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INVESTIGATION OF AN EXPERIENCE-JUDGEMENT APPROACH TO TACTICAL FLIGHT TRAINING

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Air Force tactical flying training is one of a number of task situations where various constraints have minimized the acquisition of experience, and in turn judgement, by traditional means. Systematic phased training in synthetic environments is one way of overcoming these difficulties and was the approach adopted in this research. Due to the critical role which vision

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plays in tactical operations, the experience-judgement approach emphasized visual cues and referents. A theory of internal pilot performance provided the framework for this approach. Visual referent details were carefully defined in their relationship with complex performance. An expanded surface task analysis which stressed cues and cognitive activity started the process of categorizing flying tasks into behavioral components. Visual cues and their referents were further analyzed to develop environmental background scenes for each task through an intermediate word to picture conversion. Behavioral components were structured into instructional procedures from which behavioral goals were specified. The resulting goals and background scenes were integrated to form a phased learning plan that included event requirements, instructional techniques, and instructional features. These procedures are also applicable to other advanced training situations which have complex visual perception, decision making, and motor output requirements.

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PREFACE

How can judgement be acquired...judgement to do what is needed in a difficult and demanding situation?

As straightforward as this question is, its solution required the integration of several diverse disciplines in order to find answers. This report considered judgement, what it is, and how it could be taught in the realm of tactical flying training. Ideas and concepts were put together from several areas into a workable format which resulted in a multidisciplinary holistic approach.

Ideas came from three areas. The behavioral sciences were a major contributor for educational psychology, training technology, perception, and cognition all played roles in this approach. These ideas and concepts were tempered by the realities of the operational environment of the fighter pilot, for in the end the approach must meet their needs. The visual world of the artist also played a vital role because pilots operate predominately from visual information. The integration of artistic elements, however, was not unusual for R. B. Freeman of the Department of Psychology, Pennsylvania State University, best expressed its importance when he wrote: "It is a surprising fact that much of what we know about visual space perception is due not to the investigation of visual scientists but rather to the writings and paintings of the Renaissance artists" (1970, p. 73).

Informational gaps in various areas required the development of additional concepts. These new concepts were primarily theoretical since available experimental evidence could support alternatives. Thus, this research was a conceptual experiment where thought and analysis rather than data collection was emphasized. Validation came from internal consistency and the meeting of objectives. Based on these criteria, the experiment was successful since it defined how judgement can be acquired and structured in a phased learning environment for its acquisition.

If anything can be said about this approach, it should be that the reader not become disturbed by the departure from some traditional lines of thought. As a total view of an extremely complex training situation, the perspective was to look at the whole without the constraints of any one concept. It is anticipated that as time goes on these ideas will be refined while others may be changed; however, a start had to be made. This is that start.

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OVERVIEW

<u>The Problem</u> - Many complex task situations require experienced personnel to possess good judgement so that correct actions can be taken. The nuclear power control room operator, the fighter pilot, and submarine commander are all faced with making correct decisions and taking appropriate actions under rapidly changing conditions. Such complex situations require constant awareness and the selection of relevant information from many, and sometimes conflicting, sources. Although personnel such as these receive training in the technical aspects of their work, judgement is usually acquired through long task related experience.

In many critical work roles there is insufficient time or opportunity to acquire accurate judgement in the traditional way. For instance on the first day on a job, many civilian and military personnel must be ready to perform their tasks with flawless precision. They must have already gained experience and judgement through training because of increasing time or equipment constraints. In the past, experience has been the best teacher of judgement for demanding situations. Weiss (1966), for example, showed that the probability of survival in aerial combat was related to the number of engagements; if a pilot made it through the first ten missions, the chances of surviving later missions was quite high. The Air Force has made use of this information by providing experience in Operation Red Flag where pilots fly against other pilots trained in aggressor tactics and in an aggressor type environment. In another area, experience and training influencing judgement was confirmed for soil judges (Shanteau, 1980), who like pilots are required to make difficult perceptual judgements.

Although judgement can be trained through experience, a unified methodology for this purpose has not existed. Further, the most efficient environment for gaining experience, and in turn judgement, has not been considered in detail. These problems must be addressed for many military personnel, since in the future they may no longer have the luxury of apprenticeship programs to gain experience and judgement on the job. Of particular interest is the attrition rate in the military which has reduced the experience level of Air Force pilots (Allen, 1979). "Five years ago, 70 percent of US Air Force fighter pilots had flown in actual combat; today, that same percentage has never seen combat" (Knickerbocker, 1979, p. 2). Further, the limited fuel and high cost of operational missions have made it difficult for the novice pilot to gain vitally needed experience. These and related problems must be considered if appropriate training programs are to be developed.

<u>Research Goals</u> - The objective of this research was to develop a systematized approach to impart experience which will lead to judgement in the shortest possible time. The approach was based on a comprehensive method of learning and appropriate instructional techniques. Fighter pilot training was selected for investigation

because it is representative of a class of complex experience training requirements. With the numerous constraints on actual flight time, the effort also emphasized synthetic training devices* as the appropriate environment for experience and judgement training.

Approach - The essence of the approach was to determine theories of cognition and learning of sufficient depth to encompass the complex task requirements of tactical flying and relate these to a visual orientation and synthetic training device in which a pilot could develop the experience and judgement needed to perform these tasks. The approach also emphasized techniques which converted theory and philosophy into application methodologies. In all, seven sections address the experience-judgement approach to training. Each of the following paragraphs briefly describes, in order of presentation, the material in each section.

1. An Experience-Judgement Theory was first developed to integrate information concerning how pilots operate in their complex environment. The theory was based primarily on the stimulus-organism-response (SOR) model and modified to deal with

FOOTNOTE:

* Synthetic training device was used to encompass the range of training devices including simulators, operational flight trainers, part task trainers and the like. The term provides the broadest perspective for such devices, removing the particular utilization and limitations of specific devices. In this approach, a task is matched to whatever device characteristics are most appropriate.

the complexity of flying training requirements. It also considered perceptual, cognitive, psychomotor, information processing and decision making procedures. The expanded SOR model provided insight into learning theory which resulted in a phased approach to the instruction of complex tasks. This resulted in determining the relationship between experience and judgement, and fostered the definition of judgement oriented to complex flying tasks. The resulting experience-judgement theory organized tasks into cue, mental action, and motor action components and provided the basis for the analysis techniques used throughout the research.

2. A visual philosophy was then expressed which divided cues into background, foreground, and performance groups. Information about specific cues was referred to as cuing referents. Cuing referents were defined in terms of visual elements used by artists to describe the characteristics of objects. This concept was expanded to include those additional referents which were specific to the realm of flying. Cues and cuing activities were also introduced which were related not only to tactical flying tasks, but to all flying.

3. Two tactical fighter maneuvers, the Low Angle Dive Bomb and the Acceleration Maneuver, were chosen for analysis. These tasks are considered representative of the basic air-to-air and air-to-ground domains. An analysis was developed based on the SOR model and expanded to include cues, cuing referents, and

cuing activities; mental actions; motor actions and cognitive requisites. This expanded task analysis of the two basic tactical tasks was the information base for the research.

4. An instructional review was performed which used analysis information, particularly from the mental actions and cognitive requisites of the tasks. The instructional review consisted of a three part effort. The first was an analysis of cognitive components which produced behavioral goals. Secondly, these goals then were organized into a phased learning structure. The third part utilized the behavioral goals within the learning structure to formulate training event requirements.

5. A visual conversion process was developed which adapted task analysis information into a graphic or pictorial format. Several areas were involved in the visual conversion process. Task related cuing information was summarized and cross-checked. Geomorphic considerations and tactical implications were then related to the cuing data. The results were "word-pictures" which graphic designers and artists could use to develop task oriented background environment scenes for synthetic training devices.

6. A visualization methodology was explored which utilized the word-pictures developed from the analysis information to produce appropriate background environments. Levels of stylization were introduced which allowed the cues within a background to be

categorized from natural photography to abstract symbology. Example task oriented background environments, including targets, were developed and are shown in Slide Figures.

7. An experience-judgement learning plan integrated the visual and non-visual aspects of a phased approach to instruction in a synthetic training device. The Low Angle Dive Bomb and the Acceleration Maneuver were used as task examples to show the manner in which the learning plan was accomplished. Instructional techniques and instructional features were introduced which reflected task behavioral goals for the training event requirements of the learning phases. Selected training events have been illustrated showing the visual aspects of the instructional features developed for that specific event. These have been depicted in slides, called Slide Figures, and accompany the text material.

1. THE EXPERIENCE-JUDGEMENT THEORY

Introduction - Many situations require experienced personnel who possess good judgement. The physician, the manager, and the military officer are all faced with the task of making correct decisions and taking appropriate actions in rapidly changing complex situations. Such situations require constant awareness and the selection of relevant information from many information sources. Although personnel receive training in technical matters, judgement usually is acquired through long experience rather than through training.

In many situations there is sufficient time to gain judgement. On the first day of a combat situation, however, personnel such as tank commanders and aircraft pilots must be ready to perform their tasks with maximum effectiveness. They must already have the needed experience and judgement which can only come through prior training. However, training does not equally impart judgement to all people. Some personnel perform correctly immediately, others take varying amounts of time, and still others never attain judgement. This occurred even though all personnel received the identical training course and met all course requirements.

Ideally, training should be structured to impart experience and judgement so that all trainees reach the necessary level to perform their jobs. Current training programs do not do this, although the fact that some people do gain experience and judgement in training implies that others should be able to do so as well. The solution is to appropriately structure training programs.

If new training programs are to be developed, the nature of experience and judgement must be understood. A unified plan which integrates elements of cognitive, perceptual, and psychomotor learning theory, and information processing and decision making theory with actual operational problems is required. The experience-judgement theory concentrates on personnel who control complex systems which operate in an environment with other systems. These systems have different performance capabilities and limitations where some may be cooperative, or friendly, while others may be non-cooperative, or hostile. Further, each system has some level of uncertainty in its performance due to operator characteristics. Although the tank commander, destroyer captain, and fighter pilot all must deal with this high level of complexity, the theory will, for consistency, deal only with the fighter pilot.

The Fighter Pilot Problem - Fighter pilots operate in a complex and dynamic environment. Sensory information from the environment must be analyzed and integrated with the situation and with prior experience to make judgements appropriate for tactical actions. The pilot must be correct; indecision or error can be fatal. These judgements are performed in time periods short enough to provide what appears to be continuous performance while the pilot attends to the task of flying the airplane. A single fighter engagement with one friendly and one enemy aircraft can occur in thirty to forty-five seconds and larger dog fights take only slightly longer. For example, four aircraft were reported shot down in a one-and-one-half minute engagement between Israeli and Syrian forces (Kelly, 1979).

Even with the constraints of short decision making time, some pilots do acquire the needed skills and knowledge to effectively utilize experience and judgement. Only a small group of fighter pilots have been responsible for many kills. About five percent of pilots shot down forty percent of enemy aircraft in combat (Youngling, Levine, Mocharunk & Weston, 1977). The remaining ninety-five percent of pilots received the same training, but failed to do as well. The superiority of certain pilots due to chance was discounted by Youngling, et. al., but rather experience due to flying missions and learning were mentioned as explanations.

The Air Force pilot training program recognizes experience and judgement, but utilizes the term, "Situational Awareness" (SA). Situational Awareness is the embodiment of pilots knowing their position in space and comprehending the changing tactical environment while exercising experience and judgement in order to accomplish a specific task. In practical terms, a pilot expressed it as, "knowing where you're at and what's going on around you while you're trying to do your job". It is necessary to fly not just the aircraft, but to fly in a global tactical sense. In structured interviews with instructor pilots and fighter pilots training to be instructors at Nellis Air Force Base, Nevada, SA was given a high priority although it was not taught in the curriculum; Situational Awareness was learned through tactical flying experience with instructors identifying when the student had mastered the concept.

Even from this limited description, many diverse elements are needed for task performance including information acquisition through the sensory/perceptual system, decision making based on judgements supported by background and experience in memory, and appropriate motor outputs. Thus, an experience-judgement theory will require the integration of perceptual-motor, cognitive and information/attention models.

The theory will be described in three sections. A background section will cover the elements and theories which influenced the Experience-Judgement Theory development. The Experience-Judgement Theory Components Section will describe the theory in detail. The implications of the theory to tactical flying training then will be discussed.

Influences on the Theory - Three areas have influenced theory development. The first is the specific components of experience and judgement and how they define the tactical environment. How the pilot implements experience and judgement through decision making and information processing is the second area. The third area deals with how experience and judgement are imparted through learning theory.

<u>The Nature of Experience and Judgement</u> - Experience and judgement are closely tied together so the phrase, "experience-judgement", has been developed to express this relationship. Both terms have the same general and psychological definition with judgement being "the process of discovering an objective or intrinsic relationship between two or more objects, facts, experiences or concepts" (Woldman, 1973). Judgement becomes more difficult when its relationship to experience is considered since experience, as defined by Woldman (1973), is the "skill or understanding which is the result of living through something, or of practice, or of participation in something." Some training programs are geared towards extensive practice and participation, but few if any provide the capability to live through something and provide experience from active involvement.

Judgement is a term frequently used in flying and flying training. It is said that a pilot must be a good judge of distance and must exhibit good judgement in the complex tasks of flight. However, being able to judge distance based on perception does not use the same mental processes as making good judgement decisions in difficult situations. Two types of judgement, spacial judgement and organizational judgement, were identified as expressing the cognitive and informa' .on processing aspects of tactical flying. The judgement types are equally important, though different in application. Further, all tasks require varying amounts of each type.

Spacial judgement is defined as the synthesis of perceived information which is used to estimate the flying conditions in real time situations. The concept of spacial judgement is based on the knowledge that pilots use to deal with and react to perceptual cues. In addition to perception, estimation and imaging are necessary because in the vastness and fluidness of three dimensional space, there are few natural cues which can be used directly. Cues must be interpolated to become useful information to the pilot. For example, the horizon is used to approximate a level flight attitude. Yet in this simple task, just where the aircraft should be in relation to the horizon must be estimated since the horizon may be based on clouds or ground features not at the position of the actual horizon. Further, a visual picture or visualization of this estimation must be learned and applied to appropriate motor skills. Thus, the pilot must invent, improvise, or image visual patterns and relationships from his environment to test, check, and cross-check what is occurring in space. Visual cues are expressed not only as knowing where to look, but also how to look at what is available.

The capability to distinguish visual elements such as the shape, contour, color, size, texture, and perspective of an object is part of spacial judgement, but so is the distinguishing among the relative differences of these visual elements as a pilot's position changes relative to these items. Since no aircraft remains fixed in space, so all objects are relative to the aircraft. Subtle changes to the relationship between the aircraft and an object are critical, providing an on-going update to the pilot of what is occurring.

Organizational judgement is the basis of the intellectual requirements of flying. It is defined as the synthesis of learned knowledge and perceived information in order to make decisions, or form conclusions about real time flying situations. This judgement is essential in a flight environment since it is the basis of comprehension for spacial judgements and summarizes the use of these elements in predicting task goals. Organizational judgement is the repository for stored data and knowledge gained from experience. This mental activity involves not only learning factual information, concepts, principles, and rules, but also relates and integrates this information with real time experience to create task comprehension.

A dichotomy of judgements is not unique, for independently Jensen (1978) identified two types of judgement for the less complex environment of the general aviation pilot. One type of judgement is perceptual dealing with distance, altitude, speed, and clearance in which simple responses due to highly learned behaviors are performed. The other type is cognitive judgement in which complex behaviors require the deliberation among several alternatives. There is an overlap between spacial and perceptual judgement and between organizational and cognitive judgement although spacial and organizational judgements are more detailed due to the tactical flying situation.

Spacial and organizational judgements are composed of several parts. Spacial judgement contains discrimination and angular concept components, while organizational judgement contains data and strategy components. Together, these components form the cognitive requisites for flying training.

Within spacial judgement, discrimination involves the ability to distinguish differences between objects in a flying environment. In order to do this, the pilot must be able to differentiate objects in terms of such basic visual elements as shape, contour, color, size, texture, aerial perspective and linear perspective. This means being able to relate knowledge of aircraft shapes to different perspectives in the real time environment to perform detection and identification. In a more subtle sense, this relates to differentiating the detailed contour and textural features of objects. Being able to distinguish between a deciduous and coniferous forest's color and texture is an example.

A further ability to differentiate extends to the use of the basic visual elements to distinguish movement, direction, and range of objects. This involves relating the shape and textural qualities of one object with another, such as distinguishing the positional progress of an aerial target across varying ground texture. It also means the distinguishing of significant features which permit a pilot to estimate whether an object is pointed at some angle either towards or away from the aircraft.

In summary, there are two types of discrimination:

1. To distinguish shape, contour, color, size, texture, and perspective among objects

2. To distinguish the relative movement, direction, and range of objects

The second component of spacial judgement is angular concept which is used to estimate the significance of the variations which occur to the shape, contour, size, color, texture, and perspective of objects in the cuing environment relative to the pilot's continually changing spacial position. Angular concept differs from discrimination in that the importance of cue-bearing objects is estimated from the tactical considerations of a situation. The estimation of size, shape, color, and contour detail changes as a target comes closer, or recedes from a pilot's view; their effects are manifested in relative angular position changes which must be understood and utilized for effective tactical performance. This holds true for all air-to-air and air-to-ground targets, as well as a pilot's own aircraft movement changes relative to the ground and aerial environments.

Angular concept also is concerned with the estimation of spacial patterns and relationships among cuing objects in the actual world environment. These patterns with their geometry of relative bearing, aspect angles, and the aircraft position are interrelated to the basic visual elements of these objects. Essentially, the geometry of objects conveys tactical positioning to the pilot, while the visual elements tell what those objects are doing. This combination of information is particularly important in multiple engagements where, for example, angular position gives the pilot relative bearing information but the visual elements tell him if the target is friend or foe, whether it has turned or is turning toward or away from him, and give him an estimation of range and closure rate.

