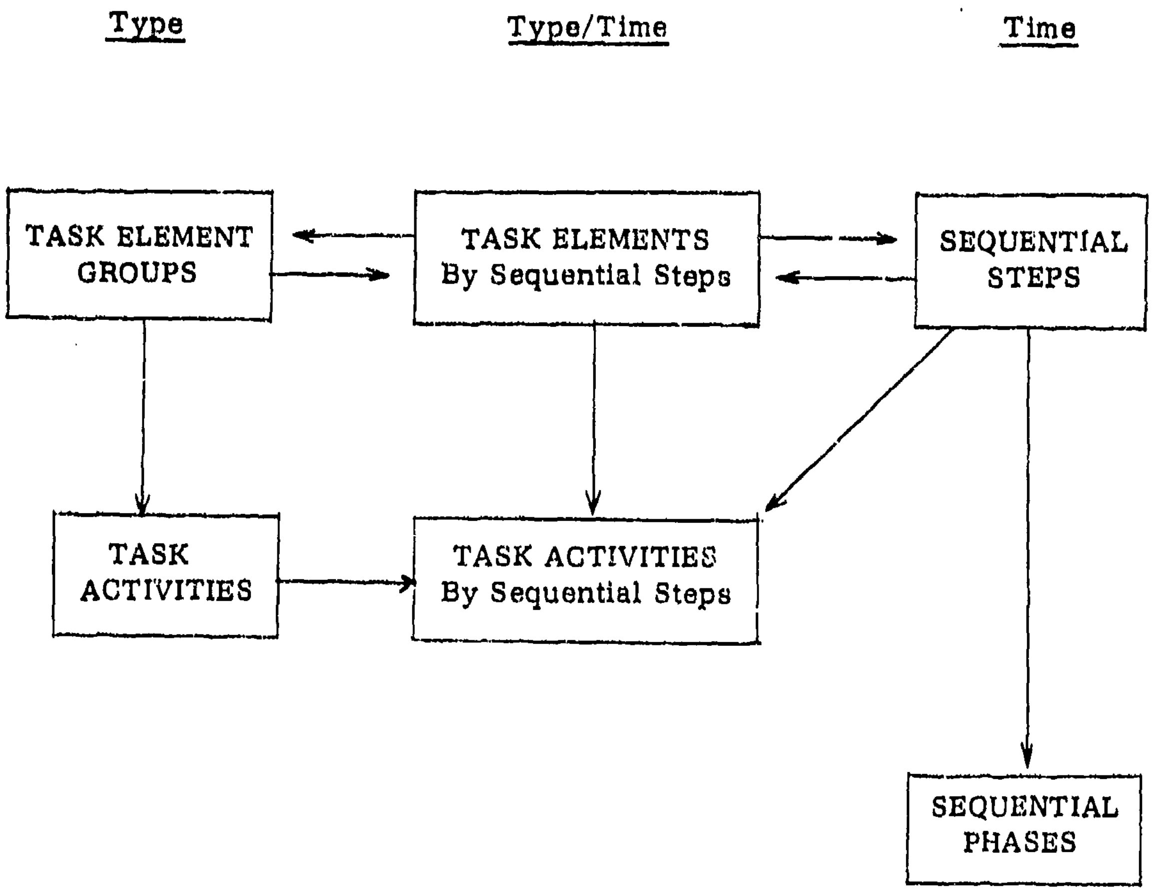
Since each elemental scanning and control response represents a potential error, four questions seemed to be of importance. First, what is the probability that the average student will commit this error? Second, since the student becomes more proficient over time, what is the conditional probability that the error will occur by the time all maneuvers have been introduced (Hop 9)? Third, what is the conditional probability that the instructor will consider the error to involve Headwork, Basic Airwork, or Procedures? After each hop, the instructor is required to rate the student on these three global items? Fourth, what is the conditional probability that the student will receive a Below Average or Unsatisfactory rating if he commits the error? The answer to these four questions would provide information concerning the frequency of an error, its persistence over time, the type of behavior the error represents, and its judged criticality by the instructor. Following the conceptual model proposed above, these questions can be dealt with along the specific dimensions of time, type, and time/type. Therefore, the most elemental tasks can be combined into several meaningful categories with probability statements assigned at all levels of analysis.

Table 1

Descriptions of the Levels of Analyses

Dimension		Level Description
A.	TIME	Sequential Step - arrangement of those task elements performing the same procedural operation concurrently. Sixteen are contained in the spin.
		Sequential Phase - arrangement of those sequential steps according to aircraft changes in flight attitude, configuration, airspeed or power setting. Five are contained in the spin.
B.	TYPE	Task Element Group - arrangement of those task elements performing the same perceptual or psychomotor function throughout the maneuver. Seventeen are contained in the spin.
		Task Activity - arrangement of those task element groups performing the same discrete or continuous perceptual-psychomotor function throughout the maneuver. Five are contained in the spin.
C.	TYPE/TIME	Task Element/Sequential Step - arrangement of tasks which are performed concurrently. Sixty-eight are contained in the spin.
		Task Activity/Sequential Step - arrangement of the task elements which are performing the same perceptual-psychomotor operation concurrently. Forty-one are contained in the spin.

Figure 1


Type
Type/Time
Time
TASK ELEMENT GROUPS
TASK ELEMENTS By Sequential Steps
SEQUENTIAL STEPS
TASK ACTIVITIES
TASK ACTIVITIES By Sequential Steps
SEQUENTIAL PHASES

In summary, the successful execution of any maneuver can be conceptualized as a series of responses to external cues as well as to the displays and controls within the aircraft. To adequately describe each maneuver, it is necessary to define the required set of simultaneous responses for each of the sequential steps. In this way, both the parallel and serial processing requirements for each maneuver can be outlined within the proposed conceptual model. With the help of this model and its three dimensions of time, type, and time/type, meaningful estimates of error frequency at several levels of analysis can be generated.

As stated previously, the present research effort was directed toward the isolation of the most important problem areas the student pilot encounters during Primary flight training. Specifically, the aims of the present investigation were to: (1) select those maneuvers taught during primary flight training which provide the most difficulty to student pilots; (2) develop highly detailed descriptions of these maneuvers; (3) isolate those behaviors within these maneuvers which are judged to be recurring student pilot errors; (4) assess the criticality of these errors as they relate to the grades a student receives; and (5) provide behavioral definitions of those global skills, Basic Airwork, Headwork, and Procedures.

METHOD

Due to the relatively large number of maneuvers which the student is required to learn during primary training, only those were selected for analysis which were considered to provide the most recurring problems. From the present grading forms used during Primary flight training, maneuvers were selected by considering the item distributions of "Below Averages" (BA) and "Unsatisfactories" (U). Those maneuvers were selected for further analysis which produced the highest number of Below Average and Unsatisfactory ratings. Using this rationale, six maneuvers were selected. These included the spin, the approach-turn stall, slow flight, the high altitude emergency, standard field entry, full flap approach/landing/takeoff. Performance on these six maneuvers was considered to be highly indicative of the student's overall performance during Primary training. Three other items on the instructor's rating form had higher BA's and U's than the maneuvers selected; Basic Airwork, Headwork and Procedures. As indicated, these items do not lend themselves to detailed descriptions, since they are global skills encompassing all maneuvers. Appendix A contains a description of the flight syllabus and number of flight hours in the Pre-Solo and Precision stages of training at VT 1, the Navy's Primary flight training squadron.

The task analysis procedure seemed to offer a workable methodology for the development of detailed maneuver descriptions. Accordingly, each maneuver was divided into a number of sequential steps. For each step, the scanning and control movement responses to be performed concurrently were specified. These individual elemental responses formed the basis of the resulting maneuver descriptions.