The two types of angular concept are:

1. To estimate the significance of basic visual elements such as size, shape, contour, texture, and perspective of objects in relation to the position and performance of a pilot's own aircraft

2. To estimate the significance of spacial patterns and relationships among cue-bearing objects

Spacial judgement utilizes both short term and long term information processing. Long term processing relates to the knowledge of how to distinguish and estimate. The actual distinguishing and estimation is short term processing. Organizational judgement is the basis of the long term memory storage for flying information. Preliminary input for the organizational skills came from Gagne and Briggs' (1974) identification of human capability. Memory and information processing will be described in a later discussion.

The data component of organizational judgement involves the utilization, through memory and retrieval, of facts and procedures. Facts are values such as weights, velocities, times, and frequencies which are used in tactical flying. Procedures include items such as the proper sequence of steps to activate a weapons system or perform a specific maneuver.

The strategy component is concerned with determining where a pilot is in relation to where he should be in order to accomplish a task. The three types of strategy are:

1. Comprehension of concepts, principles, and rules - Comprehension is an understanding of ideas, and how and where to use them. The understanding of aerodynamic properties of how an aircraft flies is an example, and the use of these properties to determine combat maneuvering characteristics also is comprehension.

2. Selection and ranking of alternative concepts, principles, and rules concerning specific situational requirements - This selection makes it possible to reach a desired outcome in an environment of constantly changing priorities and conditions.

3. Integration of comprehension and selection for specific future tasks - This is concerned with the planning of tasks and the anticipation of follow-on tasks. It is the cognitive decision maker and the final determination of how a specific task or tasks must be shaped or modified to achieve a required goal.

Figure 1.1. summarizes the functional relationships among judgement skills.

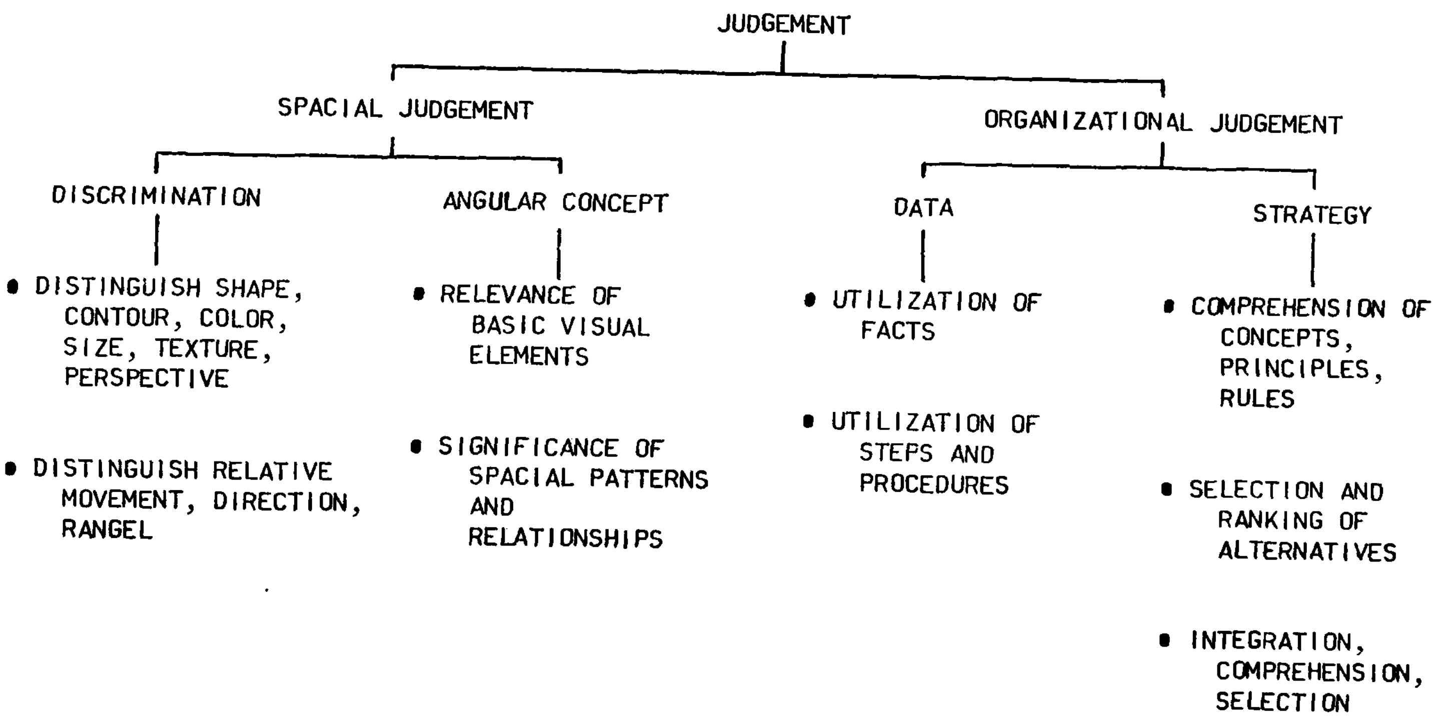


Figure 1.1. Components of Judgement

Judgement has traditionally been learned through actual flying experience supported by classroom instruction for flying fundamentals and topics related to flight. The major drawback of alternatives to actual flight has been the difficulty of providing active involvement which is the key to experience. If properly structured, however, alternatives can substitute for actual experience and are referred to as "vicarious experience" to emphasize this substitution. The simulator, as a training device, comes closest to providing the substitution.

Simulation is not the only way to provide active involvement and total immersion. As long as sufficient motivation on the part of the trainee exists, concentration and focus on the relevant subject can occur. Then the task can be shown to be relevant to the ultimate task found in tactical situations, and vicarious experience is possible. Classroom instruction, training texts, and other training or synthetic devices can be used to impart vicarious experience if they are properly structured. In the following discussion, how a pilot operates and how a pilot learns are defined to provide the structural requirements for vicarious experience training.

Decision Making and Information Processing - Gagne (1977) described several types of associative learning: signal learning, verbal learning, stimulus-response learning and chaining. Of these types, stimulus-response learning and chaining, in which stimulus-response pairs are connected, conform to the cognitive requisites of the complex tactical environment.

Although stimulus-response learning is appropriate to the Experience-Judgement Theory, a better expression which includes the critical role of the pilot is the stimulus-organism-response (SOR) formula. "From this point of view, psychology is the study of those intervening variables within the organism which mediate between stimuli and responses. For example, the process of memory is an intervening variable whose integration must be undertaken by utilizing various stimuli (word lists, nonsense syllables, etc.) and then measuring the subject's responses under various conditions of memorizing. Therefore, the psychologist never investigates memory directly, but only indirectly through the subject's responses. He <u>infers</u> information about the memory process by studying the subject's responses. The investigation of intervening variables is not limited to psychology. Physicists and chemists often study intervening variables in much the same manner. Resistance, for example, is an inferred variable which is measured by the flow of current through electrical circuits" (Chaplin and Krawiec, 1968, p. 12).

When taken outside the laboratory, the SOR model and chaining cannot account for the complexity and speed required in tactical decision making. Broadbent (1971) found that in laboratory studies for well matched signals and responses, as the number of alternatives increased so did reaction time. Further, Broadbent noted that for not so well matched signals and responses, reaction times are longer. Imperfect matching of signals and responses is typical of the tactical environment. Coupled with numerous alternatives and minimum response times, some alternative means of decision making in which steps are short circuited seems to occur.

One alternative is a high order mental process known as production in which actions based on conditions result without the need to go through a sequence of steps (Larkin, McDermott, Simon and Simon, 1980). In this method, complex perceptual patterns are stored; when a specific pattern is recognized, a related action is appropriate. The complexity of production is illustrated by a chess game. "A chess master recognizing that one of the files on the board is open - free of pieces - realizes immediately that one of his rooks might be moved to the foot of the file. A feature of the board, noted consciously or unconsciously, produces in a fraction of a second the intuition that a certain action may be appropriate" (Larkin, et. al., 1980, pp. 1336-1337). Fighter pilots may use this technique since it is a logical outgrowth of chaining. Production is what we can observe in pilots when they indicate that they have attained Situational Awareness.

The SOR formula, chaining, and the production of condition-action pairs fit "the popular concept of flying skill as perceptual-motor coordination" (Eddowes, 1974, p. 5). Yet it is the cognitive model of what is learned that is important for as Eddowes continues, "Once the student pilot has fully developed this cognitive structure, it will enable him to accomplish a flying mission with optimum effectiveness and maximum avoidance of mission-interruptive circumstances"(p. 5). The organism part of the formula is concerned with cognition as well as perception so that the formula is still applicable.

The distinction between cognition and perception is not clear for complex perceptual processes appear to be learned (Dember, 1960). Rudolf (1971) stated that, "My contention is that the cognitive operations called thinking are not the privilege of mental processes above and beyond perception but the essential ingredients of perception itself" (p. 13). Thus, cognition includes the receiving, the storing, and the processing of information through sensory perception, memory, thinking, and learning. The concept is reinforced by Gibson (1975) for vision and visual perception that, "...perceiving is an act, not a response, an act of attention, not a triggered impression, an achievement, not a reflex" (p. 6).

The importance of cognitive behavior in operational flying situations was addressed by Barnhart, Billings, Cooper, Gilstrap, Lauber, Orlady, Puskas, and Stephens (1975) in their development of a methodology for human factors study in the aviation environment. Of the various types of behavior, they placed cognition first dealing with it as follows (pp. 9-10):

> "Cognition encompasses the behaviors by which a person becomes aware of, and obtains knowledge about, his relationship to his environment. In aviation, the flight crew and certain others (air traffic controllers, dispatchers) must all have knowledge of an airplane's location, status, and intentions. Cognition is the process whereby each person acquires and appreciates this information.
>
> "Having become cognizant of the required information, each of the persons in the aviation system is in a position to do something about it. The process involved is called decision-making. A decision is the formulation of a course of action (from among a limited number of alternatives) with the intent of executing it. A decision may, of course, be to allow things to continue as they are...to do nothing.
>
> "The execution, or implementation, of a decision involves one or more actions. The remaining functions (flight or ground handling, subsystem operation, subsystem monitoring, communication behavior) may be thought of as implementation functions: the actions one takes to implement a decision. In a sense, they all involve the same goal; they are separated, however, because they represent fundamentally different categories of behavior."

Overall, the best procedure is to consider cognition, perception, and psychomotor or perceptual-motor coordination together in a combined information processing and decision making model for the fighter pilot in tactical situations.

A model of how a person operates is shown in Figure 1.2. Based on information processing and decision making, the model is divided into three parts: senses, brain, and muscles. Perception is related to the senses, cognition to the brain, and motor coordination to the muscles. The sensory input are temporarily stored in short term memory where if they are not dealt with in a few seconds they fade away and are lost. The short term memory is accessed by an input selector which can pass only one item at a time, limiting the brain to the sequential processing of information.

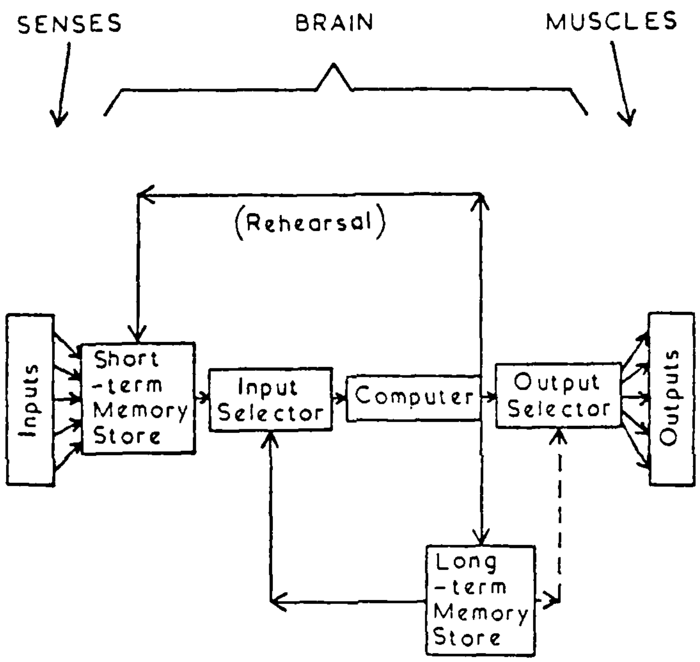


Figure 1.2. Information Processing and Decision Making Model of the Brain

(from Poulton, 1970, p. 6)

Information is processed by the decision making computer and is placed in long term memory, and/or initiates a motor action. After sufficient rehearsal which connects the computer to short term memory, an activity reaches an acceptable level of performance. Once a long term memory item is established, it can be used to select appropriate input. When a response is well practiced, it can be initiated by the computer and run automatically by long term memory permitting stimulus-response pairs to occur.

While other models of the brain exist, all models have common attributes. "There is little real dispute that the human information-processing system is limited in its capacity to handle multiple inputs" (Massaro, 1975, p. 291). Other common characteristics are selective perception, short term memory, sensory registers, and long term memory (Massaro, 1975; Loftus and Loftus, 1976; Rumelhart, 1977; Kidd and Van Cott, 1972). However, the model described does the best job of dealing with the complex flight environment.

Learning Theory and Learning to Fly - The previous discussions have identified what a pilot must be able to do with respect to experience-judgement. The nature of judgement and experience has been dealt with, along with a structure based on decision making and information processing, to carry out experience-judgement. "How" these elements can be imparted is the concern of learning theory since, "Learning is a change in human disposition or capability, which persists over a period of time, and which is not simply ascribable to the process of growth" (Gagne, 1977, p. 3).

Although authors have organized learning into various types in order to relate them with given behavioral objectives, no current organization best addresses the complex, integrated learning of cognitive, perceptual and psychomotor skills required for judgement training in flying situations. Gagne (1970), for example, categorized learning into eight types for academic classroom instruction. Others, such as Ellis (1972) and Travers (1972), modified the eight types into fewer categories but kept the academic orientation. However, other efforts in the classification of educational objectives in the psychomotor domain (Simpson, 1972; Harrow, 1972) provided insight into a complex learning structure.

Another basis for learning is Klein's (1977) Phenomenological Approach to Training which "...focuses on the way a task is experienced, rather than on the overt responses performed" (p. 5). This requires a holistic understanding with an overall comprehension of a task, a changing in perspective from consciously doing something to doing something in an automatic mode. Smooth and coordinated performance, such as found in tactical flying, may not be reflected in task analysis but may require alternate training.

As appealing as the Phenomenological Approach is, it too does not provide the entire basis for tactical flying training. Stimulus-response pairs, chaining, and production all are necessary precursors. Thus, one must start with the whole, break it into component parts, and then build up to the whole - an analytical approach. An appropriate analytic technique based on the SOR model and behavioral task analysis was developed by Meyer, Laveson, Weissman and Eddowes (1974) and refined by Meyer, Laveson, Pape and Edwards (1978).

Using task analysis, control movement is often the first aspect to be considered when flying and flying training are addressed. The psychomotor skills are part of flying, but as discussed in the decision making and information processing area are far from the whole picture. However, these skills do serve as a useful starting point. "Skilled motor activity is a function of Input (sensory and perceptual functions) X Central Processing (decision and command functions) X Output (motor functions). The integration of these processes leads to more purposeful behavior. Plans of action, or programs, need to be established. Complex learning is obviously much more than the association of a particular response to a given cue" (Singer, 1978, pp. 83-84).

A skill within the behavioral task analysis framework is defined as those elements which are required to perform a task sequence. Meyer, et al.,(1974) used a cognitive approach considering attributes such as memory, judgement, imagery, cognitive processes, perceptual and psychomotor activities to determine that cues (C), mental actions (Me), and motor actions (Mo) made up the behavioral elements of a basic skill sequence. Further, specific groupings of basic skills made up a task or task segment through chaining. The C-Me-Mo sequence is similar to the Input X Central Processing X Output activity of Singer (1978) and the SOR model. However, the C-Me-Mo terminology more appropriately describes the complex tactical environment.

Based on learning theory and the behavioral task analysis, learning in the experience-judgement area was divided into five phases.

1. Readiness Phase - This phase involves the gaining of knowledge and understanding for the first time of equipment and systems to the point of verbalizable understanding of parts, functions, steps, sequences, and numerical values involved. It also includes knowledge of the goals, functions, steps, and sequences of specified tasks or sub-tasks.

2. Awareness Phase - This phase involves the gaining of knowledge, and understanding of specific cues concerned with the performance of a task or group of tasks. It is the phase in which the student becomes aware of specific cuing objects, the quality of these objects, spacial relationships, and the relation of other sensory information which is important to task performance.

3. Initial Skill Development Phase - This phase involves emphasis on the components of the more complex task, and provides the first modeling of basic skill (C-Me-Mo) elements

into task sequences. These sequences are primarily developed and chained through carefully guided rehearsal. This phase also has the discovery aspects of the two preceding phases.

4. Advanced Skill Development Phase - This phase is essentially the secondary rehearsal portion of skill chaining where sub-tasks are smoothed and blended into complete and instinctively performed routines. A final perceptual-motor relationship is sought to resolve any uncertainty of response to the end goal of the task. These instinctively performed routines then become part of the repertoire of useful alternatives.

5. Inventive Phase - This phase involves the use of instinctively performed task routine alternatives and the modification of these routines to meet the demands of changing situations. This final phase also includes the creativity which comes from the complete comprehension of all skill components so that new tasks can be originated to execute existing goals or new situational goals.

The establishment of the phases of learning for flying completes the necessary components for the Experience-Judgement Theory. The phases will allow researchers to attach an experimental framework to training objectives and the training requirements. The phases also will allow researchers to relate the task analysis data to specific areas of training.

Experience-Judgement Theory Components - The basic theory considers the pilot in terms of cue, mental action, and motor action sequences. Each sequence requires a series of operations dealing with cues, then mental actions, and finally motor actions as shown in Figure 1.3. Although only implicitly addressed until this point, the aircraft is another element of the theory as all motor outputs go to the aircraft.

Cues, which are all input to the pilot, are obtained from the environment in which the aircraft and pilot fly. They may be from the world external to the aircraft - the ground and aerial environment, from the status of the aircraft, or from internal feedback of the human motor system. The feedback loops are important for performance appraisal to assess how well the motor actions resulting from mental actions yielded the desired results. Motor actions are what the pilot does with the aircraft flight controls or subsystems while mental actions are the cognitive processes which utilize cues and precede motor actions. As appropriate, corrections are made to motor actions to have the required output match actual output.

Single sequences of cues, mental actions, and motor actions must be put together to form complex tasks. This occurs through chaining in which the mental actions are tied to other mental actions. Based on observations of pilots, it is apparent that the sequences are performed in close temporal proximity so that

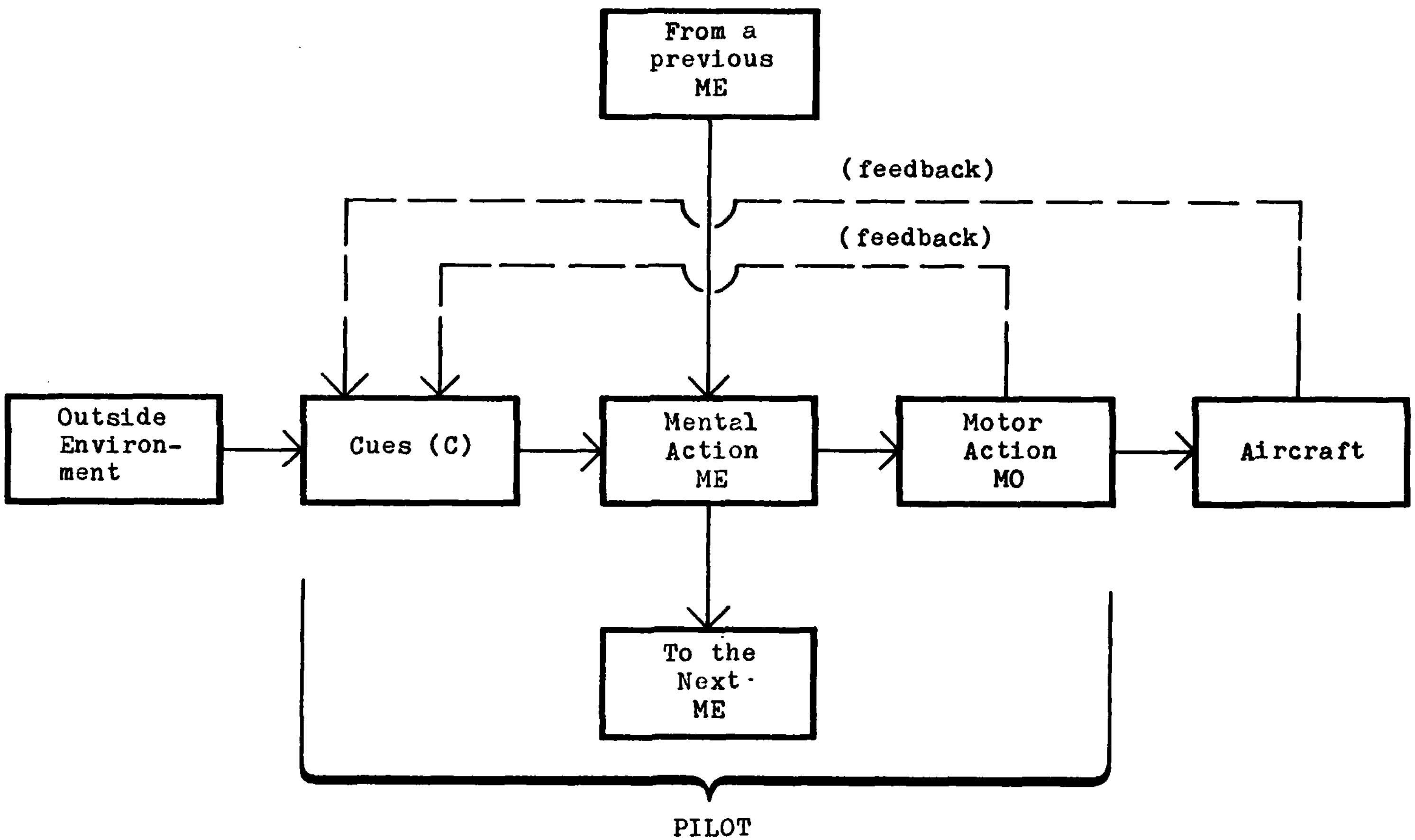


Figure 1.3. Experience-Judgement Theory

they appear continuous. However, each sequence is discrete so that it can be analyzed separately.

The order of obtaining the cues-mental actions-motor actions associated with the sequence starts with those items which are observable, that is the cues and motor actions. The mental actions are derived from an evaluation of what is required to process the cues into motor actions. The theory emphasized mental actions, as numerous cognitive and perceptual processes have been identified.

Cues - The cues portion of the Experience-Judgement Theory follows Rumelhart's (1977) model of the environmental and sensory system. In this model, environmental stimuli such as light, sound, and motion impinge upon sensory receptors setting up neuron patterns. The patterns are stored for short periods of time, approximately one second, in registers which save a representation of the stimuli as shown in Figure 1.4. The mental actions acquire all information from the cuing system if acquisition is within the appropriate time period. Any selective attention and related information loss due to system limitations occur after perceptual processing in short term memory (Shiffrin, 1975), corresponding to the mental action portion of the theory .

Mental Actions - The mental action portion of the theory is the most complex element and is shown in Figure 1.5. Mental action requires that decisions be based on current environmental

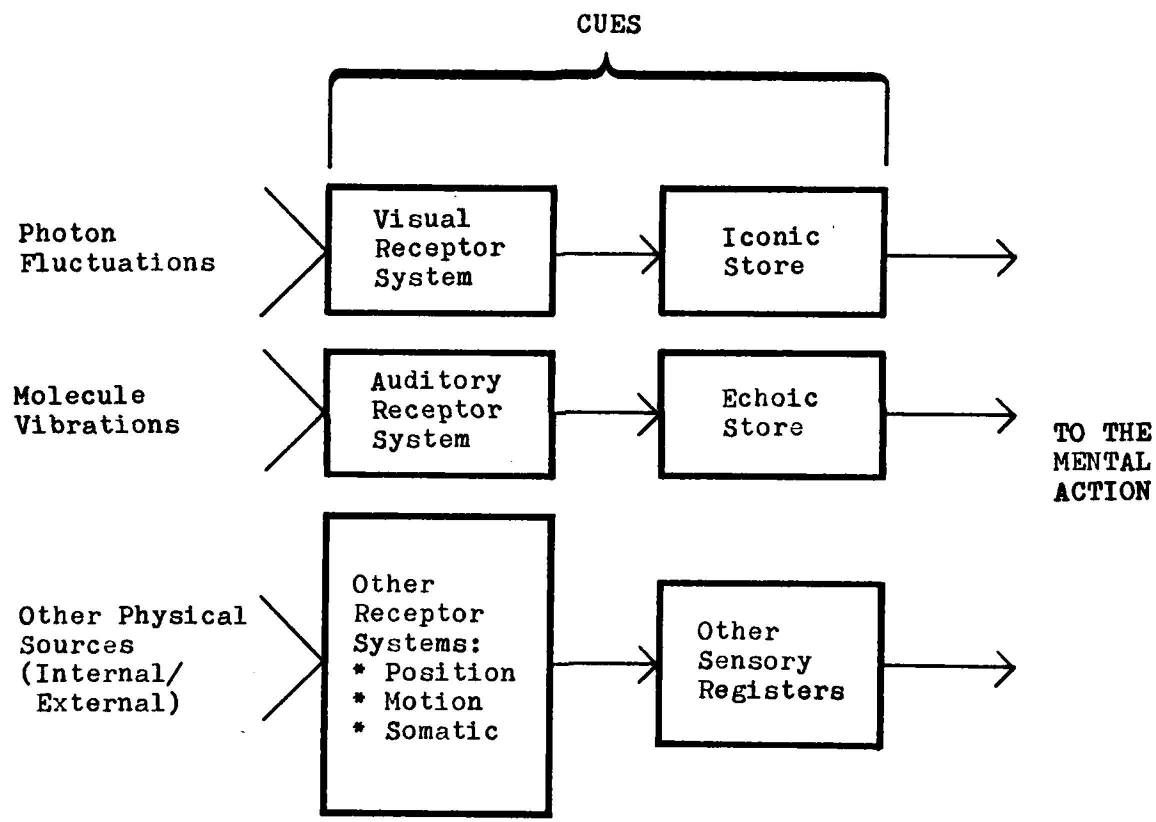


Figure 1.4. Experience-Judgement Cue Acquisition
(Adapted from Rumelhart, 1977)

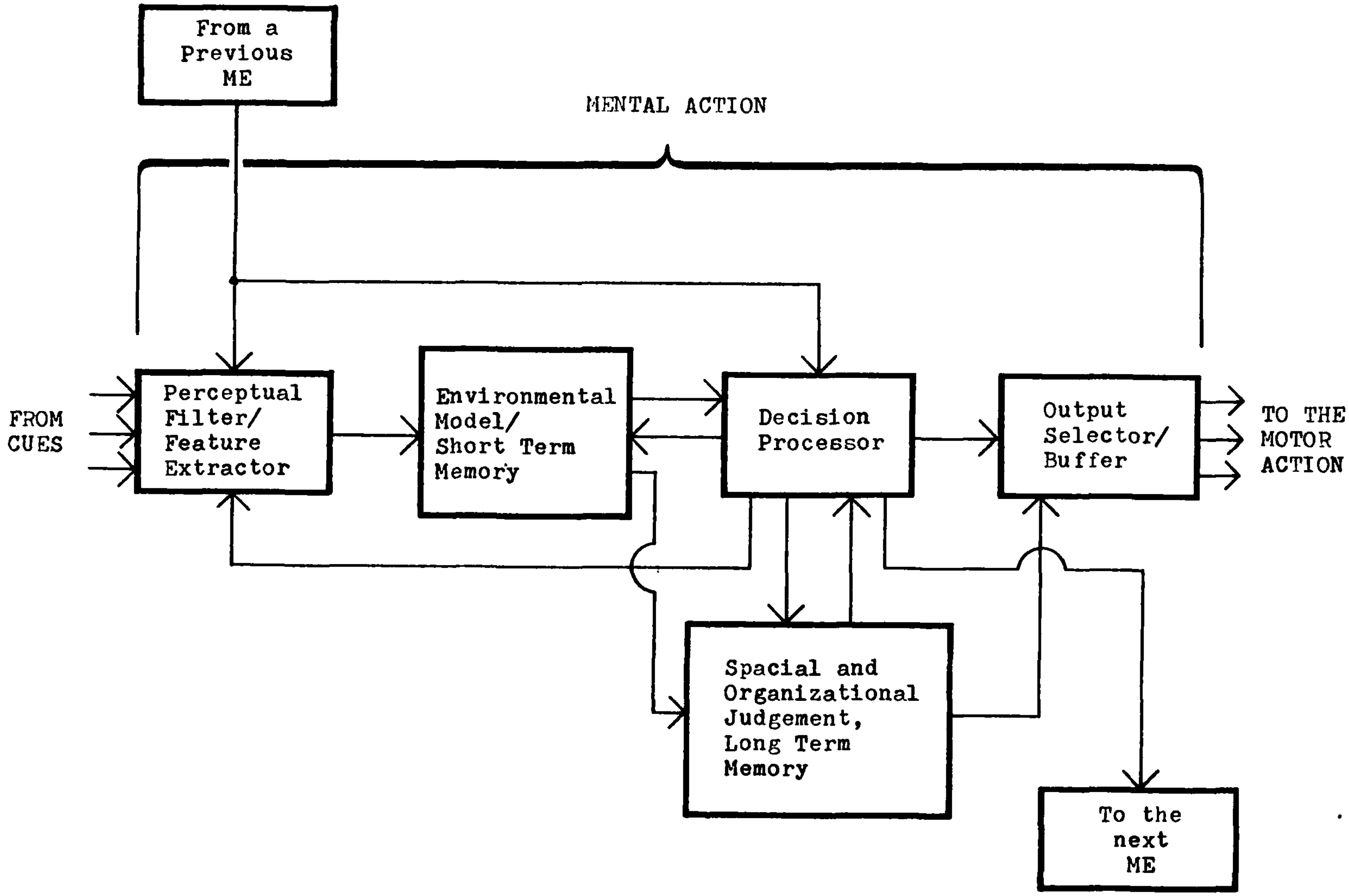


Figure 1.5. Experience-Judgement Mental Processing

information combined with prior experience and judgement. Further, any limits to information processing appear to occur in this portion of the theory so that all information must be assessed for relevancy to prevent unnecessary information from tying up processing capability.

The incoming cues are selected, based on their relevance, by a perceptual filter which extracts appropriate features for further processing. The perceptual filter is driven by the preceding mental action allowing a rapid transition to the current sequence and setting up the pattern condition for production in the experienced pilot. The perceptual filter also is influenced by the current decision in the event that crucial environmental changes must be immediately processed.

The perceptual filter is needed to extract those cues necessary for a particular element sequence from a myriad of cues due to the limitations of the information processing system previously discussed. The extraction may be the two stage perceptual process developed by Laberge (1975). For letter codes, Laberge assumed that the first stage consists of selecting relevant features, or cues, and not dealing with irrelevant ones. The second stage organizes cues into higher order cognitive units.

Due to the complexity of the environment, the perceptual filter does not simply segregate relevant from irrelevant cues but probably differentiates relevant cues into at least four subsets; primary, secondary, complementary and conflicting cues are described by Matheny, Lowes, Baker, and Bynum (1971). Of these, the pilot need only deal with primary cues which are necessary for later processing. However, the pilot may need to use a limited number of secondary cues (cues which support primary cues and are in the same sensory modality), and complementary cues which are cues supporting primary cues but are in different sensory modalities. Further, some of the cues may be obscured due to other masking cues.

In addition to the categorization based on types of cues, a more critical factor may be the number of cues which can be utilized by the short term memory in accepting the output of the perceptual filter. Miller (1956) in his development of the magic number seven plus or minus two, determined that memory capacity is about seven units. Each unit refers to a chunk of information, so that by proper coding, many bits of information can be stored. Part of the progress a pilot makes is the ability to more efficiently store information in chunks since there is no way to increase the number of memory units available. This is even more critical if current evidence of three or four units for laboratory studies of memory skill (Ericsson, Chase and Faloon, 1980) is applicable to piloting tasks.

The reorganization of chunks fits observations of student pilots who have difficulty replacing irrelevant cues with primary cues. These students acquire a set of cues which work for a specific condition such as landing at the home airport, but which are inappropriate for other conditions at alternate airports. Even though the students recognize that something is wrong for other conditions, they cannot try other cues to see what will help because their memory capacity is saturated with irrelevant cues filling up remaining chunks. Only practice can overcome the problem.

An environmental model which provides a current and predictive assessment of the situation resides in short term memory. Utilizing the filtered cues and long term memory information, a model is developed to assist in making appropriate decisions. The model consists of an internal structure which integrates information such as capabilities of own and aggressor aircraft; current aircraft velocities, accelerations, attitudes, available weapons and altitudes; own and aggressor tactics; and prior training of experience-judgement. Through the model, predictions of the best course of action can be made as the future locations of aircraft can be estimated. The model is continually updated so that the pilot has an awareness of what is going on around him. However, should information be lost for even a fraction of a second due to an unusual situation such as entering a cloud or preoccupation with an irrelevant task, the model is dissipated until sufficient time has transpired for total model regeneration which takes up to a few seconds. Thus, a change in concentration for an instant is serious.

Model loss results in disorientation. For example, a pilot who is flying an instrument approach for landing has redundant cockpit displays of aircraft position. Yet there are cases where in less than a second and without any change in the cockpit environment, a pilot believes the aircraft's position to have changed by many miles although all instruments agree to the correct position. During that time, the model is lost and the instrument indications are not sufficient to reestablish the model. The pilot, even with all instruments agreeing, will not believe them. All prior training to "fly the instruments" cannot immediately overcome the loss of the model.

Like other portions of the theory, the environmental model must be learned. As it is learned, the part of Situational Awareness dealing with knowing where you're at and what is going on around you is gained. Further, the pilot's purview increases so that more of the overall situation can be considered. Aircraft not immediately involved in the situation are then dealt with along with detailed ground elements.

The environmental model is influenced by and influences the decision processor which Poulton (1970) calls the computer. The decision processor is another bottleneck in the system; it must systematically determine what should be done, combining numerous information sources and making many decisions. All this must be rapidly performed and even with the preprocessing functions of the environmental model, the processor can overload. The result can be a pilot "freezing" or an irrational decision being made.

The decision processor integrates the environmental model and long term memory to form appropriate actions and it also builds up judgements in long term memory. This duality makes it possible for the pilot to learn through the increase in available judgement information and to apply that information when necessary. Like the perceptual filter, the decision processor is keyed by the prior mental action so that it can start to search long term memory for the appropriate judgement types to ensure rapid transition to the current element sequence.