The actual development of these descriptions entailed a series of check procedures and revisions. The initial task analysis was written using the training command T-34 Primary Maneuver Description handbook (1). These initial analyses were checked for completeness and accuracy by a small sample of flight instructors (N = 7) assigned to VT-1. On the basis of their comments, suggestions, and criticisms, revisions were made and "proofed" by a second set of instructors (N = 4). Following this second screening, revisions were again made leading to the final maneuver descriptions. Appendix B contains the final 68 task elements presented to the instructors in a questionnaire format.

It seemed reasonable that the flight instructors assigned to the Primary training squadron should best be able to assess the frequency of student pilot errors in terms of the detailed maneuver descriptions. Accordingly, a rating form was developed for each maneuver in which the individual task elements formed the basic item pool. In an attempt to meet the objectives of the study, the following questions were asked about each task element. First, did the elemental response represent an error which was committed by the average student? In the event the answer was "no", the instructor proceeded to the next item. Otherwise, he answered the remaining questions. Next, the instructor estimated "time to correct" or simply the hop number by which the error was normally corrected. The subsequent question concerned the instructor's judgement concering type of error. The item was to be rated an error involving either Basic Airwork, Headwork, or Procedures. Lastly, the item was to be judged "critical" or "non-critical." In the event the instructor would give the student a Below-Average or Unsatisfactory rating for committing the error, the item was to be rated "critical". This questionnaire was given to a sample of 97 flight instructors assigned to VT 1. Appendix C contains the questionnaire's Foreward, Instructions, Biographical Information page, and Parts A and C of the maneuver description. Part B of the maneuver description is the 68 task elements presented in Appendix B.

From the instructor's responses to the individual items several error estimates were computed. The next two paragraphs were outlined in the Introduction, but due to the novel approach to error isolation as outlined in this paper, the authors felt these ideas should be repeated. The probability that an item represented an error committed by the average student was estimated from the percentage of instructors responding to that particular item. The resulting estimates are termed probability of error frequency. The probability that the error occurred after Hop 9 was estimated from the percentage of instructors indicating that the error was normally corrected by Hop 10 or beyond. Such estimates are labeled probability of error persistence. The probability a student would receive a Below Average or Unsatisfactory in the event he committed the error was estimated from the percentage of instructors marking the item "critical." These estimates are termed probability of error criticality. The probabilities that an error was perceived as representing Basic Airwork, Headwork, or Procedures was estimated by the percentages of instructors marking these three categories and are referred to as probability for type of error. All estimates of error frequency, error persistence, error criticality, and type of error were conditional probabilities in that they were based only upon the responses of those individuals indicating the item to be an error committed by the average student.

These estimates were computed for each of the task elements as well as various higher level categories. For some of the higher level categories, such as the levels of analysis in both the time and type dimensions, an additional measure was computed, the expected number of errors. This measure is another way of stating probability of error frequency, and is an estimate of the number of errors committed by the average student on this maneuver throughout Primary flight training (all hops). Such an estimate seemed appropriate whenever categories consisted of multiple task elements. Furthermore, estimates of error frequency, persistence, and criticality for higher order categories reflected the probabilities that at least one error would be committed, occur after Hop 9, or be considered critical from the pool of individual task elements.

RESULTS AND DISCUSSION

The maneuver to be presented in this report is the spin. The following description of the maneuver is contained in the T-34 Primary Maneuver Description handbook (1). This maneuver is introduced on Hop 7.

PRECISION SPIN (LEFT/RIGHT) (MINIMUM ENTRY 4500')

Brief: A spin is an aggravated stall resulting in autorotation. The aircraft is completely stalled, falling nose low toward the ground, following a corkscrew path through the air. Spins develop your ability to recognize their entry and to recover promptly and automatically from unintentional spins, build confidence, and teach orientation in unusual attitudes.

Description: Before entering the clearing turn for the spin, complete the stall checklist, check the altitude, minimum entry altitude is 4500 feet, and select a large landmark or prominent section line near the horizon. At the start of the last 90-degrees of clearing turn, close the throttle, do not retrim, smoothly raise the nose to complete the clearing turn with wings level and the nose 15-degrees above the normal cruise attitude with 75 knots or less. Maintain this attitude and as the stall approaches begin to apply full rudder in the direction of desired rotation. At the stall, apply full rudder, then full back stick (straight back). After two complete turns, recover by applying opposite rudder to the neutral position, followed by forward stick to the neutral position When rotation stops, level the wings and raise the nose to the 100-knot climb attitude. Check the oil pressure and smoothly apply full throttle. Recovery should be made above 3000 feet and under 140 knots.

The completed questionnaire shown in Appendix C and the four-scale rating form for the 68 items shown in Appendix B were administered to a sample of 97 flight instructors. As outlined in the Introduction, the results will be reported according to: (1) Isolation of error by time; (2) isolation of error according to type of behavior; and (3) isolation of error according to type of behavior over time. Additional sections will deal with the specification of criticality in the execution of the spin and an attempt to behaviorally define the global skills of Basic Airwork, Headwork, and Procedures which have become a part of naval aviation.

Error Isolation by Time

The 68 task elements defining both the sequential and concurrent processing requirements of the Spin Maneuver comprised 16 sequential steps (see Appendix B). These sequential steps were further collapsed into five sequential phases according to aircraft changes in fundamental flight attitude, configuration, power setting and airspeed. The results of the breakdown according to time are presented in Table 2. For each sequential step and phase the number of task elements comprising each category is presented. Probability estimates of error frequency, error persistence, and the expected number of errors are also presented.

As indicated in Table 2, the resulting probabilities of committing at least one error (error frequency) during each sequential step and sequential phase were extremely high. Those steps having the lowest likelihood of student error were also those comprised of the lowest number of task elements. Likewise, steps and phases with the highest number of expected errors were also comprised of the highest number of individual elements. Thus it appears that

Table 2

Analysis of Sequential Phases and Steps Within The Spin Maneuver

Sequential Phase/Step Description	No. of Elements By Time	Probability For Error Frequency	Estimated No. of Errors	Probability For Error Persistence
Phase A - Maneuver set-up in clearing turn	19	1.000	11.2	.649
Step 1 - Commence second clearing turn	8	.979	4.9	.474
Step 2 - Close throttle in turn	2	.691	.9	.299
Step 3 - Maintain clearing turn	9	.990	5.5	.583
Phase B - Maneuver set-up prior to stall	14	.938	6.0	.473
Step 4 - Roll wings level at the 90° position in the clearing turn	8	.907	3.4	.409
Step 5 - Maintain the nose 15° above the normal flight attitude	6	.866	2.6	.410
Phase C - Initiate and maintain spin	9	.979	5.7	.189
Step 6 - Apply slight rudder prior to stall	1	.515	.5	.060
Step 7 - Apply full rudder when aircraft stalls	1	.649	.6	.063
Step 8 - Apply full back stick	1	.691	.7	.046
Step 9 - Maintain spin through first 360° turn	3	.836	1.8	.086
Step 10 - Maintain spin through second 360° turn	3	.928	2.0	.144
Phase D - Initiate spin recovery	7	.990	4.4	.406
Step 11 - Apply rudder to neutral position after completion of two turns	2	.866	1.2	.098
Step 12 - Apply forward stick pressure to neutral position	1	.887	.9	.200
Step 13 - Roll wings level	4	.918	2.3	.316
Phase E - Initiate climbing recovery	19	.990	9.2	.521
Step 14 - Raise the nose to the 100 knot climbing attitude	7	.969	3.8	.372
Step 15 - Check oil pressure gauge	1	.711	.7	.169
Step 16 - Add full power to commence a climb	11	.928	4.7	.400

error probability, when considered along the dimension of time, is a function of opportunity and perhaps also overload. In other words, those sequential segments requiring the largest number of responses are also those producing the highest error rates.

A similar pattern emerges when the probability of committing at least one error after Hop 9 is considered. Those steps and phases comprised of the largest number of elements tended to yield the highest probabilities of error persistence. These results are consistent with the classical finding of degraded performance under conditions of task overload. Recall that each sequential step is comprised of task elements which are being performed concurrently. Those steps with the highest number of elements are also those in which the highest number of multiple responses are being performed simultaneously. Consequently, it could be expected that such conditions would lead to increased probabilities of error. The data lend support to such an hypothesis. In summary, the data suggest that the incidence of error will be highest for those segments of the maneuver during which the workload is greatest.

As indicated by Table 2, Phases A and E produced the highest number of expected errors. During the maneuver set-up in the clearing turn, or Phase A, Steps 1 and 3, which involved commencing and maintaining the clearing turn, should be viewed as the highest potential source of error. As indicated by Appendix B, the essential items involved proper scan for other aircraft, maintenance of proper angle of bank and balanced flight, and an increase in nose attitude to reduce airspeed. During the initiation of the climbing recovery or Phase E, Steps 14 and 16, which involved raising the nose and adding power to commence a climb, are the highest potential sources of error. Proper scan for other aircraft, maintenance of proper angle of bank and balanced flight, and the establishment and maintenance of proper nose attitude again emerged as important sources of error. The addition of full power also represented a significant potential for error. These findings suggest that on a sequential time dimension, the maneuver set-up and climbing recovery phases produce the greatest number of errors. During Primary flight training, concentration on these phases by the instructor will most likely produce the greatest amount of error reduction.

Error Isolation by Type of Behavior

The 68 task elements were reduced to 17 task element groups on the basis of their functional equivalence. These task element groups were further collapsed into five task activities. Accordingly, task element groups were categorized into one of these activities involving continuous control of the aircraft in the three flight axes or one of the two activities involving discrete visual scanning or control movement responses. These results are presented in Table 3.

Table 3

Analysis of Task Activities and Task Element Groups Within the Spin Maneuver

Task Activity/Task Element Group Description	No. of Tasks Elements By Time	Error Frequency	Estimated No. of Errors	Error Persistence	Error Criticality
Task Activity A - Continuous control in pitch axis (CP)	19	1.000	11.5	.577	.794
Task Element Groups:					
1 - Use elevator pressure	8	1.000	5.4	.474	.763
2 - Scan horizon for nose attitude	6	.876	3.5	.376	.588
3 - Scan airspeed indicator	3	.784	1.6	.355	.421
4 - Scan altimeter	1	.630	.6	.323	.274
5 - Trim elevator pressure	1	.423	.4	.195	.122
Task Activity B - Continuous control in roll axis (CR)	14	.979	6.0	.421	.663
Task Element Groups:					
1 - Use aileron pressure	7	.918	2.6	.404	.629
2 - Scan horizon for angle of bank	7	.918	3.4	.337	.562
Task Activity C - Continuous control in yaw axis (CY)	18	.928	9.1	.6[illegible]2	.600
Task Element Groups:					
1 - Use rudder pressure	10	.928	5.2	.544	.578
2 - Scan ball for balanced flight	7	.773	3.4	.573	.253
3 - Trim rudder pressure	1	.536	.5	.209	.250
Task Activity D - Discrete control in all axes (DC)	7	.969	3.[illegible]	.234	.840
Task Elements Groups:					
1 - Use elevator pressure	2	.928	1.6	.222	.856
2 - Use rudder pressure	3	.804	1.7	.103	.679
3 - Use throttle control	2	.464	.6	.022	.489
Task Activity E - Discrete visual scan (DS)	10	.990	6.1	.448	.781
Task Element Groups:					
1 - Scan area for other aircraft	3	.897	2.0	.299	.529
2 - Scan area for a particular position	5	.897	2.6	.138	.632
3 - Scan airspeed indicator	1	.691	.7	.239	.50[illegible]
4 - Scan oil pressure gauge	1	.711	.7	.1[illegible]	.391

For each task element group and task activity the number of task elements comprising each category is presented. Probability estimates of error frequency, error persistence, error criticality, and the expected number of errors is presented.

As seen in Table 3, the probabilities of committing at least one error for each task element group and task activity were quite high. The only exceptions involved discrete use of the throttle and proper trim control in the pitch and yaw axes. The most persistent errors involved continuous control of the aircraft in the yaw axis through the appropriate application of rudder pressure and proper scanning of the ball for balanced flight. Continuous use of elevator pressure was also a persistent source of error.

The task activities producing the highest number of expected errors involved continuous control in the pitch and yaw axes. The two task element groups with the highest number of errors involved continuous use of elevator and rudder pressure. Considering error criticality, the task activity involving discrete control produced the highest value. At the task element group level, discrete use of the elevator and continuous elevator control produced the highest values. In summary, it appears that proper elevator control (pitch axis) is perhaps the most important skill the student must learn in order to successfully execute the Spin.

Error Isolation by Type of Behavior Over Time

From the data presented for the task elements by sequential steps, probability statements were generated for the task activity by sequential step level of analysis. It is at this level rather than at the task element/step level that the greatest information in terms of error isolation is yielded. Each step represents a synthesis of continuous control about the three flight axes interspersed with discrete control and scanning responses. It is at this level of analysis that the instructor can most readily detect the occurrence of an error. Consider continuous control in the pitch axis during descent, the pilot must continuously scan for proper nose attitude and airspeed while continuously controlling the elevator. Suppose the resultant glide slope angle is incorrect. The instructor is able to observe the improper glide slope angle but cannot observe exactly which response is in error. Does the pilot fail to scan for proper nose attitude, fail to scan for proper airspeed, or fail to properly control the elevator? In many cases, the instructor is simply unable to directly observe pilot behavior at the elemental response level. In other words, errors are most often detectable only at the task activity level. For this reason, it is suggested that the analysis of student pilot error according to task activity for each sequential step should provide the most useful information. For these reasons, it seemed that error isolation at the task activity level for each sequential step would be most consistent with what the instructor is able to observe.

In this dimension, the 68 task elements were collapsed into 41 "task activity by sequential step" categories. For each category, probability estimates of error frequency, error persistence, and error criticality were completed. A complete listing of these results is presented in Appendix D. Table 4 presents those categories in which the error frequency was .60 or greater. Although the choice of .60 was arbitrary, it seemed that these represented the most significant sources of error. Of the 41 groups contained in Appendix D, 24 are presented in this table.

The five errors producing the highest frequency estimates occurred during the manouver set-up in the clearing turn and the spin/climbing recovery. Maintaining a constant altitude while commencing the second clearing turn and raising the nose throughout the turn so that the aircraft is in a 15° nose-up attitude upon completion had the highest probability of error frequency during the set-up phase. Both errors required continuous control of the aircraft in the pitch axis which involved control of elevator stick pressure, scan of the horizon for proper nose attitude, and scan of both the airspeed and altitude indicators.

During the two recovery phases, application of forward elevator stick pressure to the neutral position, leveling the wings once rotation had ceased, and raising the nose to the 100 knot climbing attitude were the most frequent errors. Moving the stick forward to the neutral position involved the discrete use of elevator pressure. Rolling the wings level was a continuous activity requiring the appropriate use of aileron pressure and the scan of the horizon for proper angle of bank. Appropriate use of elevator pressure and scan for proper nose attitude were involved in raising the nose to the 100 knot climbing attitude.

The most persistent errors were the maintenance of altitude when commencing the clearing turn, maintenance of proper angle of bank while raising the nose throughout the clearing turn, and maintenance of balanced flight after power addition during the climbing recovery. Each of these four most persistent errors involved continuous control of the aircraft--one in the roll axis, one in the yaw axis, and two in the pitch axis.