The selection cf judgement type is a function of whether or not a maneuver anticipation point is reached. Anticipation points are the places where an alternative maneuver may be selected. They always occur at the end of a maneuver, but also can be found within maneuvers. In the event that an anticipation point is reached, organizational judgement is required. Otherwise, more spacial than organizational judgement is needed. Appropriate organizational and spacial judgement skills are used according to current circumstances.

It is not necessary for a maneuver to be completed prior to the initiation of a new maneuver. The tactical environment is fluid and for a pilot to be committed to flying a limited set of well defined maneuvers would make it easy for an aggressor to anticipate conditions. Maneuvers have anticipation points at which the state of the aircraft permits a transition to other maneuvers. The points provide the pilot with a limited, but more than adequate, selection of alternatives allowing for changes in tactics as the situation demands. As judgement is acquired, more alternatives are placed in long term memory.

The manner in which judgements are stored and retrieved from long term memory may be as event probabilities. Such probabilities would offer a relatively compact way of dealing with information. This technique also would account for the difficulty to verbalize what needs to be done in a given condition, for most training occurs through demonstration and practice. Long term memory is appropriately structured to allow the insertion and retrieval of information.

Long term memory also provides the means of allowing element sequences to be performed without utilizing all mental action elements (Poulton, 1970). After a great deal of practice, sequences can be performed in an automatic way - freeing mental capacity for concentration on tactics. The connection to long term memory from the environmental model and from long term memory to the output selector/buffer provides the path for automatic operation.

The automation of element sequences is the first step towards chaining and Situational Awareness. As automation increases, the pilot no longer needs to be consciously concerned with specific sequences but can more readily deal with accomplishing a complete task. The more chaining of sequences which occur, the closer the pilot comes to Situational Awareness.

Patterns then can be established which result in actions so that the rudiments of production appear. With a larger repertoire of judgements, more condition-action pairs exist. A practical limitation to production may be maneuver anticipation points. To establish larger patterns would commit a pilot to fly long sequences of well defined maneuvers which an aggressor could easily recognize. By keying maneuvers to anticipation point boundaries, a wide variety of alternatives is available.

Once a decision is reached by the processor or an automatic decision is made through long term memory, the appropriate motor output are placed in the output selector/buffer for implementation. The selector/buffer is needed as motor output are slower than the other parts of mental action. The selector/buffer allows the other parts to work at full capability; when the motor system is ready, the motor actions occur.

Motor Actions - The motor actions are accomplished based on the commands stored in the output selector/buffer. The motor actions control the aircraft, and aircraft actions are monitored as part of a feedback loop to the cues. To ensure that the motor actions are appropriate, additional internal feedback to the cues exists from the output effectors, or muscles. A completed motor action indicates the end of an element sequence and the start of the next sequence.

Experience-Judgement Theory Implications - The theory provides the basis for the development of analytical techniques to implement an experience-judgement approach. Having described how the fighter pilot performs his tasks along with how learning occurs for these tasks, procedures which structure vicarious experience can be developed. Based on an extension of the behavioral task analysis, these procedures form an expanded task analysis which emphasizes the cognitive elements and requisites of flying.

Since "Vision is probably the most important single sense modality employed by the human operator in his gathering of information concerning his relation to the real world" (Fogel, 1963, p. 65), visual cues received special consideration. Cues and their relation to the environment were defined. The resulting visual philosophy provided cuing requirements for tasks to support synthetic training.

2. VISUAL CUING IN COMPLEX TASK PERFORMANCE

Introduction - Visual cues are of primary importance in the performance of complex tasks. This is particularly true of tactical flying where visual cuing makes up over eighty percent of all information processed about the task. Because of this, emphasis was placed on the area of visual cuing. First, an accurate analysis of tactical flying tasks depended on a precise and consistent description of visual cues. Secondly, the experience-judgement approach to training underscored the use of synthetic training devices and the visual representation of task-related cuing. Finally, since a clear-cut vocabulary of visual terminology has not existed, describing the subject was very difficult. Thus, a visual cuing philosophy was developed in order to provide a foundation for this visual emphasis.

Visual Philosophy - The first item in the development of a visual philosophy was the definition of the term, cue. Although a review of literature indicated many overlapping connotations of the word, in general, cues are stimuli that excite the sensory system of the body and provide the mind with information which may result in a course of action. Cues are thus, forms of physical energy which are perceptible by the sensory system and interpretable by the brain. Since this study is task performance oriented, the following definition was established: visual cues are discernible, useful information in the form of light energy which describes the substance of the pilot's environment from which task related decisions may be made.

All visual cues within the flying environment have perceptible substance which can be categorized as stable, or non-stable, forms. These basic cue types have been defined as:

1. Stable Forms - natural or man-made opaque objects with characteristics of substantial visual constancy, such as rocks, trees, and buildings.

2. Non-stable Forms - natural or man-made liquid or particle/gaseous substances with momentary visual constancy such as water and clouds or an amorphous character such as haze and fog.

From an analysis point of view, these cuing types can be further grouped into specific locations in which they occur in the flying environment. These logical groups are: 1. sky cues which comprise the aerial layout, 2. the horizon, and 3. ground cues which constitute the surface layout. Table 2.1. shows a listing of most major cues in each group. These cues have been defined collectively as background environment cues since they occur at a distance away from the pilot and aircraft.

Background Cuing Environment - The background cues in Table 2.1. comprise the end of space against which pilots must select, extract, and process specific information in order to determine the state of their aircraft. A progression of visual perception in flying may thus be thought of in the following manner.

Table 2.1. Background Environment Cues

<u>Sky Cues</u>

Aerial Layout	1.	Sun
	2.	Skytone
	3.	Cloudforms - weather clouds, precipitation, haze, etc.
	4.	Targets - aircraft, aerial missile types
	5.	Weapons Discharge -(transitory) flak, missile trails, tracers

<u>Horizon Cues</u> - Skytone/cloudforms, profile

<u>Ground Cues</u>

Surface Layout	1.	Patterns - cultivation areas, flora/vegetation areas, geological formation areas, bodies of water
	2.	Profiles - hills, flats, mountains, valleys
	3.	Landmarks - all prominent patterns and profiles, i.e., lakes, river courses, shoreline, islands
	4.	Checkpoints and IPs - all conspicuous patterns and profiles, and roads, highways, rail lines/ intersections, towers, tanks, bridges, dams, power stations, monuments, cities, towns, villages, airfields, strip mines
	5.	Targets - (strategic) roads, highways, rail lines, towers, tanks, bridges, dams, industrial areas, power stations Targets - (tactical) weapons emplacements, command posts, ground forces, communication centers, supply dumps, airfields, armored and supply vehicles, barges, ships
	6.	Weapons Discharge - (transitory) missile launches, muzzle flashes, tracer flashes, smoke, dust, cast shadows

1. The space in which a pilot flies is usually visual emptiness and so contains no visual cues.

2. The depth of space is the distance between the pilot/aircraft and the outer surfaces of stable and non-stable forms.

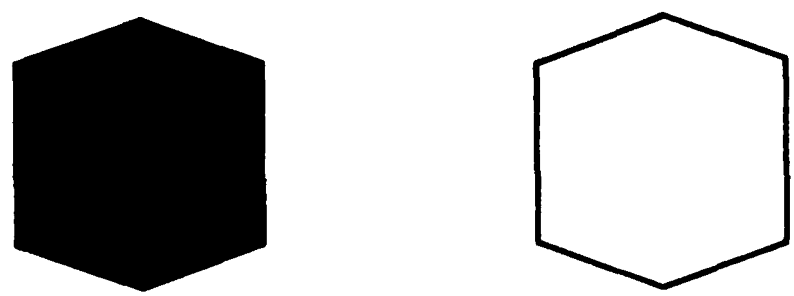
3. The surfaces of forms are the perceptible background which contains basic cuing information.

The specific information about a cue which is used in the control of an aircraft has been called a referent by Matheny, et. al, (1971). It was necessary to refine and expand the cuing referent concept for this task analysis. A cuing referent was defined as the useful visual elements and symbologies contained within the cuing form which allows task related spacial and organizational judgements about control and performance to be made by the pilot. The refinement and expansion of the cuing referent concept would require a working understanding of what types of information were being extracted from which cues, and the usefulness of these activities to the performance of the task. A clearly defined structure and organization was also required to accomplish this understanding.

<u>A Discussion of Visual Referents</u> - A workable vocabulary was needed to describe the specific information about cues, relative to the environment in which they would be found. The visual elements commonly used by artists were found to describe many useful referents upon which spacial and organizational judgements could be based. Further, cuing referents and visual

elements stem from some physical property of a cues surface form. Shape, size, contour, perspective, texture, detail, contrast, and color are eight visual elements which were found to be useful cuing referents.

Shape - Shape is the visible outline or edge characteristics of a form or area. Figure 2.1., for example, shows two cuing forms with identical shape.



Shape - A   Shape - B

Figure 2.1. Shape Characteristics

Shape - A provides a silhouette while Shape - B shows a linear presentation of the shape edge. The shapes above have an essentially two-dimensional visual quality and identify an area bordered on six sides. It is extremely rare when the surface of any form has only one cuing referent. Forms usually have visual referents in combination although the observer may find only one or two useful at any given time.

Size - Size is the relative magnitude of the shape or contour characteristic within a shape. Since size is always relative to something else, it is a comparison referent. Size can relate or be compared to one's self, something in one's memory, two objects on the same visual plane or on different visual planes. Thus, size may also be related to time and distance. Figure 2.2. is a comparison between the relative magnitude of two identical shapes. Without additional visual referents, little more useful information can be determined.

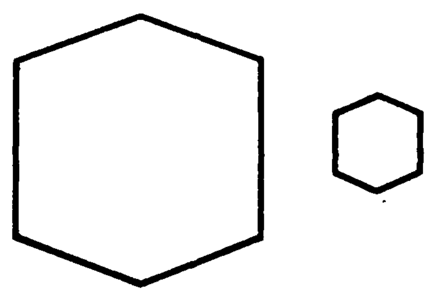


Figure 2.2. Size and Shape Characteristics

Contour - Contour is the visual delineation characteristics within the outline shape or boundary of a form. The simple line of Figure 2.3 identifies the shape as the linear representation of a cube, and does much to clarify and classify the object.

If center lines were added to the two shapes in Figure 2.2., the result would be as shown in Figure 2.4. The contour line has added measurably to the identification of the cue in terms of both size and shape relationships.

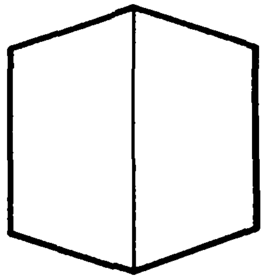


Figure 2.3. Contour and Shape Example

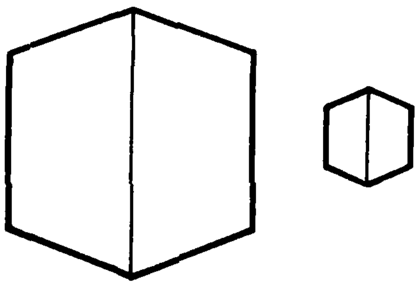


Figure 2.4. Size, Shape, and Contour Example

For example, Figure 2.4. shows two cube-like objects, one visually larger than the other. However, the addition of this single contour line can also give the visual impression that the two cubes may not be on the same plane and that some distance could be involved. With the possibility of relative distance, it is no longer possible to determine whether the two objects are truly meant to be different sizes. What has entered the visual presentation is the referent of perspective.

Perspective - Linear perspective is the visual alteration of boundary shapes and contours of objects or areas as a result of differing distances and viewing angles. Figure 2.5. shows the integration of perspective, size, shape, and contour.

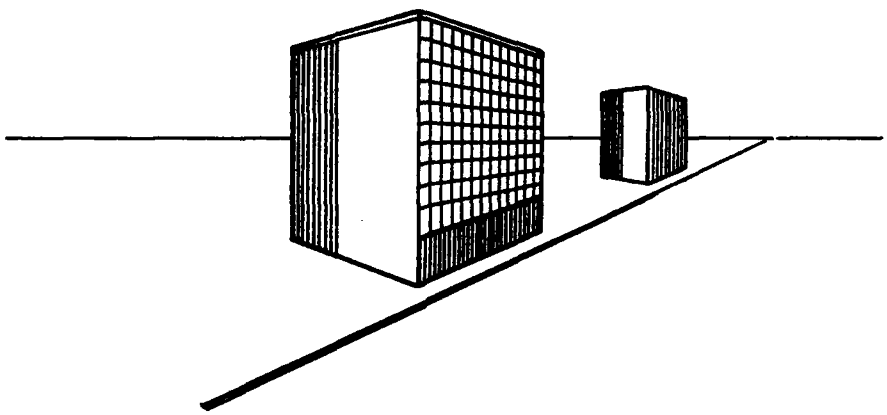


Figure 2.5. Perspective, Size, Shape, and Contour Example

The referent of perspective brings with it an observer's eye level, and a real or imagined horizon with vanishing points, or the vanishing limits described by Gibson (1975). Vanishing points and vanishing limits possess many common aspects but should not be confused. Vanishing point perspective is a collection of man-made rules which were developed by artists, and has many limitations because of its picture plane orientation.

The vanishing limit of optical structure at the horizon comes from natural perspective, ecological optics, and the theory of ambient array. Thus, vanishing limit also includes aerial perspective as described in Wulfeck, Weisz, and Raben (1958), where contours become indistinct, apparent color saturation becomes reduced, and changes in brightness and contrast occur with increasing distance. Figure 2.5. further shows usefulness of contour in determining information about an object's surface.

Texture and Detail - Texture is the characteristic structure of a surface given it by the physical size, shape, density, arrangement, and proportion of its individual parts. Texture and detail referents are often considered together. Figure 2.6. shows a defined textural pattern from which the detail of the texture is emerging. Detail is defined as the visual emergence of an individual part or parts from a larger structure or area. The texture in Figure 2.6. which emerges into detail is a function of density so that as density is lessened, the singular detail of the surface can be seen. The texture/detail relationship also can be a function of distance. Closer portions of the surface show the detail which resolves into texture with distance and atmospheric attenuation in the actual world. The term, gradient, will be used to describe variation in texture, contrast, and color. Gradient is defined as the rate of change taking place on useful cuing referents of a variable nature in perceptible degrees or stages.

Contrast and Color - Contrast is the comparison of the intensity levels of light energy as it is reflected from the surfaces of forms. Color is the light energy spectrum which is visible to the eye.

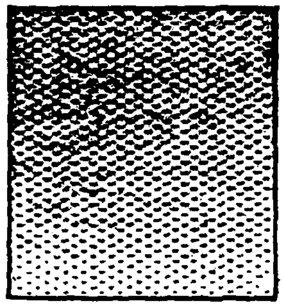


Figure 2.6. Texture and Detail Example

Figure 2.7. shows contrast as a tonal gradient between white and black. Where the tonal gradient of the three scales are perceived as the same, a zero contrast is shown.

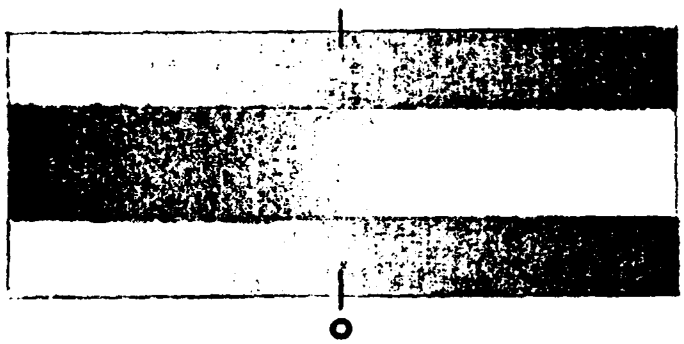


Figure 2.7. Contrast Scale

Figure 2.8. shows the cube form in four contrasting situations. The A cube is a white on white situation; therefore, the shape and contour must be shown in contrasting line. In B, a close vertical contour was added to one face in order to

increase the contrast so only the light side requires delineation. In C, the dark background is at maximum contrast to the cue form - thus making it highly visible. Letter D again shows the close contour lines on one face of the form separating the two faces and giving the impression of a light side and a shaded side. The highly contoured side, however, is greatly reduced in contrast from the dark background.

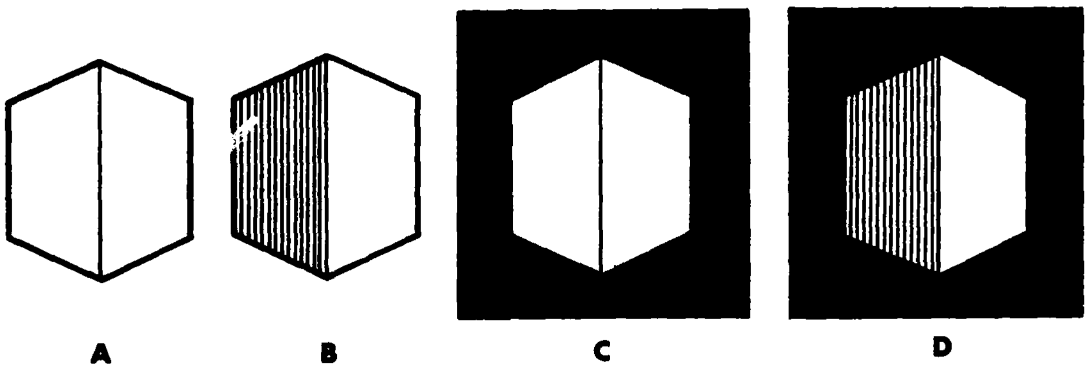


Figure 2.8. Shape, Contour and Contrast

<u>Visual Flying Cues and Referents</u> - In determining the extent of visual cues and referents available to a pilot, the background environment will be discussed and defined in physical and visual terms. The background, or those cues found away from the pilot and aircraft, involve aerial layout, horizon, and surface layout. A second important group was the foreground cues which are those on or in the aircraft and within the pilot's cockpit field of view. These will be discussed regarding their relationship to

the background environment and specific cuing activities. Cuing activities describe the integration of cues and referents in terms of a flying oriented usefulness.