Specification of Criticality in the Spin

From Table 4, it is apparent that the most critical errors occur during the initiation, maintenance, and recovery from the spin itself. The two errors with the highest criticality ratings involved the discrete use of elevator pressure--one during spin entry and the other during spin recovery. One of these errors, the application of forward elevator stick pressure during spin recovery, not only had a high criticality estimate (.779), but also a high frequency (.877). It is likely that this one error may be the most important for the spin maneuver.

Table 4

Most Significant Errors (Task Activity/Sequential Step) Within the Spin Maneuver

	Error Description	* Task Activity	Error Frequency	Error Persistence	Error Criticality
Phase A - Maneuver set-up in clearing turn					
1.	Scan area for other aircraft when commencing the second clearing turn.	DS	.742	[illegible]	.361
2.	Roll the aircraft so as to establish 45° angle of bank in the clearing turn.	CR	.732	.197	.169
3.	Maintain a constant altitude when commencing the second clearing turn.	CP	.907	.330	.455
4.	Maintain 45° angle of bank in the clearing turn.	CR	.691	.328	.224
5.	Raise the nose smoothly in the clearing turn after throttle closure to establish the nose 15° above the normal attitude and an airspeed of 75 knots or less.	CP	.959	.462	.569
6.	Scan area in the clearing turn for other aircraft.	DS	.753	.247	.438
Phase B - Maneuver set-up prior to stall					
7.	Maintain the nose 15° above the normal attitude when rolling the wings level.	CP	.804	.256	.474
8.	Maintain the nose 15° above the normal attitude with the wings level.	CP	.701	.250	.500
Phase C - Initiate and maintain spin					
9.	Apply full rudder pressure when the aircraft stalls in the direction of the last clearing turn.	DC	.649	.127	.651
10.	Apply full back stick upon spin entry.	DC	.691	.119	.716
11.	Maintain full rudder pressure in the first 360° spin turn.	CY	.619	.067	.600
12.	Maintain full back stick in the first 360° spin turn.	CP	.691	.060	.657
13.	Maintain full rudder pressure in the second 360° spin turn.	CY	.608	.085	.610
14.	Maintain full back stick in the second 360° spin turn.	CP	.649	.127	.651
15.	Scan for the approach to the landmark for an indication of the second 360° turn.	DS	.784	.092	.605
Phase D - Initiate spin recovery					
16.	Scan landmark for an indication of the second 360° spin turn.	DS	.732	.113	.606
17.	Apply forward elevator stick pressure to the neutral position.	DC	.887	.233	.779
18.	Roll the wings level when rotation of the aircraft ceases.	CR	.876	.188	.624
Phase E - Initiate climbing recovery					
19.	Raise the nose smoothly prior to power addition to establish a 100 knot climb attitude.	CP	.856	.229	.518
20.	Scan the airspeed indicator to ensure raising the nose prior to 140 knots.	DS	.691	.269	.507
21.	Maintain the wings level while raising the nose.	CR	.639	.177	.371
22.	Scan the oil pressure gauge for indication prior to adding full power.	DS	.711	.174	.391
23.	Maintain the nose at the 100 knot climb attitude during power addition.	CP	.732	.211	.338
24.	Maintain balanced flight during power addition.	CY	.742	.361	.250

* DS = Discrete Scan; DC = Discrete Control; CY = Continuous Control in Yaw Axis; CR = Continuous Control in Roll Axis; CP = Continuous Control in Pitch Axis.

It is interesting to note that estimates of error persistence are lowest during the initiation, maintenance and recovery from the spin, yet the criticality estimates are the highest. This may be explained by the fact that, although they have a low probability of occurrence during the later hops of Primary training, their occurrence will most likely result in a student receiving a Below Average or Unsatisfactory rating if they are committed. This high criticality rating is not too surprising since these two phases represent the essence of the spin maneuver. From the T-34 Primary Maneuver Description handbook (1). Spins develop your ability to recognize their entry and to recover promptly and automatically from unintentional spins, build confidence, and teach orientation in unusual attitudes". The remaining phases, proper set-up in the clearing turn and the climbing recovery, are not critical components within the Spin Maneuver. A student receiving a Below Average or Unsatisfactory rating for the execution of the Spin will most likely have committed errors during the initiation, maintenance, or recovery from the Spin itself.

One further point should be made. The estimates of criticality were for single errors only. In practice, it usually occurs that the student will commit multiple errors. Unfortunately, the present data do not provide estimates in the event multiple errors are committed. Nevertheless, the individual criticality estimates do represent a lower bound in the event of such an occurrence. Certainly, the likelihood of a Below Average or Unsatisfactory rating will be increased. By what amount, however, the data does not indicate. To compute all combinations of errors is simply impractical although theoretically possible.

Behavioral Definitions of Basic Airwork, Headwork, and Procedures

For each task element group and task activity, the probabilities that the error was perceived to involve Basic Airwork, Headwork, or Procedures were computed. These results are presented in Table 5. It is apparent that those task element groups and task activities involving continuous control of the aircraft in its three major axes are perceived by flight instructors to represent Basic Airwork skills. In most cases probabilities for these three task activities of being rated Headwork or Procedures were quite low. Those task element groups involving discrete control movements loaded most highly on the Procedures skill, although the discrimination among the three categories was not as great as that for Basic Airwork. Those task element groups involving discrete visual scanning responses were considered to represent Headwork skills.

From the consensus of instructors sampled, it would appear that poor Headwork can be defined as improper discrete visual scanning response patterns which become manifested through inadequate monitoring and detection of potential

Table 5

Analysis of Type of Error by Task Activities and Task Element Groups Within the Spin Maneuver

Task Activity/Task Element Group Description	Type of Error Probabilities BAW	HDWK	PROC
Task Activity A - Continuous control in pitch axis (CP)	.720	.128	.152
Task Element Groups:			
1 - Use elevator pressure	.676	.119	.206
2 - Scan horizon for nose attitude	.793	.133	.074
3 - Scan airspeed indicator	.612	.164	.224
4 - Scan altimeter	.860	.099	.033
5 - Trim elevator pressure	.878	.098	.024
Task Activity B Continuous control in roll axis (CR)	.840	.089	.071
Task Element Groups:			
1 - Use aileron pressure	.827	.083	.091
2 - Scan horizon for angle of bank	.850	.093	.056
Task Activity C - Continuous control in yaw axis (CY)	.822	.089	.088
Task Element Groups:			
1 - Use rudder pressure	.792	.089	.120
2 - Scan ball for balanced flight	.870	.086	.044
3 - Trim rudder pressure	.820	.120	.060
Task Activity D - Discrete control in all axes (DC)	.283	.107	.521
Task Element Groups:			
1 - Use elevator pressure	.384	.205	.411
2 - Use rudder pressure	.288	.170	.542
3 - Use throttle control	.032	.242	.726
Task Activity E - Discrete visual scan (DS)	.250	.553	.197
Task Element Groups:			
1 - Scan area for other aircraft	.199	.686	.115
2 - Scan area for a particular position	.311	.522	.167
3 - Scan airspeed indicator	.323	.385	.292
4 - Scan oil pressure gauge	.103	.456	.441

problems, the failure to use sensory cues to detect display or environmental changes, and poor anticipation of or planning for a future series of occurrences. Procedures can be defined as improper discrete control movement responses which become manifested in the omission or misordering of a required response or series of responses. Basic Airwork can be defined as improper continuous scanning/control movement responses which serve to control the aircraft in its three major flight axes. It involves poor perceptual-motor coordination of hand/eye/foot. Such empirically determined behavioral definitions of Basic Airwork, Headwork, and Procedures should aid in the standardization of intructors' judgments regarding the meaning of these global terms.