Aerial layout contains the group of cues and corresponding referents which extend upwards from the horizon. This area contains, for tactical flying purposes, five basic cues: skytone, sun (assuming daylight conditions), cloudform, weapons, and targets. These basic cues have been defined as follows:

Skytone - the vertical light gradation of a sky area free of cloudform.

Sun - the most prominent natural source of illumination.

Cloudform - an obscured area imposed over the skytone.

Weapon - a transitory object, trail, or burst which conveys the presence of a destructive missile.

Aerial Target - a craft capable of flight, designated as an object of search or attack.

Each of these basic cues has referents associated with them. The cue/cuing referent associations are shown in Table 2.2. The referents for each cue were designated by applying the physical properties of the cue with specific referent definitions.

Table 2.2. Aerial Cues and Referents

Basic Cues	Referents
Sun	Contrast (gradient)
Skytone	Color (gradient)
Cloudform	Size, Shape, Contour, Contrast, Texture
Weapons	Size, Shape, Contrast, Color
Target	Size, Shape, Contour, Texture, Detail, Perspective, Color (plus Wing Plane and Fuselage Plane)

Targets are perhaps the most important aerial cues in the tactical sense. Since targets can be either friendly or hostile, their referents are of great importance to the pilot. A target contains the visual referent characteristics of all objects - size, shape, contour, texture, detail, perspective, contrast, and color plus two excogitative referents which have been called fuselage plane and wing plane. Fuselage plane was defined as an imaginary line drawn fore and aft through the fuselage and used to estimate pitch rate and angle while wing plane was defined as an imaginary line drawn through from wing tip to wing tip and used to estimate a target's roll and roll rate. Figure 2.9. shows these referents.

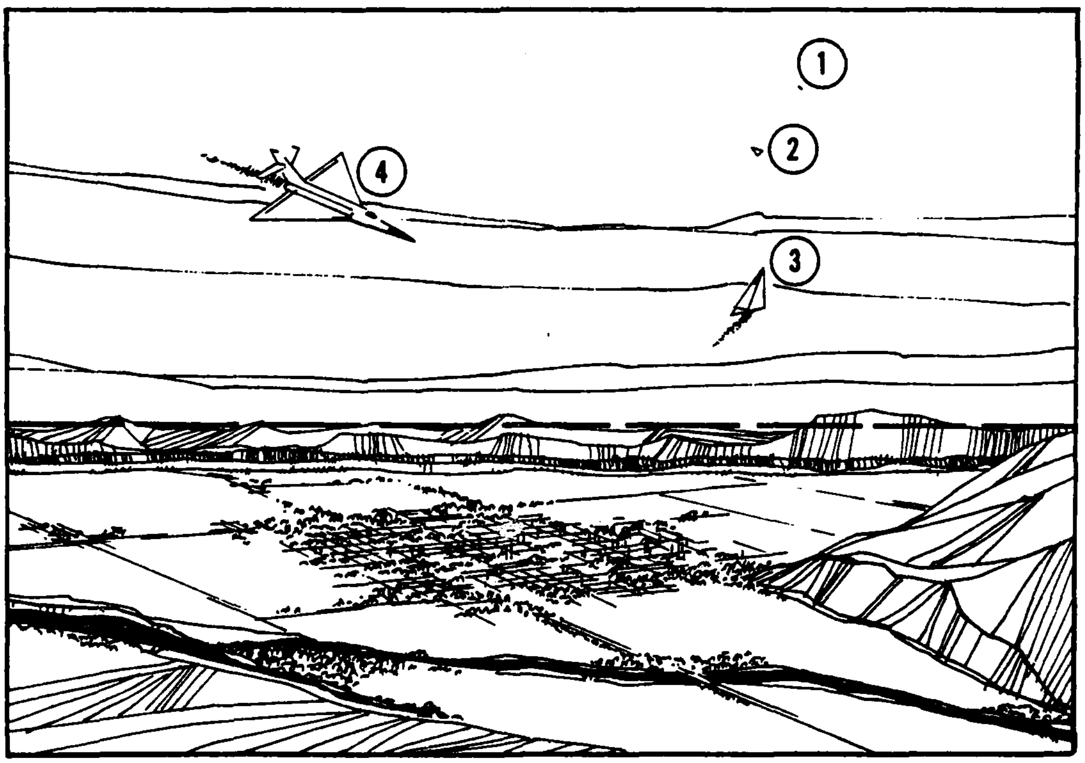


Figure 2.9. Examples of Target Characteristics

Target 1, as an object form, has sufficient size and contrast referents to provide detection. Its size referent and position above the horizon indicate that it is higher than the observer's eye level and at extreme visual range. Target 2 has sufficient size and contrast for detection. Its shape and size referents along with relative movement provide useful information such as estimated range, relative direction, and a possible clue to its identification. Its relative size, shape, and position to the horizon indicate that it is higher than the viewer's eye level but not as high as Target 1. At altitudes up to 50,000 feet, the horizon appears at the viewer's eye level (Langewiesche, 1944). Thus, cues above the horizon are actually higher than the viewer. Target 3 contains size, shape, contour, contrast, and perspective referents. The addition of internal contour provides the final detail for identification. The perspective of the object helps to determine its aspect away from the observer and the relative size and position of Target 3 shows that it is lower and closer than Targets 1 and 2. Target 4 shows the same cuing referent characteristics as Target 3. Both targets show how the wing and fuselage plane referents could be used to determine relative pitch and bank angle, and rate in a dynamic situation.

The usefulness of the horizon as a visual cuing referent has already been mentioned when discussing relative target positions. The horizon has a number of characteristics which make it the most important of all background cues. Technically, it is the line which separates aerial layout from the surface layouts; however, as a basic cue it incorporates a little of both domains. Figure 2.10. shows a background environment containing the horizon. The horizon, as a cue, is loosely indicated by the bracket and at the left. In the actual environment, this area is usually softened by atmospheric attenuation and haze. The useful horizontal referent is, thus, a mental averaging of the sky/earth elements into an imaginary line indicated as letter a.

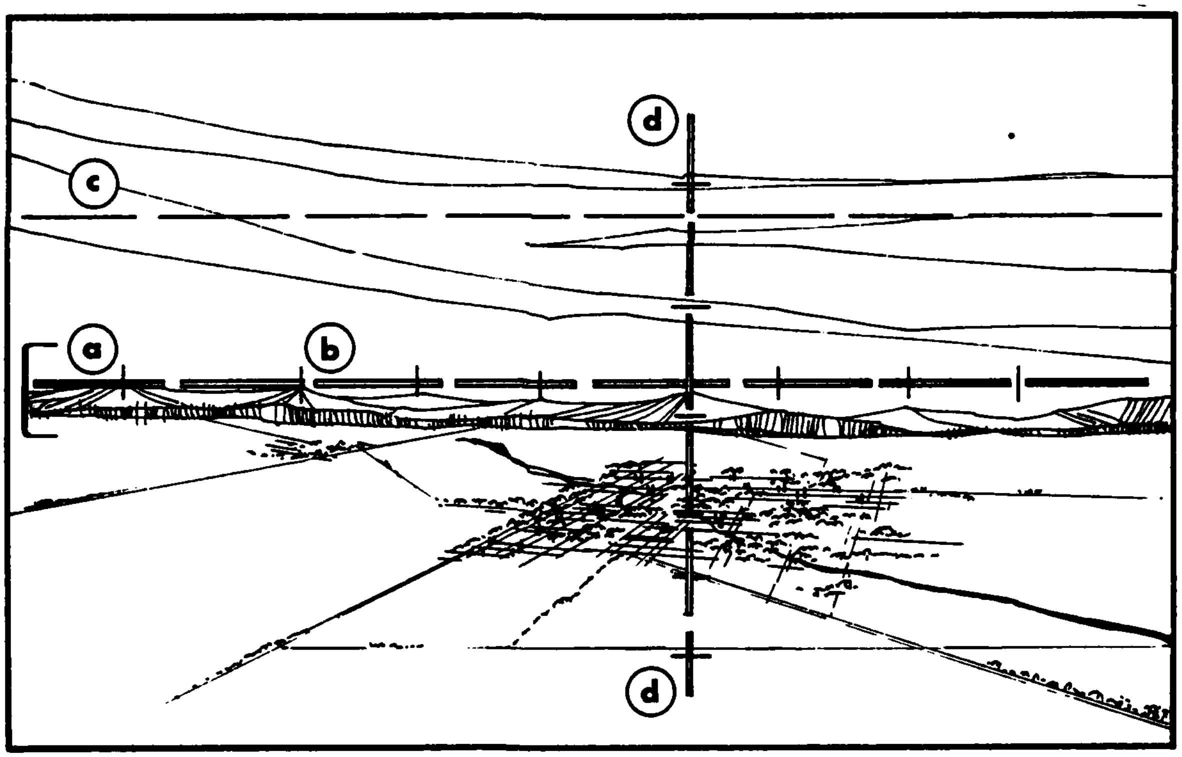


Figure 2.10. Horizon Referent Examples

In actual contact flying under fair weather conditions, the horizon extends all around the background environment providing the only constant visual cuing referent in flying. The profile of the horizontal constant shown in Figure 2.10. is usually not a smooth shape. The visible jutting changes in profile provide imaginary "tick mark" referents indicated as b in the figure and are useful in the estimation of the turn rate around the horizontal constant. Cloudforms in c may be used as an imagined secondary horizontal referent since they, too, generally parallel the horizontal constant. Although the horizon is essentially horizontal, a vertical referent may be constructed from it. This vertical construct referent is estimated as being a 90° perpendicular to the horizontal constant as shown in d - d of Figure 2.10. This referent ranges above and below the horizon, and is important in orienting the direction of gravity. It also contains imaginary "tick mark" referents useful in estimating pitch attitude and rate. The following shows the relationship between the horizon cue and cuing referents.

	Cuing Referents
Horizon Cue	Horizontal Constant - the real or imaginary line referent of the earth's profile used to establish and maintain level flight, and used to estimate roll rate, bank angle, and turn rate.
	Vertical Construct - the imaginary perpendicular referent from the horizontal constant used to estimate pitch attitude, pitch rate, and relative altitude of other aerial targets.

It has been said (Langewiesche, 1944), that although driving a land oriented vehicle could be done by instinct, flying requires imagination. This has already been shown by the excogitative manner in which pilots must extract useful referents from the background cuing environment.

Surface layout describes the earth's outer face of the background cuing environment. In determining ground cues and referents, this face or surface must be defined and discussed in visual and physical terms. The horizon determines the edge of the surface and also represents the perpendicular or downward pull of gravity. In order to better understand this group of background cues, a greater emphasis must be placed on its surface characteristics. The earth's visual "surfaceness", or the end of space as the pilot looks out or down when flying, has been divided into what can be observed as pattern and profile cues. Visual pattern has been defined as the clustering of similar physical parts or materials in a specific area with a definable boundary shape. Profile was defined as the visible changes in elevation of the earth's surface. Thus, the arrangement of visible patterns and profiles into specific relationships forms the general "surfaceness" or surface layout of basic ground cues. Upon this layout of patterns and profiles, in a tactical sense, lie other more definable visual cues such as landmarks, check-points, initial points and targets. Each of these cues is defined as follows:

Landmark - a prominent pattern or profile feature which serves the pilot as a guide to location.

Checkpoint - a conspicuous object or prominent surface feature which has been designated as a specific location reference or action point.

Initial Point (IP) - a conspicuous object or prominent surface feature which has been designated a specific tactical action start point.

Target - a designated object of search or attack.

Surface layout features such as patterns and profiles have been used to express general surface characteristics. Checkpoints, IPs, or targets, although part of the surface layout, will always be expressed as specific cues. All surface layout components or ground cues are subject to the eight referents already discussed. They are size, shape, contour, perspective, texture, detail, contrast, and color. The term, gradient, again will be used with ground referents to express the rate of visual change in texture, contrast, and color. Table 2.3. shows the surface cues and cuing referents.

Table 2.3. Surface Cues and Referents

Basic Ground Cues	Referents
Pattern	Size, shape, contour, perspective, texture, contrast, color
Profile	Size, shape, contour
Landmark (Object)	Size, shape, contour, perspective, texture, detail, contrast, color
Initial Point (Object)	Size, shape, contour, perspective, texture, detail, contrast, color
Target (Object)	Size, shape, contour, perspective, texture, detail, contrast, color
Weapons Discharge	Size, shape, contrast, color

Surface layout represents the total arrangement and relationship of patterns, profiles, and specific cuing objects on the earth's face. However, since pilots may fly either high or low and can rotate their visual arc to observe cues from directly downward out to the horizon and upward, changes in cuing referents such as size, shape, contour, and perspective become extremely critical. To begin to illustrate this point, Figure 2.11. presents the earth's patterns and profiles including a large target cue as represented on a topographical chart. Figure 2.12. shows the side view of the target area from different heights, visual angles, and distance positions. These two figures are presented to orient the reader as to the direction of flight relative to changes in cuing referents due to alterations in viewing angles and distances which will be shown in Figures 2.13. through 2.16.

Figure 2.13 shows an overhead view of the immediate target area from a specific altitude. The figure shows the effects of height on target referents such as size, shape, contour, contrast, texture, and detail. It is also useful to note the mental visualization required to relate the patterns and profiles of the chart in Figure 2.11. with the visual cuing information shown in Figures 2.13. through 2.17. These scenes greatly enhance the availability of cues and referents over the topographical chart of the same area.

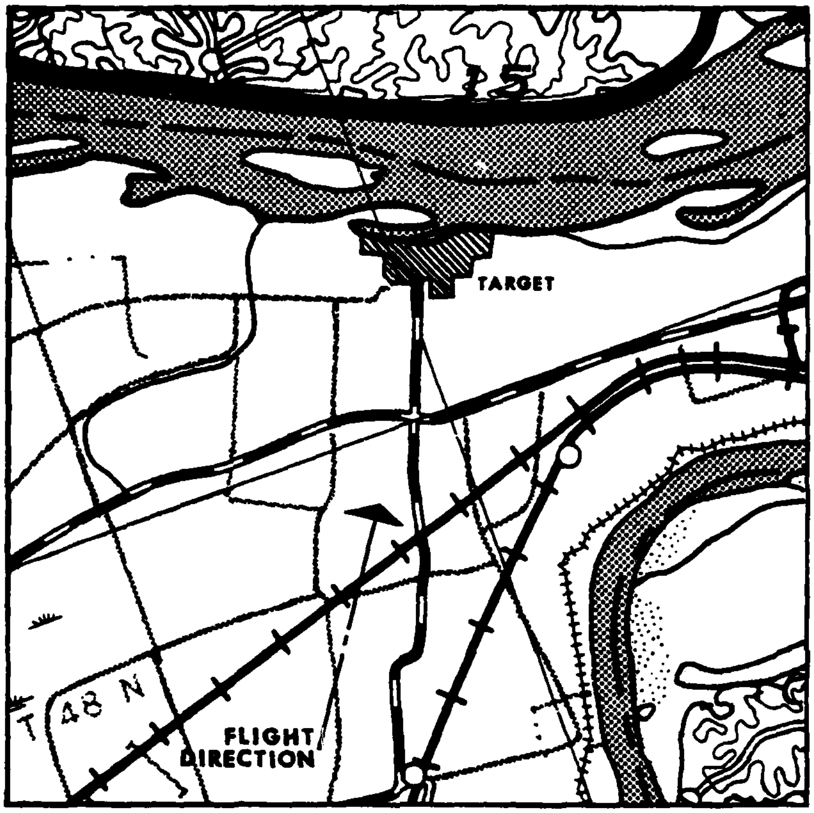


Figure 2.11. Target Area Chart

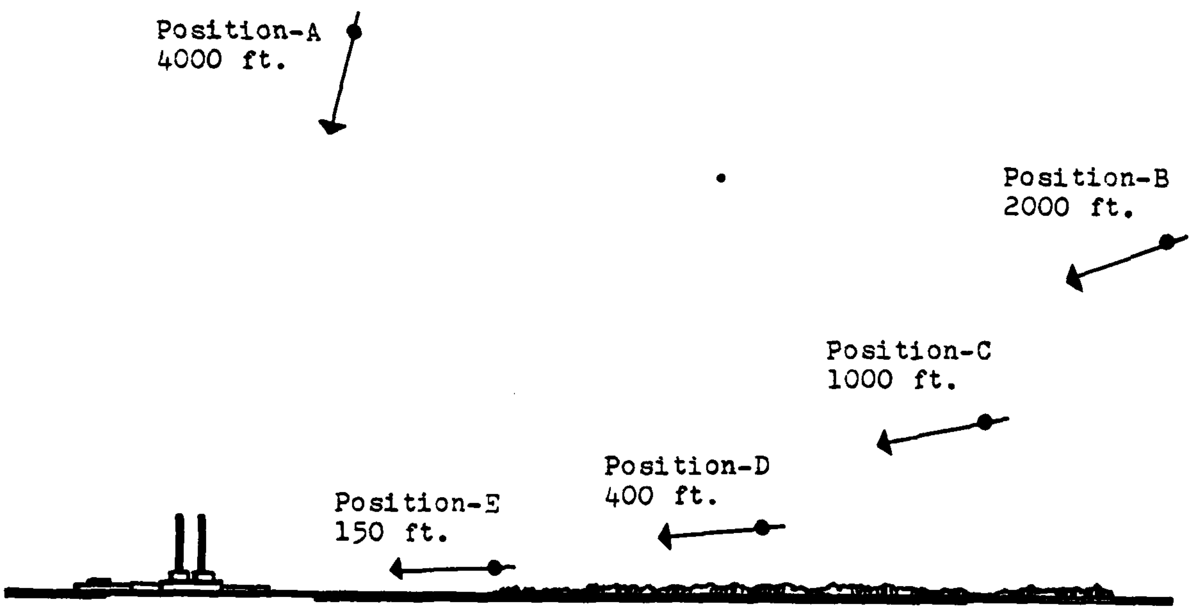


Figure 2.12. Target Side View with Viewing Positions

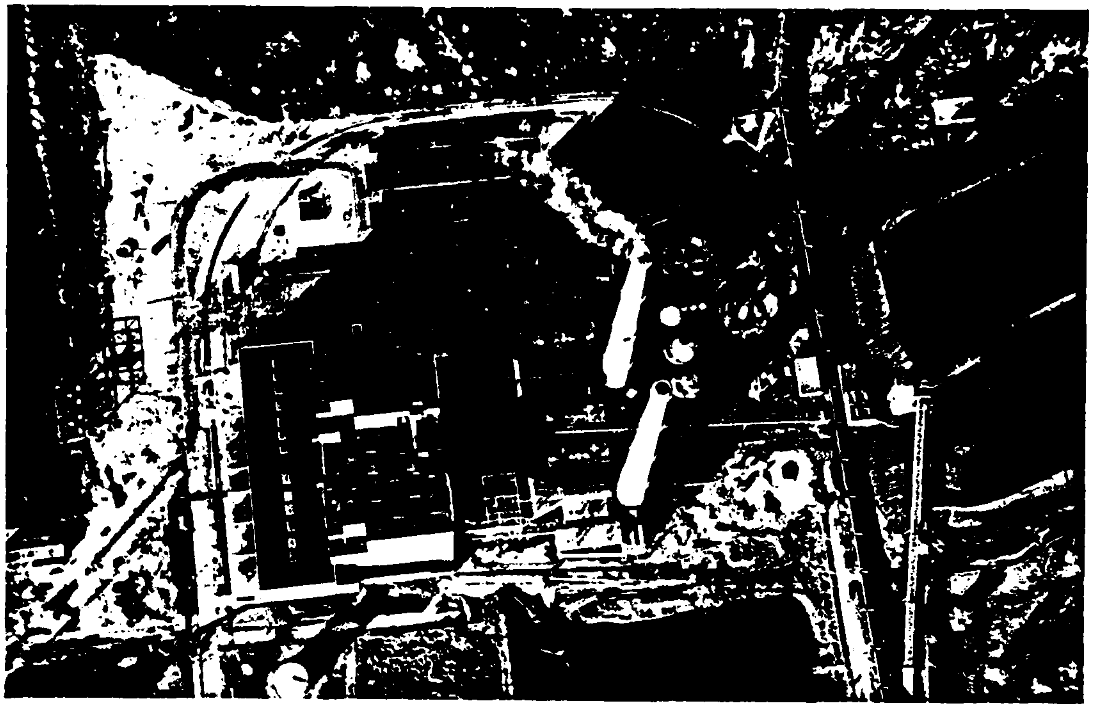


Figure 2.13. View of Target at Position - A

Figure 2.14. View of Target at Position - B

Figure 2.14. shows a view of the target area cues from Position B of Figure 2.12. At this height and distance, which is called slant range by pilots, the target perspective referents and the earth's partially obscured horizon profile are the most notable changes from Position A. Note also that the rivers, highways, and railroad tracks so easily seen on the chart have been lost. All that remains is the large smoke stack structure target and as the slant range changes at Positions C, D, and E, so too will the appearance of the target cues and associated referents.

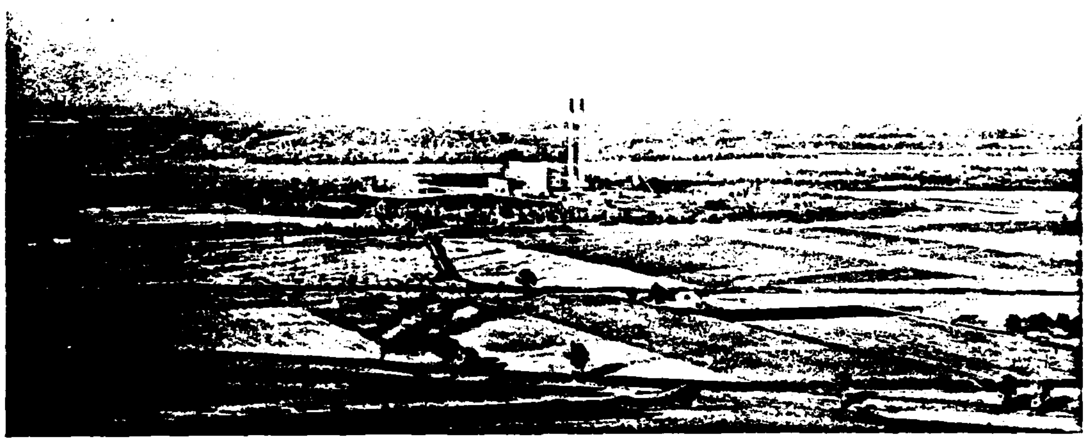


Figure 2.15. View of Target at Position - C

In Figures 2.14. through 2.17. the target no longer bears any visual resemblance to the overhead views. Thus, the pilot must mentally rotate and estimate these scenes as tracking continues to the target. The changing slant ranges of these figures yield a growing multitude of visual cues and referents. To the pilot tracking into the target, however, useful referents such as size, shape, contour, perspective, and horizontal constant become a matter of extraction. Figures 2.18 through 2.21. show this simplified symbology, from a theoretical point of view, of those cues and referents which provide the needed cuing activities to track into a target in the previous four figures.

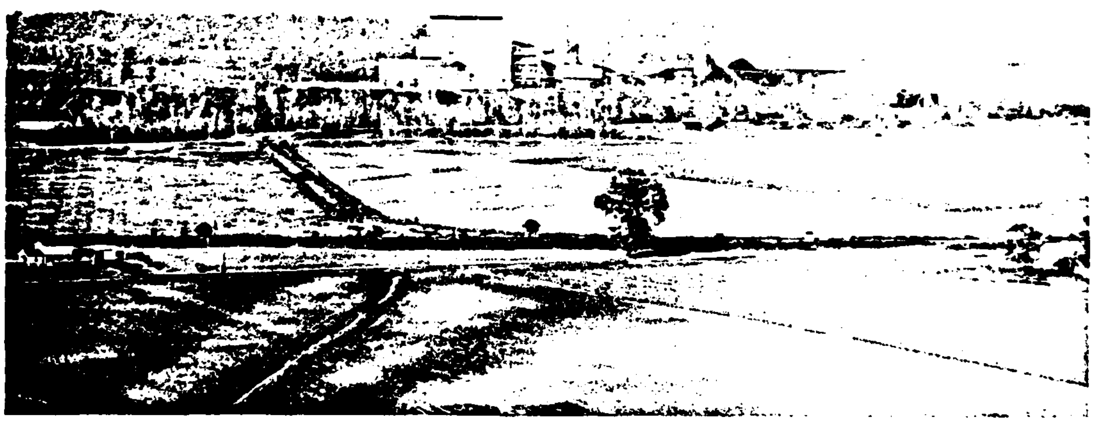


Figure 2.16. View of Target at Position - D

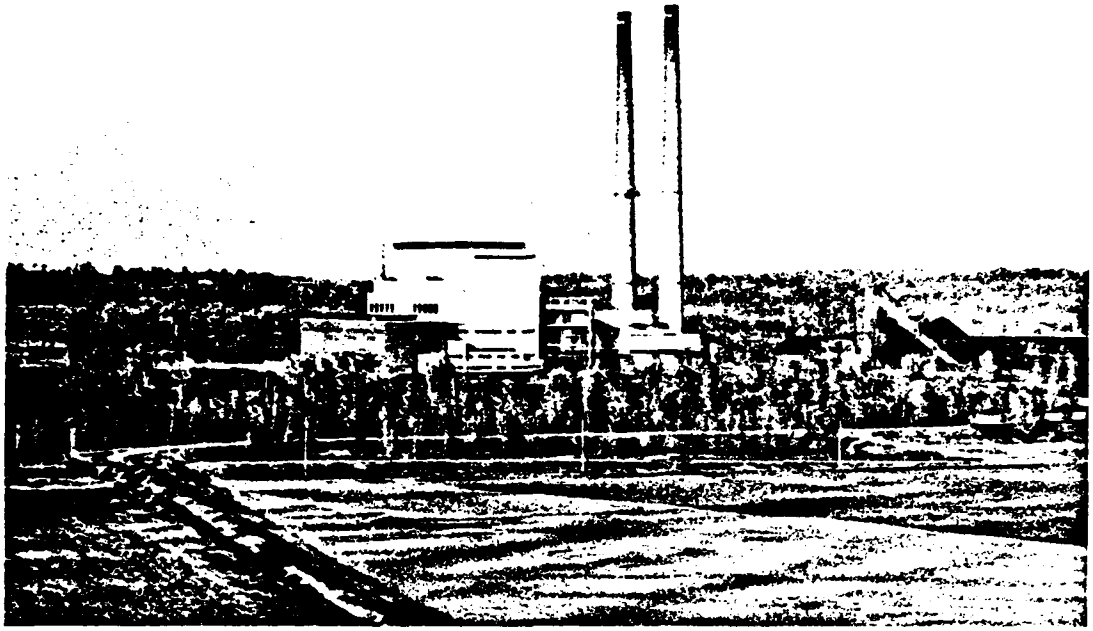


Figure 2.17. View of Target at Position - E

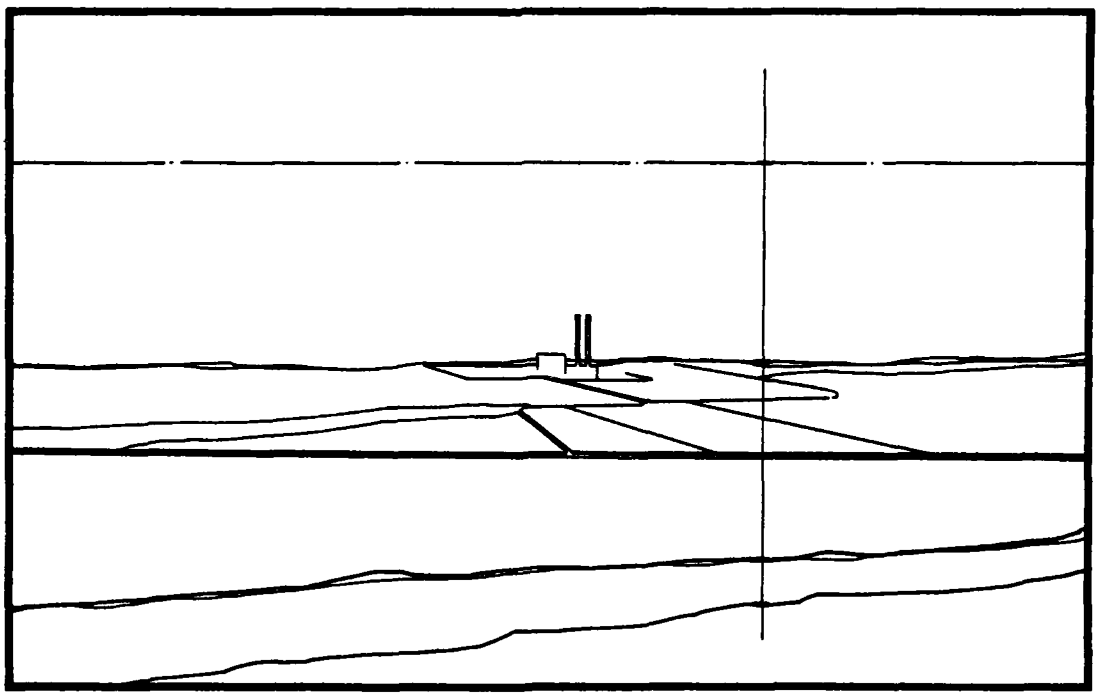


Figure 2.18. Referent Extraction at Position - B

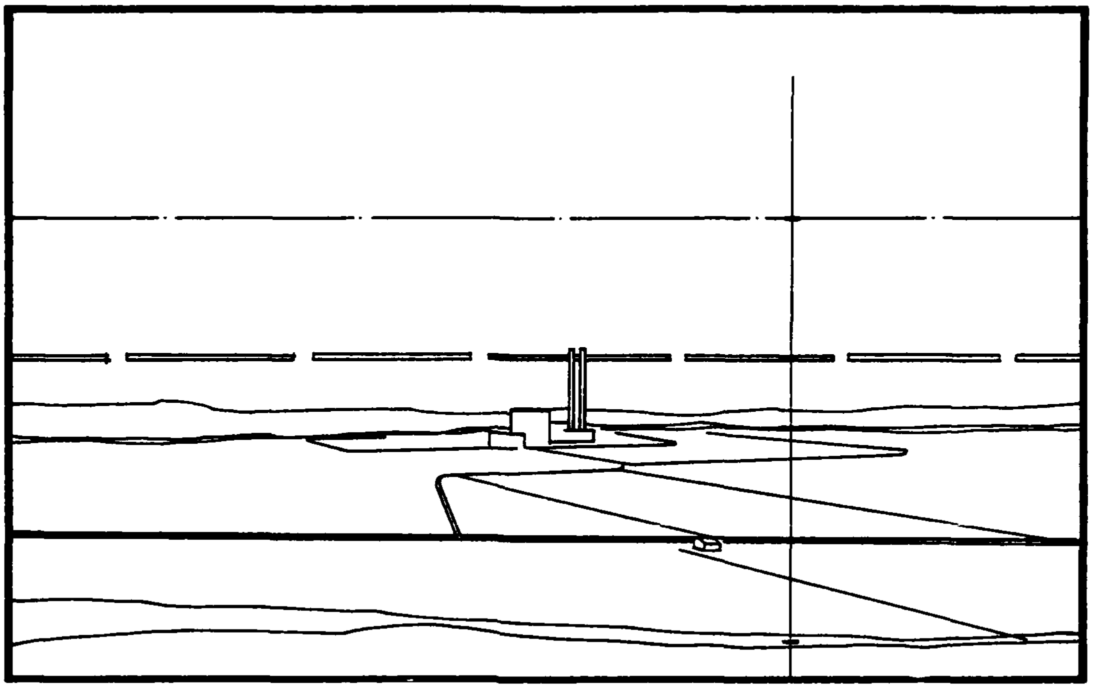


Figure 2.19. Referent Extraction at Position - C

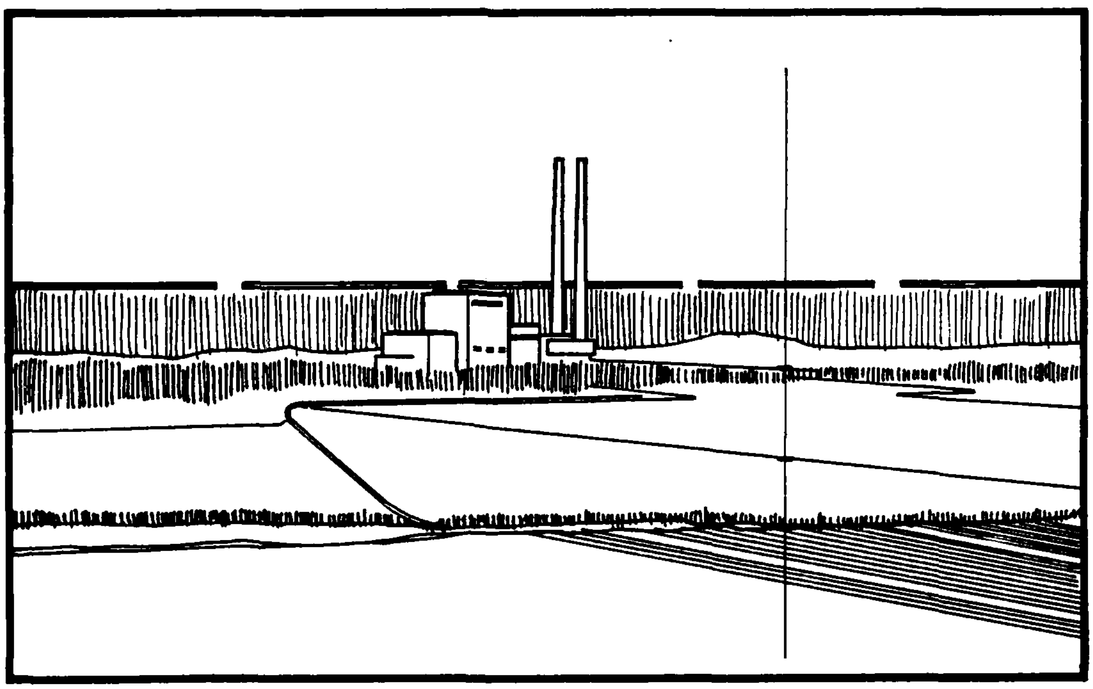


Figure 2.20. Referent Extraction at Position - D

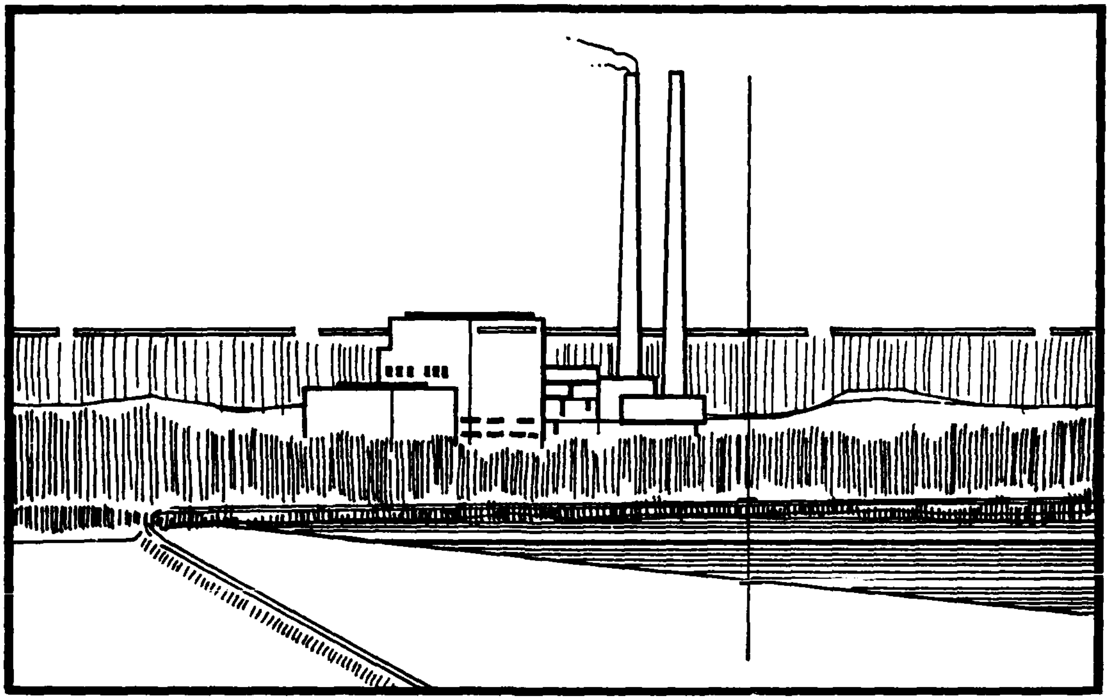


Figure 2.21. Referent Extraction at Position - E

Relative changes in size, shape, and perspective of surface patterns are of fundamental importance. The altering of target referents such as size, shape, perspective, contour, textur , and detail are of major use in tracking in on the target. Contrast and color gradient changes and emerging detail become supporting cross-check information.