IMPLICATIONS

The results of this investigation have identified those student flight errors which are committed by the students during the Spin Maneuver in Primary flight training. Concerning specific error items, application of elevator control in the clearing turn in order to maintain altitude immediately followed by raising the nose to 15° above the normal attitude during the maneuver set-up phase were found to represent the areas of major student difficulty. However, the application of forward elevator stick to the neutral position during the spin recovery phase may be the single most important error in the Spin Maneuver due to its high criticality estimate and a high estimate of error frequency.

The flight characteristics or skills (task element group) which are considered important to the Spin Maneuver have also been isolated. Continuous and discrete use of the elevator control had the highest probabilities of error frequency as well as the highest criticality ratings, while the most persistent errors were continuous use of rudder and scanning the ball for balanced flight.

The meaning of Basic Airwork, Procedures and Headwork were defined according to type of activity being performed. Headwork and Procedures loaded very heavily on discrete visual scanning responses and discrete control movement responses, respectively, while Basic Airwork loaded on continuous control of the aircraft in the three flight axes.

Quite logically, error criticality appeared to be dependent upon the essential portions of the Spin or the reasons <u>why</u> a Spin is taught. A Below Average or Unsatisfactory grade was found to result from an error during the initiation, maintenance, or recovery from the Spin itself.

This isolation of error has several important implications. First, a diagnostic manual for incoming flight instructors and/or students might be developed. In such a manual, information could be provided regarding the successful execution of the Spin Maneuver, the critical points at which students are likely to encounter difficulty, and recommended types of remedial action.

Second, a revised rating form could be developed from those errors listed in Table 4. The revised grading sheet could emphasize performance on the most frequent errors within the Spin. This grading sheet hopefully would give more empirical data concerning number of Spin Maneuvers performed in Primary; the relationships between grade, hop, and error; and lastly, the validity of the questionnaire.

Third, a model of error probability has been devised concerning student performance on the Spin in Primary training. From these probabilities a perceptual-psychomotor test battery could perhaps be developed for the prediction of performance on the Spin Maneuver prior to a student's arrival at VT-1. The resulting test battery should represent an analog to the response configuration required for the performance of a given component or phase within the Spin Maneuver.

Fourth, a method has been devised along the dimensions of time and type of behavior in a hierarchical manner for combining the most elemental tasks into meaningful categories. In this way human error in the Spin Maneuver was analyzed in an apparently effective manner. Hopefully, the methods used in this investigation will serve as an aid for future studies into human error.

Lastly, the empirical definitions of Basic Airwork, Headwork, and Procedures, which were outlined in this report, could be an aid to the instructor. These definitions and interpretations should help to standardize the instructors' understanding of these terms and use of the grading system.

REFERENCE

1. T-34 Primary Maneuver Description, CNAT P-1621 PAT, Chief of Naval Air Training, Naval Air Station, Pensacola, Florida, Feb 1973.

APPENDIX A

This section contains the flight syllabus and number of flight hours contained in Pre-Solo and Precision stages of Primary flight training

Primary flight training is divided into two stages, Pre-Solo and Precision. Pre-Solo consists of dual instruction for the purpose of preparing the student pilot to fly solo while the Precision stage is directed toward instruction in precision and acrobatic maneuvering. The Pre-Solo stage consists of 1 . dual instructional hops. By the ninth hop, all maneuvers have been introduced and the student begins to prepare for his final check hop prior to solo. That is, after Hop 9, the student should be able to execute all maneuvers without committing any major errors. Hop 12 is the safe-for-solo check flight, and if considered safe by the instructor, the student will solo on Hop 13.

The flight syllabus at VT-1 consists of 26 instructional hours, 17.6 hours in Pre-Solo stage and 8.4 hours in Precision stage. During this period of training, the student receives 20.8 hours of dual instruction and 5.2 hours of solo flight time.

Beginning with Hop 4, the instructor rates a student's performance on each maneuver and procedure executed. For each graded item, he rates the student's performance to be Above Average, Average, Below Average, or Unsatisfactory. In addition to specific maneuvers and procedures, three global skills must be graded--Headwork, Basic Airwork, and Procedures.

The following is a description of Primary flight training in mid-1972 when the data were collected:

SYLLABUS PERIOD	DESCRIPTION	HOURS
	PRE-SOLO STAGE	
	This stage is devoted to dual instruction for the purpose of qualifying students to fly solo. It consists of eleven (11) dual instructional flights, one (1) check flight, one (1) solo (PS-13) flight. The student shall be instructed in the fundamentals of good airmanship, with emphasis on the principles of attitude flight, coordination of controls, smoothness, basic airwork, effective use of trim tabs, and landing techniques. The student shall also be taught stalls and spins, entry recognition, and proper recovery technique. Students will perform all previously introduced material on each subsequent flight.	
PS-1 DUAL	Instructor introduce pre-flight inspection and cockpit fundamentals. Student start engine under supervision of instructor; instructor will warm	1.3

SYLLABUS PERIOD	DESCRIPTION	HOURS
	up engine, read, execute, and report check-off list (assisted by student), taxi, take-off, and proceed to area. Instructor introduces use and effects of controls, fundamental flight attitudes, and transitions. Explain course rules and point out prominent landmarks. Use this flight to orient the student in the air. Introduce taxiing after return to home field.	
PS-2 DUAL	Student conduct pre-flight inspection, start and warm up engine. Student read, execute, and report check-off list. Review taxiing, fundamental flight attitudes, transitions, area orientation, and course rules. Introduce take-off, operation of gear and flaps, and coordination maneuver. Demonstrate inherent stability of aircraft. Stress the proper use of trim tabs in all attitude changes and emphasize the importance of learning to fly the aircraft by the attitude method.	1.3
PS-3 DUAL	Student taxi, take off, and proceed to area. Review previous work as necessary. Introduce steep turns, slow flight, and home field entry. Encourage student to develop a definite pattern of scan for observation of attitude indications, instrument reading, and air traffic. Stress use of trim tabs in relieving control pressures in all changes of airspeed, and power setting. Review engine fire during start/after start.	1.3
PS-4 DUAL	Review previous work as necessary. Introduce power-off spirals, standard field entry, full-flap touch-and-go landings, wave-off at outlying fields, and standard field departure. Demonstrate torque effect. Re-emphasize principles of attitude flight as applied to the execution of a landing. Student fly home field entry on this and subsequent flights. Review engine fire in flight, smoke elimination, and fuel fumes.	1.3
PS-5 DUAL	Review previous work as necessary. Introduce no-flap landings and low-altitude emergency. Instructor demonstrate wind effect and crab correction. Review electrical fire, generator failure.	1.3
PS-6 DUAL	Review previous work as necessary. Introduce power-off stall and high-altitude emergency. Review complete and partial engine failure (altitude cannot be maintained.)	1.3
PS-7 DUAL	Review previous work as necessary. Introduce precision spins, left and right, and approach turn stall. Demonstrate emergency landings. Review propeller failure on take-off/airborne.	1.3
PS-8 DUAL	Review previous work as necessary. Introduce cross-wind landings. Review flat tire, brake failure, hard landing.	1.3
PS-9 DUAL	Review previous work as necessary. Introduce procedure at solo fields, including full-stop landings. Demonstrate the progressive spin and emergency landing gear operation. Review gear-up landing.	1.3
PS-10 DUAL	Review previous work as necessary. Demonstrate skidded turn stall and operation of the emergency fuel system. Review landing with one main gear retracted, nose gear retracted.	1.3
PS-11 DUAL	Instructor's check of all maneuvers previously introduced. Introduce home field wave-off procedure. Review lost-plane procedures.	1.3
PS-12 DUAL CHECK	Check all work introduced in pre-solo stage to determine whether or not student is safe-for-solo. The student will be required to:	2.0

a. Inspect the plane, start, warm up, perform cockpit check, and test engine correctly.

SYLLABUS PERIOD	DESCRIPTION	HOURS
	b. Taxi safely and use brakes correctly. c. Take off without excessive swerving. Use propeller, throttle, and landing gear controls properly. d. Recognize stall conditions and perform satisfactory recovery from stalls introduced. Perform satisfactorily: slow-flight procedures, spins, steep turns, and power-off spirals. e. Demonstrate proper procedure and good headwork during simulated high- and low-altitude emergencies. f. Execute safe full-flap and no-flap landing on a hard-surfaced runway. All landings must be in the first third of the runway. g. Demonstrate satisfactory drift correction in cross-wind landings. h. Execute a minimum of three (3) landings, including one (1) full-stop landing at a solo field. Perform three (3) solo landings if considered safe-for-solo by the check pilot. i. Make a successful approach and landing at home field and return to flight line. j. Stop engine and secure cockpit correctly.	
PS-13 SOLO	Practice high-work maneuvers (as recommended by instructor) and into-the-wind landings. DO NOT practice the following maneuvers: Spins, crosswind landings, simulated emergencies, inverted flight, or aerobatics. Student may make a total of four (4) landings with no more than six (6) approaches.	1.3

PRECISION STAGE

This stage consists of six (6) flights devoted to instruction and practice in precision and aerobatic maneuvers. The sixth flight is a precision check on maneuvers introduced in this stage and pre-solo stage. The instructor shall be alert to any evidence of mechanical flying by the student and take such corrective action as necessary. Primary consideration shall be given to development of basic airwork and coordination.

SYLLABUS PERIOD	DESCRIPTION	HOURS
PCN-1 DUAL	Review cross-wind landings and the precision spin. Introduce the wingover, loop, unusual attitudes, emergency landing practice, and recovery from accidental spins. Introduce precision landings. Demonstrate the split "S" and inverted stall. Make a minimum of six (6) landings this flight. Review airborne damaged-plane procedures.	1.5
PCN-2 SOLO	Practice wingovers, loops, slow flight, power-off spirals, precision landings, and work recommended by the instructor.	1.3
PCN-3 SOLO	Same as PCN-2 flight. Emphasis on precision landings.	1.3
PCN-4 DUAL	Review wingover, loops, unusual attitudes, stalls, spins, emergency landing practice, and precision landings. Demonstrate barrel roll, Cuban "8", and Immelmann. Make a minimum of six (6) landings this flight, including cross-wind landings. Review bailout, ditching.	1.5

SYLLABUS PERIOD	DESCRIPTION	HOURS
PCN-5 SOLO	Practice all maneuvers introduced to the student, with emphasis on basic airwork.	1.3
PCN-6 DUAL CHECK	Final check on all maneuvers introduced to the student in pre-solo and precision stages. Include the following maneuvers:	1.5

a. Steep turns
b. Slow flight
c. Power-off stall
d. Approach turn stall
e. Unusual attitudes, recovery from
f. Precision spin and accidental spin
g. High-altitude emergency
h. Low-altitude emergency
i. Precision into-the-wind and cross-wind landings.
j. Emergency landing practice
k. Wingovers
l. Loops

APPENDIX B

This section contains an analysis of all task elements by sequential steps within the Spin Maneuver

(68 elements/steps are listed)

Description	*Task Activity	Probabilities For: Error Freq	Error Persistence	Type of Error: BAW	HDWK	PROC	Error Criticality
PHASE A - MANEUVER SET-UP IN CLEARING TURN							
Step 1. Commence a Second 45° Clearing Turn to the Right							
a. Scan area to the right for other aircraft.	DS	.742	.111	.200	.700	.100	.361
b. Apply right aileron stick pressure to establish the proper angle of bank.	CR	.266	.115	.923	.000	.077	.154
c. Scan horizon for 45° angle of bank.	CR	.680	.258	.905	.079	.016	.152
d. Apply right rudder pressure to maintain balanced flight.	CY	.485	.362	.936	.064	.000	.149
e. Scan ball for balanced flight.	CY	.526	.549	.957	.043	.000	.098
f. Apply back elevator stick pressure to maintain a constant altitude throughout the turn.	CP	.784	.316	.959	.027	.014	.355
g. Scan altimeter for constant altitude.	CP	.639	.339	.869	.098	.033	.274
h. Scan horizon for proper nose attitude.	CP	.742	.278	.886	.086	.020	.375
Step 2. Close the Throttle After Commencing The Second Clearing Turn							
a. Close throttle completely.	DC	.278	.000	.037	.222	.741	.296
b. Apply appropriate rudder pressure to maintain balanced flight.	CY	.577	.393	.926	.056	.019	.064
Step 3. Maintain Second Clearing Turn to the 90° Position							
a. Apply back elevator stick pressure throughout the turn to smoothly raise the nose 15° above the normal flight attitude.	CP	.928	.367	.600	.100	.300	.467
b. Scan horizon for proper nose attitude.	CP	.670	.231	.855	.065	.081	.415
c. Scan the airspeed indicator for the approach of 75 knots.	CP	.691	.373	.636	.167	.197	.299
d. Maintain appropriate rudder pressure to maintain balanced flight.	CY	.485	.362	.915	.021	.064	.128
e. Scan ball for balanced flight.	CY	.505	.531	.915	.064	.021	.122
f. Maintain appropriate aileron stick pressure to maintain 45° angle of bank.	CR	.608	.339	.948	.034	.017	.203
g. Scan horizon for 45° angle of bank.	CR	.615	.280	.918	.082	.000	.160
h. Scan for the approach to the landmark at 90° position of turn	DS	.361	.086	.371	.514	.114	.200
i. Scan area for other aircraft.	DS	.753	.247	.254	.606	.141	.438
PHASE B - MANEUVER SET-UP PRIOR TO STALL							
Step 4. Roll Wings Level at the 90° Position of the Second Clearing Turn							
a. Scan landmark at the 90° position of the clearing turn.	DS	.247	.083	.478	.391	.130	.260
b. Apply left aileron stick pressure to level wings.	CR	.103	.100	.900	.000	.100	.300
c. Scan horizon for wings level.	CR	.423	.146	.925	.050	.025	.268
d. Apply left rudder pressure to maintain balanced flight.	CY	.454	.455	.977	.023	.000	.114
e. Scan ball for balanced flight.	CY	.506	.510	.896	.063	.042	.082
f. Maintain back elevator stick pressure to maintain the nose 15° above the normal flight attitude.	CP	.598	.241	.873	.055	.073	.448

*DS = Discrete Scan; DC = Discrete Control; CY = Continuous Control in Yaw Axis; CR = Continuous Control in Roll Axis; CP = Continuous Control in Pitch Axis.