The horizontal constant becomes increasingly useful as the slant range decreases and structural detail, such as the building and stack height to horizontal constant, appears. The vertical construct can also be obtained from the surface patterns and profiles, and the horizontal constant.

Ownship Cuing Environment - In contact flying, all cues are relative to the aircraft's position in space and must be visually estimated by the pilot. In order to estimate such things as rate of movement or establish a rate of directional change, pilots must relate the cues and referents of the background to the cues and referents of their own ship. Thus, the term, "ownship" was coined to express this aircraft environment. The ownship environment consists of two parts:

1. Foreground Cues - Those visual cues and referents which are made up of portions of the aircraft within the pilot's field of view.
2. Performance Cues - Those visual and non-visual cues and referents which constitute the aerodynamic energy management and equipment capability represented by the cockpit.

The foreground cues and cuing referents of ownship are made up of portions of the aircraft within the pilot's field of view such as parts of the cockpit, canopy, windscreen, wings, fuselage, and in some cases even the pilot's own personal equipment. The foreground cues and referents are very often aircraft type specific, but have been found to be generalizable across aircraft. Foreground cuing referents are often used to form a sighting or aiming reference by which the pilot relates, measures, and tests the geometric relationships between his own aircraft position in space and the background referents of the horizontal constant, or altering size, or perspective of a target. Further, the foreground cues will be referred to as "ownship" to establish the relative angle, aspect, or position estimated by the pilot in both azimuth and elevation to the horizontal constant and vertical construct which exist as background referents. In real terms, pilots refer to a specific target by "clock position" or relative angle from ownship to target - 10 o'clock low, for example, means 60° left and below the horizon.

The performance cues of ownship refer to the handling characteristics of the aircraft as viewed from the cockpit. The magnitude of the visual translation which occurs relative to a control movement, such as aileron input, is an example of ownship performance. The manner and relationship between the perceived visual attitude and related cockpit instrumentation readout is a further example of performance cues. Control pressures, control feedback, and motion onset are examples of the non-visual characteristics of ownship performance cues.

Cuing Activities - The actual flying situation has now been described as containing background cues. Both the ownship and background contain many cues and their potential referents from which a pilot may choose one, but usually chooses a number of referents, in order to perform the designated complex task. It was, thus, necessary to be able to analytically determine what cues were needed to perform a task, which referents were applied, and their activity in fulfilling a specific task or task segment. Cuing activities were defined as the useful purpose to which the pilot utilizes specific cues and referents related to tactical flying to achieve desired task goals.

In order to devise a system which would help determine such activity, a list of required essentials was developed. The list was initiated intuitively from the researchers actual flying experience. Specific tactical tasks were also considered in adding to or modifying the list. The Development and application of a task taxonomy for tactical flying, Meyer, et. al., 1978, provided useful information concerning the cuing aspects of many fighter maneuvers. Through this iterative process, a list of eight flying-related cuing activities was developed. The eight activities are:

1. Detection
2. Identification
3. Movement
4. Direction
5. Location
6. Range
7. Tracking
8. Status

Each of the cuing activities was defined as specifically as possible in order to minimize overlapping activity. It was anticipated, based on the completeness of the definitions, that the eight cuing activities would probably be generalizable to all flying tasks; however, application to the analysis of specific tasks would be required before this could be determined.

With the cuing activity definitions completed, it remained to relate each activity to a specific group and relationship of cuing referents. The concept of ownship and background cuing relationship was again used since most cuing situations in actual flight are relative and transitory, and not static or fixed. The eight basic referents were related to the cuing activities by definition. The results of this relationship are shown in Table 2.4.

Table 2.4. Cuing Activity and Cuing Referent Relationships

Cuing Activity	Cuing Referents
Detection - The use of visual and cognitive processes to discover the presence or existence of specific cuing objects such as a target aircraft, ground target, single object or area checkpoint.	Basic Background Referents Contrasting shape and size TO Anywhere within the pilot's field of view
Identification - The use of the cognitive processes to recognize the usefulness of a specific visual cue.	Basic Background Referents Contrasting shape, size, contour and color TO Anywhere within the pilot's field of view.
Movement - The use of the visual and cognitive processes to estimate the relative and/or actual degree of displacement between a specific set of cues as compared over an interval of time.	Basic Background Referents Contrasting shape, size, and contour, in positional change from another contrasting background cue TO Basic Foreground Referents Ownship - canopy, cockpit, or fuselage shape or contour within the pilot's field of view.

Table 2.4. Cuing Activity and Cuing Referent Relationships (continued)

Cuing Activity	Cuing Referents
Direction - The use of the visual and cognitive processes to estimate the position of a specific set of useful cues relative to the actual clock and elevation position of the viewer (e.g., 2 o'clock, [illegible]gh)	Basic Background Referents Contrasting shape, size, contour, perspective, and/or relative movement TO Basic Foreground Referents Ownship - clock/elevation positions within the pilot's field of view, for relative bearing OR Reference to directional instruments relative to ownship for Relative or Actual Heading
Location - The use of the visual and cognitive processes to estimate the course of ownship	Basic Background Referents Surface layout shape, size, contrast, contour, and color. TO Anywhere within the pilot's field of view
Range - The use of the visual and cognitive processes to estimate the amount of space between a set of useful cues.	Basic Background Referents Change in shape, size, contour, perspective, texture, detail, and color TO Basic Foreground Referents Ownship - canopy, cockpit or fuselage shape or contour within the pilot's field of view.

Table 2.4. Cuing Activity and Cuing Referent Relationships (continued)

Cuing Activity	Cuing Referents
Tracking - The use of the visual and cognitive processes to align ownship with another object within established parameters.	Basic Background Referents Contrasting shape, size, contour, perspective, texture, and color TO Basic Foreground Referents Ownship - aiming device and accompanying display
Status - The use of the visual and cognitive processes to estimate or conclude ownship performance condition.	Basic Background Referents None required Basic Foreground Referents Specific instruments and accompanying displays

In order to understand the roll of visual cues in the performance of complex flying tasks, it was necessary to determine what visual aspects about a particular cue could be important to the performance of a task. Visual characteristics of a cue vary in importance depending on the cuing activities of the task. Thus, this section carefully specified and defined the various referents into a meaningful structure. This structure organization has set the stage for a task analysis process which could utilize this format and be applicable to a better understanding of the visual requirements of an experience-judgement approach to tactical flying training.

3. EXPANDED SURFACE TASK ANALYSIS

Introduction - The ability to successfully analyze complex tasks was of primary importance to the development of an experience-judgement approach to tactical flying training. The analyses were used to provide the basis to extract the needed behavioral information for specific tactical tasks. The expanded surface task analysis was based on the surface task analysis developed by Meyer, et. al.,(1978) and the Stimulus-Organism-Response (SOR) model described in the Experience-Judgement Theory. The end result of the analysis format was a complete description of a flying task on a sequence by sequence basis.

Two tactical fighter maneuvers were chosen for analysis. They were the Low Angle Dive Bomb and the Acceleration Maneuver (Low Yo-Yo). These tasks were considered representative of the basic air-to-air and air-to-ground domain of tactical tasks. A pilot interview technique was used to acquire the in-depth working detail needed to perform these analyses. Meyer, et. al., (1978) contains a complete description of the interviewing techniques and a total of fifteen air-to-air and air-to-ground tasks from which these two were chosen.

Analysis Format - The analysis identified and described the most significant piloting behavior relative to input, cognitive activity, and motor output for specified flying tasks. In terms of input, major emphasis was placed on visual cues, cuing referents, and cuing activities because of their dominant function; however - aural, control, and motion cues were also considered. The input was related to the mental action and resulting motor action involved in the control of the craft. Finally, the analysis was expanded to include the cognitive requisites or the judgemental factors needed to fulfill the performance of a particular task sequence. The categories of the expanded surface analysis were:

1. Cues and Cuing Referents
2. Cuing Activities
3. Mental Action
4. Motor Action
5. Cognitive Requisites

To produce a useful and consistent analysis, information from the previous sections was organized into workable guidelines for each of the five categories.

Cues and Referents - Cues were defined as all stimuli input from the aircraft and the outside world which a pilot would use to properly perform a specific tactical maneuver. Cues were divided into four types: visual, aural, control, and motion. A cuing referent was defined as the useful visual elements and symbology contained within a cuing form which allowed task-related judgements and actions concerning control/performance of an aircraft to be made by the pilot. Thus, the referents have a visual orientation and will not be found among the aural, control, and motion cues.

Visual Cues and Cuing Referents - Visual cues were divided into the three basic areas of sky, horizon, and ground discussed in the previous section. The concept of background cues was preserved and the foreground cues have been generalized by the term, ownship, which connotes all aircraft contiguous cues and referents. All cues and referents have been listed in a constant format in this category and no attempt has been made to determine primary, secondary, or complementary subsets. An example of the analysis format can be seen in Figure 3.1. This figure shows that the areas are listed under each specific cuing area while the referents for those cues are shown in parenthesis.

Aural Cues - Aural cues are those stimuli which can be sensed through hearing. These cues have been broken down into the following:

Engine	Weapons Tones
Slipstream	Warning Tones
Reconfiguration	Weapons Discharge
Communication	Hits

Slipstream and engine sound were considered basic background sounds. For this analysis, these aural cues were considered "normal" when they were constant. A variation from constant was considered a change in aircraft sound. Other examples of aural cues included warning tones and standard VHF or UHF communications.

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
A.	Sequence Goal: ESTABLISHED ON DOWNWIND TO TARGET			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (attitude) & Direction		
	Ground		Determines proper spacing from lead & distance from target	
	*Target-(shape, size, contrast, contour, perspective) to ownship	Range, Direction & Location		
	*Patterns-(shape, size, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction	Sustains level flight	
	*Landmarks-(shape, size, contour, contrast, perspective) to ownship	Identification & Location		Maintains required aileron & stabilator control
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish target location from terrain features and lead aircraft

Angular Concepts - Recognition of relative geometry of target and position in pattern relative to lead aircraft

Organizational Judgement

Data - range procedures, altitude, airspeed and weapons system procedures

Strategy - initial selection of bomb pattern and ranking possible alternatives, rules of thumb to achieve bombing accuracy

Figure 3.1. Expanded Surface Analysis Format Example

Control Cues - Control cues were separated into the dynamic tactual (aileron, stabilator, and rudder) pressures of the flight controls exerted on the limbs, and the more discrete tactual pressures of such items as knobs and switches involved in the operation of system control functions. In this analysis of control cues, the term "neutral pressure" was used to describe a control trimmed condition.

Motion Cues - Motion cues were physical pressures or stimuli which could be sensed by the body. These pressures included positive or negative g forces, acceleration/deceleration, vibration, pitching, rolling and yawing. For this analysis, 1 g flight was described as "normal g".

Cuing Activities - This category described the essentials of each visual cue and referent found in the task sequence in terms of usefulness. Visual cues have been divided into eight basic cuing activities and have been discussed in the previous section. These activities are:

1. Detection	5. Location
2. Identification	6. Range
3. Movement	7. Tracking
4. Direction	8. Status

The following are the cuing activities and their definition for the aural, control, and motion cuing modalities.

Aural Cuing Activities

Tactical Information - Verbal communication of situational data to the pilot from any source.

Support System Information - Verbal communication of aircraft or ground systems data to the pilot.

Control Feedback - Non-verbal sounds which support a control input, e.g., increased engine sound as throttle is advanced.

Stable Reference Information - Non-verbal sound designated as normal.

Systems Alert Information - Non-verbal sounds emanating from auditory displays such as Missile Heat Tones or Angle of Attack Tones.

Environmental Information - Non-verbal sound from externally induced conditions, such as jet wash, turbulence or weapons impact.

Control Cuing Activities

Adjustment Feedback - Large displacement or incremental movement of flight control pressures.

Support Feedback - Holding or maintaining flight control pressures.

Discrete Feedback - Single throw movement pressure and functions.

Motion Cuing Activities

Control Output Feedback - Motion sensation as a result of adding or lessening large or small amounts of control movement.

Support Reference Feedback - Motion sensation as a result of holding or maintaining control pressure.

Environmental Input - Motion sensation due to external natural forces.

Mental Actions - Cues and referents, which were perceived/ selected by the pilot and resulted in various types of information processing, were termed mental action. For this analysis, the mental action category involved four separate processes which were considered basic to the performance of most complex tasks. Discerns, sustains, anticipates, and determines were selected as behavioral descriptors for the mental actions. Each behavioral action verb is shown with its respective type of information processing and cognitive description:

Behavior	Information Processing	Cognitive Description
Discerns	Specific Cue Processing (Short Term Memory Process/ Storage)	This behavior occurs with the perception and recognition of a specific cue. This process utilizes short term memory storage. The identification of a desired airspeed, the observation of a specific point at which a task sequence is to begin, or the comprehension of a verbal communication are examples of the activities which require that cues perceived be remembered only long enough to recognize the correlation with an actual situation and a desired state.
Sustains	Continuous Iterative Processing (Short Term Memory Process)	This behavior occurs as cyclic short term memory processing that maintains a task segment in which cue parameters remain constant. It is the mental activity required to control an aircraft during a turn, after the roll in, and before the roll out. Similar mental activity may occur during climbs, descents, and cruise flight.
Anticipates	Memory Recall Processing (Long Term Memory Process/ Storage)	This behavior occurs prior to a particular portion of a task and triggers the decision process for a number of subsequent task sequences. It is the precursor of subsequent mental actions and involves the recalling of learned facts and routines required for the planning of tasks. Anticipation involves long term memory storage of procedures or facts about the performance of the task.

Behavior	Information Processing	Cognitive Description
Determines	Multi-Cue Processing (Short Term & Long Term Memory Process)	This behavior occurs in the basic decision making and problem solving processes and always involves multiple cues and evaluations. This is the most elaborate and complex mental activity. Determines also identifies the decision making and problem solving processes which ascertain the extent a motor action should be done or has been done.

Motor Actions - The motor action category described the output of the mental activities in terms of the pilot's actions on the aircraft flight control system or subsystems in each task sequence. This category encompassed both actual flying and system functions. The action verbs and descriptions adapted for this analysis are shown as follows:

Action Verbs	Description
Coordinates	The movement of two or more controls simultaneously in their proper relationship to obtain a desired control effect.
Moves	The displacement of a control from a previous position.
Adjusts	The incremental regulation of a specific control to obtain a desired effect.
Maintains	The continuation of a controlling pressure on an aircraft control.
Increases	The augmentation of a controlling pressure on an aircraft control.
Relaxes	The reduction or easing of a controlling pressure on an aircraft control.

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INVESTIGATION OF AN EXPERIENCE-JUDGEMENT APPROACH TO TACTICAL F--ETC(U)
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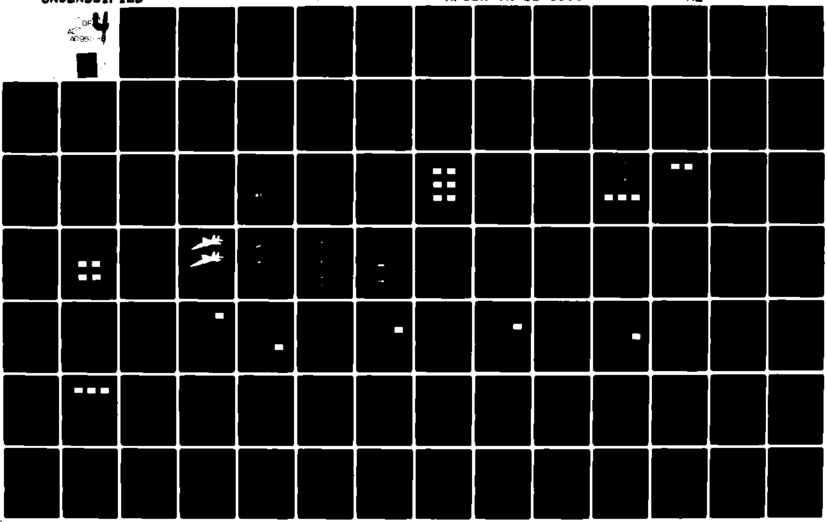


Action Verbs	Description
Activates	The discrete engagement of a specific toggle switch, push button, knob, rotary switch, lever, T-handle, or trigger.
Communicates	The motor action involved in either initiating or acknowledging radio transmissions (RT).