Description	*Task Activity	Probabilities For: Error Freq	Error Persistence	Type of Error: BAW	HDWK	PROC	Error Criticality
PHASE B - MANEUVER SET-UP PRIOR TO STALL (Continued)							
g. Scan horizon for 15° nose-up attitude.	CP	.598	.241	.818	.127	.056	.466
h. Scan airspeed indicator for approximately 75 knots (or less).	CP	.464	.267	.605	.116	.279	.378
Step 5. Maintain The Nose 15° Above The Normal Flight Attitude With The Wings Level							
a. Apply appropriate aileron stick pressure to maintain wings level.	CR	.258	.240	1.000	.000	.000	.240
b. Scan horizon for wings level.	CR	.330	.188	.903	.066	.032	.125
c. Apply increasing back elevator stick pressure to maintain the proper nose attitude as the airspeed decreases.	CP	.629	.262	.879	.052	.069	.443
d. Scan horizon for proper nose attitude.	CP	.464	.311	.857	.095	.048	.400
e. Apply appropriate rudder pressure to maintain balanced flight.	CY	.485	.383	1.000	.000	.000	.128
f. Scan ball for balanced flight.	CY	.464	.356	.909	.045	.045	.178
PHASE C - INITIATE AND MAINTAIN SPIN							
Step 6. Apply Slight Right Rudder Pressure, Just Prior to the Stuff In Order To Set The Aircraft In Unbalanced Flight in the Direction of Spin							
a. Apply slight right rudder pressure to establish unbalanced flight to the right.	DC	.515	.140	.217	.109	.674	.300
Step 7. Apply Full Right Rudder Pressure When Aircraft Stalls							
a. Apply full right rudder pressure to establish a spin to the right.	DC	.649	.127	.237	.254	.508	.651
Step 8. Apply Full Back Stick Pressure							
a. Apply full back stick pressure to establish a proper nose attitude in the spin.	DC	.691	.119	.226	.258	.516	.716
Step 9. Maintain Spin Through First 360° Turn							
a. Scan landmark for an indication of the first 360° turn.	DS	.515	.060	.271	.583	.146	.560
b. Maintain full right rudder pressure to maintain a spin.	CY	.619	.133	.339	.268	.393	.600
c. Maintain full back stick pressure to maintain the proper nose attitude in the spin.	CP	.691	.104	.359	.250	.391	.657
Step 10. Maintain Spin Through Second 360° Turn							
a. Scan for the approach to the landmark for an indication of the second 360° turn.	DS	.784	.092	.263	.553	.184	.605
b. Maintain full right rudder pressure to maintain a spin.	CY	.608	.153	.278	.259	.463	.610
c. Maintain full back stick pressure to maintain the proper nose attitude in the spin.	CP	.649	.206	.263	.246	.491	.651

Description	*Task Activity	Error Freq	Error Persistence	Type of Error BAW	HDWK	PROC	Error Criticality
		Probabilities For					
PHASE D - INITIATE SPIN RECOVERY							
Step 11. Apply Left Rudder Pressure To The Neutral Position to Initiate Recovery at the Completion of Two Turns							
a. Scan landmark for an indication of the second 360° turn.	DS	.732	.113	.304	.493	.203	.606
b. Apply appropriate left rudder pressure to initiate spin recovery.	DC	.505	.061	.417	.125	.458	.694
Step 12. Apply Forward Stick Pressure To The Neutral Position							
a. Apply appropriate forward elevator stick pressure to initiate spin recovery.	DC	.667	.233	.500	.167	.333	.779
Step 13. Roll Wings Level When Rotation Of The Aircraft Has Ceased							
a. Apply appropriate aileron stick pressure to level wings.	CR	.711	.203	.609	.203	.188	.652
b. Scan horizon for wings level.	CR	.732	.169	.704	.141	.155	.563
c. Apply appropriate rudder pressure to maintain balanced flight.	CY	.443	.442	.929	.024	.048	.163
d. Scan ball for balanced flight.	CY	.423	.390	.825	.100	.075	.122
PHASE E - INITIATE CLIMBING RECOVERY							
Step 14. Raise the Nose to the 100 Knot Climbing Attitude							
a. Apply smooth back elevator stick pressure to establish a 100 knot climbing nose attitude.	CP	.784	.211	.676	.135	.189	.539
b. Scan horizon for proper nose attitude.	CP	.515	.240	.583	.271	.146	.300
c. Maintain appropriate aileron stick pressure to maintain wings level.	CR	.464	.200	.818	.091	.091	.378
d. Scan horizon for wings level.	CR	.474	.196	.791	.116	.093	.326
e. Maintain appropriate rudder pressure to maintain balanced flight.	CY	.423	.390	.892	.054	.054	.008
f. Scan ball for balanced flight.	CY	.443	.512	.821	.128	.051	.093
g. Scan airspeed indicator for 140 knots (or less)	DS	.691	.269	.323	.385	.292	.507
Step 15. Check Oil Pressure Gauge to Insure That the Pressure Is Above Minimum Indication							
a. Scan oil pressure gauge for indication.	DS	.711	.174	.103	.456	.441	.391
Step 16. Add Full Power to Commence A Climb							
a. Advance throttle full forward.	DC	.371	.056	.029	.257	.714	.500
b. Apply forward elevator stick pressure to maintain proper nose attitude during power increase.	CP	.351	.147	.879	.091	.030	.176
c. Scan airspeed indicator for 100 knots.	CP	.443	.116	.581	.209	.209	.209
d. Scan horizon for proper nose attitude.	CP	.485	.149	.702	.191	.106	.277
e. Trim nose down to relieve pressure on the elevator control.	CP	.423	.195	.878	.098	.024	.122
f. Apply right rudder pressure to maintain balanced flight during power increase.	CY	.598	.259	.897	.052	.052	.155

Description	*Task Activity	Probabilities For: Error Freq	Error Persistence	Type of Error BAW	HDWK	PROC	Error Criticality
Step 16. Add Full Power to Commence A Climb (Continued)							
g. Scan ball for balanced flight.	CY	.515	.240	.760	.160	.080	.240
h. Trim appropriate rudder to relieve pressure on the rudder control.	CY	.536	.308	.820	.120	.060	.260
i. Apply appropriate aileron stick pressure to maintain wings level.	CR	.227	.045	.909	.000	.091	.136
j. Scan horizon for wings level.	CR	.237	.043	.957	.043	.000	.174
k. Scan area for other aircraft.	DS	.515	.200	.120	.780	.100	.500

APPENDIX C

This Section contains the Foreword, Instructions, Biographical Information and Maneuver Presentation as outlined in the Task Analysis Questionnaire.

1. Foreword

There are certain T-34 maneuvers taught at VT-1 which continually give students a great deal of trouble. On the basis of the number of Below Average and Unsatisfactory ratings which VT-1 instructors have assigned to students over the past couple of years, six maneuvers were selected which appeared to be most critical within the primary training flight syllabus. For each of these six maneuvers, a task analysis was completed which attempted to define exactly what the hand, foot, and eye are doing for each major step of the maneuver.

The emphasis of this task analysis questionnaire is on student error isolation and classification. This questionnaire will provide information concerning: (1) what types of errors students most often make; (2) frequency of such errors; and (3) the length of time it usually requires for the student to correct such errors.

The results of this investigation should be able to: (1) define student flight characteristics or skills which are critical to each maneuver; (2) identify those student flight errors which are continually performed by the students; (3) develop remedial techniques to be used by the instructor which are based on a student's typical and continuous flight errors; (4) standardize the meanings of the terms Headwork, Basic Airwork, and Procedures; (5) establish a basis for the development of a flight test battery which will be used for the prediction of student flight ability prior to his arrival at VT-1.

The success of this effort will depend on the cooperation of instructors responding to the following maneuver analysis. Hopefully, the final results will provide a better training system for the student pilot and a training aid for the instructor.

2. Instructions

A. Fill in the Biographical Information on page iv.

B. This error analysis inventory is divided into six critical maneuvers. They include: (1) Approach Turn Stall; (2) Spin; (3) High Altitude Emergency; (4) Slow Flight; (5) Standard Field Entry; and (6) Full Flap Approach, Landing, and Take-off. Of these maneuvers, two were selected for this initial investigation (Maneuver I: Spin; Maneuver II: Full Flap Approach, Landing, Take-off).

C. Each maneuver has been broken down into a number of sequential phases. In the inventory, these are numbered 1, 2, 3, etc. Within each of these phases are a number of scanning responses and control movements which must be performed concurrently. These items are lettered a, b, c, etc. These items comprise the basis for this error analysis inventory. An error for this inventory is defined as a failure to successfully perform those concurrent responses which are an essential part of each sequential phase. You are to rate each of these "potential" errors along six dimensions:

(1) First, does the item truly represent a student error by the average student at VT-1? If the item is a student error, check the first box and proceed with ratings on the next three dimensions. If the item is not a student error, leave the first box blank (as well as the ratings on the three dimensions), and proceed to the next item below.

(2) The first dimension concerns the hop number of which the error is normally corrected. If corrected on the introductory hops--that is, on hops 4, 5, 6, or 7 -- mark "I". Flights 8-12 are the last graded hops for the pre-solo stage, while 14, 17, and 19 are the three graded hops for the precision stage. Simply mark the hop on which the error is generally corrected.

(3) Categorize the error according to type. If the item were to be graded by itself, under which of the three listed items under "Type of Error" would you place the error? Mark "B" if you feel it is a Basic Airwork error, "H" if it is a Headwork error, or "P" if it is a Procedural error. Pick only one item. If the error falls under more than one type, pick the one most commonly graded of the three types.

(4) Rate the error as either critical or noncritical. Mark the error as critical or "C" if its occurrence (when taken by itself) seriously affects the performance of the entire maneuver, or if the item is an essential part of the maneuver. In other words, does the student normally receive a below average or an unsatisfactory grade for this error? Mark non-critical or "NC" if the opposite is true.

3. Biographical Information

A. NAME ______________________ SERVICE NO. ______________________
Last First Middle

SERVICE ______________ RANK _______ NUMBER OF YEARS
(Navy, Marine, CG) IN SERVICE __________

B. INSTRUCTOR TRAINING EXPERIENCE

INSTRUCTOR NUMBER _______ MONTHS AT VT-1 ______________

NO. OF INSTRUCTIONAL HOURS _____ FLIGHT OR DEPT. ____________

NO. OF STUDENTS COMPLETED ________________

C. FLEET EXPERIENCE

SQUADRON NO.	TYPE AIRCRAFT	NUMBER OF HOURS
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

4. Maneuver Presentation

MANEUVER I: <u>SPIN (TO THE RIGHT)</u>

A. Prior to Maneuver

1. Scan altimeter for 4500' minimum altitude.
2. Perform stall checklist.
3. Report checklist complete and the quantity of fuel onboard.
4. Select a landmark to be used as a reference for completed turns during the spin.
5. Trim aircraft.
6. Perform one level 45° clearing turn in either direction for 90°.

B. Maneuver (this material is presented in Appendix B, and contains the 68 task elements given to the flight instructors in questionnaire context).

C. Maneuver Completed

1. Aircraft is in a 100 knot climb.
2. Aircraft is trimmed.

APPENDIX D

This section contains an analysis of all task activities by sequential steps within the Spin Maneuver (41 activities/steps are listed).

Description	Error Freq	Error Persistence	Probabilities For Type of Error BAW	HDWK	PROC	Error Criticality
PHASE A - MANEUVER SET-UP IN CLEARING TURN						
Step 1. Commence a Second 45° Clearing Turn to the Right						
a. Continuous control-pitch axis	.907	.330	.907	.069	.025	.455
b. Continuous control-roll axis	.732	.197	.890	.077	.033	.169
c. Continuous control-yaw axis	.588	.458	.947	.053	.000	.168
d. Discrete scan	.742	.083	.200	.700	.100	.361
Step 2. Close the Throttle After Commencing the Second Clearing Turn						
a. Continuous control-yaw axis	.577	.357	.926	.056	.019	.054
b. Discrete control	.278	.000	.037	.222	.741	.296
Step 3. Maintain Second Clearing Turn to the 90° Position						
a. Continuous control-pitch axis	.959	.452	.683	.110	.206	.559
b. Continuous control-roll axis	.691	.328	.935	.056	.009	.224
c. Continuous control-yaw axis	.536	.481	.915	.043	.043	.135
d. Discrete scan	.814	.241	.292	.575	.132	.468
PHASE B - MANEUVER SET-UP PRIOR TO STALL						
Step 4. Roll Wings Level at the 90° Position of the Second Clearing Turn						
a. Continuous control-pitch axis	.804	.256	.778	.098	.124	.474
b. Continuous control-roll axis	.423	.122	.920	.040	.040	.268
c. Continuous control-yaw axis	.588	.491	.934	.044	.022	.123
Discrete scan	.247	.042	.478	.391	.130	.250
Step 5. Maintain the Nose 15° Above The Normal Flight Attitude With the Wings Level						
a. Continuous control-pitch axis	.701	.250	.870	.070	.060	.500
b. Continuous control-roll axis	.371	.167	[illegible]	.036	.018	.194
c. Continuous control-yaw axis	.536	.404	.956	.022	.022	.231
PHASE C - INITIATE AND MAINTAIN SPIN						
Step 6. Apply Slight Right Rudder Pressure, Just Prior to the Stall in Order to Set The Aircraft in Unbalanced Flight in the Direction of Spin						
a. Discrete control	.515	.060	.217	.109	.674	.360
Step 7. Apply Full Right Rudder Pressure When Aircraft Stalls						
a. Discrete control	.649	.063	.237	.254	.508	.651
Step 8. Apply Full Back Stick Pressure						
a. Discrete control	.691	.045	.226	.258	.516	.716
Step 9. Maintain Spin Through First 360° Turn						
a. Continuous control-pitch axis	.691	.060	.359	.250	.391	.657
b. Continuous control-yaw axis	.619	.067	.339	.268	.393	.600
c. Discrete scan	.515	.020	.271	.583	.146	.560
Step 10. Maintain Spin Through Second 360° Turn						
a. Continuous control-pitch axis	.649	.127	.263	.246	.491	.651
b. Continuous control-yaw axis	.608	.085	.278	.259	.463	.610
c. Discrete scan	.784	.092	.263	.553	.184	.605

Description	Error Freq	Error Persistence	Probabilities For Type of Error BAW	HDWK	PROC	Error Criticality
PHASE D - INITIATE SPIN RECOVERY						
Step 11. Apply Left Rudder Pressure to the Neutral Position to Initiate Recovery at the Completion of Two Turns						
a. Discrete scan	.732	.099	.304	.493	.203	.006
b. Discrete control	.506	.061	.417	.125	.458	.604
Step 12. Apply Forward Stick Pressure to the Neutral Position						
a. Discrete control	.887	.209	.500	.167	.333	.779
Step 13. Roll Wings Level When Rotation of the Aircraft Has Ceased						
a. Continuous control-roll axis	.876	.188	.657	.171	.171	.624
b. Continuous control-yaw axis	.464	.422	.378	.061	.061	.178
PHASE E - INITIATE CLIMBING RECOVERY						
Step 14. Raise the Nose to the 100 Knot Climbing Attitude						
a. Continuous control-pitch axis	.856	.229	.639	.189	.172	.518
b. Continuous control-roll axis	.639	.177	.805	.103	.092	.371
c. Continuous control-yaw axis	.506	.408	.855	.092	.053	.102
d. Discrete scan	.691	.239	.323	.385	.292	.507
Step 15. Check Oil Pressure Gauge to Insure That The Pressure is Above Minimum Indication						
a. Discrete scan	.711	.159	.103	.456	.441	.391
Step 16. Add Full Power to Commence a Climb						
a. Continuous control-pitch axis	.732	.211	.750	.152	.098	.338
b. Continuous control-roll axis	.299	.034	.933	.022	.044	.207
c. Continuous control-yaw axis	.742	.361	.829	.108	.063	.250
d. Discrete scan	.515	.200	.120	.780	.100	.500
e. Discrete control	.371	.028	.029	.257	.714	.500