Cognitive Requisites - The cognitive requisites category shows the critical judgemental factors which were essential to the performance of a particular action sequence of the expanded surface analysis. Cognitive requisites were divided into the two areas of spacial and organizational judgement. These categories have already been defined in the Experience-Judgement Flying Theory section, but without specific reference to the task analysis.

Briefly, spacial judgement was defined as the synthesis of perceived cuing information which can be used to estimate temporal dimensional action to be taken in a flying situation. Organizational judgement was the synthesis of acquired knowledge with perceived cuing information which can be used to make decisions or form conclusions about a flying situation. Specific cognitive requisites are shown below with appropriate examples.

Spacial Judgement

Discrimination

1. To distinguish the shape, size, perspective, contour, texture, detail, contrast, and color referents of cuing forms.

2. To distinguish differences in relative shape, size, contour, etc., between objects such as an F-15 and Mig.-23 aircraft.

3. To distinguish cuing activity such as movement, direction, or range of cuing forms.

Angular Concepts

1. To determine the significance of spacial patterns and relationships among cuing objects.

2. To determine the significance of referent changes such as perspective, shape, size, or gradients of cuing forms in relation to position and ownship performance at any specific point in an on-going flying task.

Organizational Judgement

Data

1. The knowledge of specific facts such as numbers, weights, velocities, time, and frequencies.

2. The knowledge of procedures such as the proper sequence of steps in activating a weapons system.

Strategy

1. The comprehension of whole concepts of useful problem solving task alternatives.

2. The planning of whole tasks or task segments.

3. The selection and ranking of alternatives and the predetermination of patterns and positions such as anticipating follow-on task segments before the previous one has been completed.

Completed analyses of the Low Angle Dive Bomb and the Acceleration Maneuver are found in Appendix A. Each analysis is preceded by a flight path diagram of the task. The letters on the flight path show the positions of the action sequences within each analysis.

The expanded analysis provided the task oriented visual and cognitive data base for this research. With the data base complete, a methodology had to be determined which would allow the review of this information in order to formulate behavioral goals and utilize them within a phased approach to tactical flight training.

4. INSTRUCTIONAL REVIEW

Introduction - The instructional review provided a methodology which extracted behavioral goals from the expanded surface task analysis. Behavioral goals were needed to determine training event requirements for an experience-judgement approach to complex skill learning.

The expanded surface task analysis contained information about the performance of specific flying tasks in three areas. The first area dealt with cues, cuing referents, and cuing activities. The second area was concerned with the cognitive aspects of the mental actions and cognitive requisites within the task. The third area was motor actions or effector output. The cuing information found in the analyses provided the basis for the background environment for each task. The mental actions, sequence goals, and cognitive requisites represented the information processing interaction between task sequences. Thus, the mental actions and decision information which produced the motor output was of significant importance.

The instructional review of both the Low Angle Dive Bomb and the Acceleration Maneuver used the mental action category of the surface analysis as the initiation point for further organization. The instructional review consisted of a three-part effort. The first was an Analysis of Cognitive Components of the task. The results of this analysis produced specific behavioral goals for each task segment. The second part of the review organized these behavioral goals into a phased learning plan structure. The third part utilized the behavioral goals within the learning structure to formulate training event requirements.

Analysis of Cognitive Components - The purpose of this effort was to devise a methodology which would utilize the cognitive data from the expanded surface task analyses of the Low Angle Dive Bomb and Acceleration Maneuver to determine useful learning information. Specifically, the cognitive data needed to be reorganized into behavioral goals for definable portions of these tasks. A behavioral goal is the initial requirement for the establishment of a set of behavioral objectives. Behavioral objectives as described by Mager (1962), include goals, criteria, and minimum performance specifications. Behavioral goals have been defined as explicit statements of what is to be learned in order to accomplish a task.

A format for the methodology was developed which utilized the sequence order, mental actions, and sequence goals directly from the surface task analyses. Their categorization can be seen in Table 4.1. which shows an example of the complete format layout. The four remaining categories shown in this table consist of decision function, judgement, sequence goal, and behavioral goal, and will be discussed in that order.

Table 4.1. Analysis of Cognitive Components Format - Acceleration Maneuver

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
A.	Anticipates attack	Planning	Organiz. Judg. (Strategy)	To sight target and prepare for attack		
	Sustains level flight	Estimating	Spacial Judg. (Angular Concept)			
B.	Determines need for armament set up - closure on target and "Tally-Ho" call	Remembering	Organiz. Judg. (Data and Strategy)	To start attack	1. To detect target and identify it as hostile 2. To recognize an attack situation & select plan to convert to a win advantage 3. To remember attack facts and procedures 4. To recognize when attack plan is a no-win situation	I
C.	Determines target's turn	Distinguish	Spacial Judg. (Discrimination)	To continue attack by starting offensive turn		
D.	Determines satisfactory roll rate	Estimating	Spacial Judg. (Angular Concept)	To continue offensive turning attack		
E.	Determines proper bank attitude approaching and stagnated position	Estimating Concluding	Spacial Judg. (Angular Concept) Organiz. Judg. (Strategy)	To establish offensive turn		
F.	Anticipates Low Yo-Yo	Planning	Organiz. Judg. (Strategy)	To maintain attack and prepare for Yo-Yo	5. To convert to a win attack by adopting 2nd plan	II
	Sustains turn	Estimating	Spacial Judg. (Angular Concept)			

Decision Function - This category was used to describe the kinds of decision activity involved in the mental action of each task sequence. Function categories were first selected intuitively and then defined. A process of refinement and expansion resulted through application until eight decision function descriptors covered all the mental actions in the air-to-air and air-to-ground tasks. Table 4.2. shows the decision functions and definitions.

Table 4.2. Decision Functions and Definitions

Decision Function	Definition
Distinguishing.	To recognize the differing states of a cue or the difference between different cues
Differentiating	To recognize the characteristic referents belonging to a specific cue
Estimating	To approximate regarding the actual or relative size, weight, speed, distance or aspect angle of a cue
Predicting	To determine, in advance, the condition or position of a cue
Remembering	To bring back to conscious memory pertinent facts, concepts, or principles relative to a particular situation
Planning	To formulate a method of action
Concluding	To reach a decision based on a summation of cuing information
Evaluating	To ascertain the status or progress of a plan

To determine the decision function of each mental action, researchers applied the definitions to each task sequence. Internal agreement among researchers as to the proper descriptor for each sequence mental action was over 70%, remarkably high considering no specific rules were developed. The differences which existed were resolved through discussion.

Judgement - This category involved relating the cognitive requisites of spacial and organizational judgement with the decision functions of mental actions as a check to show an informational processing interaction. This was done by relating the definitions of the decision functions and the cognitive requisites of spacial and organizational judgement. The result turned out to be a useful relationship between the decision functions, and hence the mental action and the cognitive requisites which have a direct connection to judgement. Table 4.3. shows this interaction. The judgement category was filled out in this way.

Table 4.3. Informational Processing Interaction

Decision Function	Cognitive Requisite	Judgement
Distinguishing - - -	Discrimination	Spacial Judgements
Differentiating - -	Discrimination	
Estimating - - - -	Angular Concepts	
Predicting - - - -	Angular Concepts	
Remembering - - - -	Data	Organizational Judgements
Planning - - - - -	Strategy	
Evaluating - - - -	Strategy	
Concluding - - - -	Strategy	

Task Segment - During the preparation of the expanded surface task analyses, it was noted that a number of anticipation points existed in the natural flow of the task. These anticipation sequences are shown in the mental actions and are described as planning in the decision function category. Thus, the task segments shown in the cognitive components analyses were the result of noting the anticipation or planning functions in the mental actions of the task analysis. The sequences between the start of one mental anticipation to the beginning of another mental anticipation represented a logical sub-task and manageable task segment. The behavioral goals could also now be thought of as being sub-task or segment oriented, and arrived at more easily.

Behavioral Goals - The framework created thus far, allowed researchers to successfully relate mental actions with decision functions and judgement characteristics in the context of sequence goals for each task segment. This framework plus the definition of a behavioral goal now stated as a question, "What needs to be learned to accomplish this task segment?", provided the necessary insight to determine these goals. Like the preparation of decision functions stated earlier in this section, several researchers of comparable experience independently prepared behavioral goals for each task segment of the air-to-air and air-to-ground tasks. Again, a high degree of agreement occurred. It must be noted that this agreement of goals was not stated word for word, but in general terms with approximately the same number per task segment.

Cognitive Components Analysis Example - An example of the organizational process discussed thus far for the analysis of cognitive components will be described for sequence A of the Acceleration Maneuver. Reference should again be made to Table 4.1. In sequence A, the most important aspect of the mental action is the anticipation of the plan of attack. Anticipates is a planning function or the precursor of subsequent mental actions as stated in the surface task analysis section. Table 4.3. shows this planning function is related to the strategy cognitive requisite as part of organizational judgement. The goal for sequence A, taken from the surface task analysis, describes what was to be accomplished in the sequence. The sequence goal and the mental action indicated that the most important cue was the perceived introduction of the aerial target into the instructional environment. Level flight was sustained through the estimating decision relative to the horizontal constant, a form of spacial judgement. Thus, the mental actions were the motivation for sequence A. In terms of deriving behavioral goals from this organizational structure, goals one and two of this task segment clearly reflect the information from sequence A as the input. In the task segment column, task sequences have been grouped between specific anticipation or planning functions. A complete listing of cognitive components for the Low Angle Dive Bomb and the Acceleration Maneuver can be found in Appendix B.

Structure of the Phased Learning Plan - With the development of specific behavioral goals for each segment of the two tasks completed, a structure was needed to organize these goals. This structure was based on the five phases of complex learning described earlier in the Experience-Judgement Theory section. These phases provided a learning hierarchy and a level of complexity for each goal in the structure. To make use of the phased structure, researchers developed training events for each phase. These events provided more detail to the learning hierarchy and allowed behavioral goals to be directed toward specific training event areas. The phases and events are as follows:

1. Readiness Phase - Gaining knowledge and understanding of verbalizable concepts and principles about the performance of a task. This includes general basic understanding of systems, tactics, and knowledge of specific task sequences or functional procedures of systems and equipment to be used.

   Procedural Events - Gaining knowledge of equipment or systems to the point of a verbalizable understanding of parts, functions, steps, and values (alpha/numerical) involved procedural knowledge events, also knowing goals and sequences of tasks and task segments.

2. Awareness Phase - Gaining knowledge and understanding of specific cues about performing the task. This includes the awareness of which visual cues, cuing referents, spacial relationships, and non-visual sensory information are important to performing the task to the point of verbalization.

Cue Selection Events - Gaining knowledge and understanding of cues to which a student must respond in order to perform the task such as:

* Identifying relevant cues
* Ignoring irrelevant cues
* Grouping relevant and irrelevant cuing information to the point of verbalization
* Relating cues and cuing referents to the mental image of task requirements
* Relating expected visual cues to physical cue feedback

3. Initial Skill Development Phase - Emphasis on the components of complex tasks which provide the first mental and visual modeling basic skill sequences into task/skill segments through demonstration. Sequences are developed and chained through rehearsal and provide the discovery aspects of the previous phases.

Demonstration Events - Initial exposure to the required behavioral modification by presentation of visual and non-visual example models of how selected segments should be performed. These events should also integrate verbalizable knowledge from previous phases into examples.

Imitation Events - Involves the task/segment performance by the student as a direct response to the perception of the demonstration events.

Primary Rehearsal Events - Involves relating appropriate responses with feedback, and exploration of parameter limits of the demonstration events and task segments. Events should allow and lead to the discovery of the task by the student.

4. Advanced Skill Development Phase - Essentially the secondary rehearsal of skill chaining, where task segments and system sub-tasks are blended into instinctively performed routines.

Reorganization Events - The rehearsal of tasks and task segments to refine perceptual-cognitive-motor skills. It also involves the resolution of any uncertain aspects of the maneuver in terms of visual picturing, sight picture, sequencing, and control feedback so tasks can be performed with maximum efficiency and minimum effort.

Secondary Rehearsal Events - Involves the practice of tasks to the point that they can be done instinctively and can be related to other previously learned tasks.

5. Inventive Phase - Involves the use of instinctively performed task routines and the modification of these routines into variable alternatives which meet the demands of the tactical situation.

Adaptive Events - Involves the use of task segments and combinations as alternatives to improvise complex perceptual-cognitive-motor performances to meet or counter problem situations.

Creative Events - Involves the use of previously learned task/skill repertoire to perform tasks which are unique to a specific situation or set of circumstances.

Converting behavioral goals to the phased learning structure was performed by comparing the goals found in the Analysis of Cognitive Components with the definitions for each phase and event. Researchers were quite consistent among themselves as to the placement of goals for the first three phases. Agreement regarding the goals and their placement in phases four and five, however, had to be reached through discussion. This was not considered unreasonable since the analyses tended to proceduralize activity and those phases were, by definition, less proceduralized. The structuring of the first three phases and their events did provide an insight into phases four and five - the Advanced Skill

Development and Inventive phases - which made it possible to more easily arrive at these goal requirements. Goals for the air-to-air and air-to-ground tasks are found in Appendix B under the title, Training Event Requirements and Behavioral Goals by Learning Phases.

Development of Training Event Requirements - Training event requirements were the final step in the Instructional Review methodology. Training event requirements were defined as instructional activity needed to achieve the stated behavioral goals within a particular training phase. The event requirements were intuitively determined with assistance from previous information. For instance, the Decision Function column of the Analysis of Cognitive Components was used to determine the on-going mental activity, and thus supplied a positive link between the behavioral goals and the possible instructional alternatives for a group of task sequences. As an example, when Estimating or Predicting functions were shown, a demonstration of these specific relationships could be a useful instructional activity. The Remembering function was defined as the recall of facts and procedures and so has verbalization implications while Distinguishing and Differentiating functions have a visual comparison orientation.

The definitions of the learning events which helped place the behavioral goals into the learning phase structure, also assisted in determining training event requirements. For example, the demonstration events clearly require the use of dynamic visual examples. Table 4.4., which shows the format of the training event requirements and behavioral goals by learning phases and events, illustrates this example. Completed training event requirements and behavioral goals by learning phases and events are found in Appendix B.

With the completion of the Instructional Review for both tasks, the question, "What to teach?", became clearly delineated. The phased structure also provided a rationale as to the order in which the various training events should be taught. In the actual instructional environment, the phases and event divisions would not be so sharply defined; however, the learning phase concept has brought about a logical and systematic order to an experience-judgement approach to training.

As stated earlier, the expanded task analysis data base contained both visual and cognitive information. The next step was to determine what kind of basic visual environment would best facilitate the training event requirements finalized in this section.

Table 4.4. Format of Training Event Requirements & Behavioral Goals by Learning Phases for the Acceleration Maneuver

III. Initial Skill Development Phase - Demonstration Events

Training Event Requirements	Behavioral Goals
Show stagnation situations from various angles, positions, and circumstances.	*4. To recognize when attack plan is a no-win situation.
Show Low Yo-Yo as solution to stagnation in various angles, flight planes and positions - present other alternatives as required.	5. To convert to a win attack by adopting 2nd plan.
Show how to determine target lead point from various attitudes and airspeeds.	7. To predict target lead point.
Show flight path/lead point relationships.	8. To estimate target/lead point/ownship relationship.
Show out-of-plane/acceleration task portion	9. To distinguish lead point/target relative to out-of-plane angles of ownship.
Show pull-up and return into target plane, proper closure angles and improper closure angles.	11. To estimate closure angles relative to target.
Show closure rates and angles to target relative to lead point and ownship closure angles.	12. To establish closure angles.
Show proper launch envelope and common mistakes in correct envelope and angle assessment at launch.	13. To recognize correct launch envelope.

FOOTNOTE:

*These numbers refer to the order in which they were found in the Analysis of Cognitive Components.

5. THE VISUAL CONVERSION PROCESS

Introduction - The design of visual environments for synthetic training devices which permit an experience-judgement approach to instruction required a unique methodology to scene development. The first essential was to determine a way of converting analytical data about a task or group of tasks to be trained into a graphic or pictorial format. The ultimate problem for anyone attempting to design a visual training environment has been - what should the environment look like?

To begin to solve this problem, researchers had already divided the visual environment into background cues consisting of aerial layout, horizon, and surface layout; and the foreground and performance cues of ownship. These ownship cues, which include the pilot's cockpit, are rather aircraft specific in nature. Because of this, project researchers decided to concentrate on the cues and referents of task oriented background environments.

Conversion Development - The first problem discovered by researchers was that although tasks could be analyzed in detail, the results of the analysis alone presented very little insight into the visual properties of a training environment in which judgement about specific task situations could be taught. A way had to be found to bridge the gap which existed between scientific analysis and the graphic and sometimes artistic realm of the visual instructional environment. A start had already been made by formatting the expanded surface task analysis so that cues were described in terms of cuing referents that contained visual descriptors understandable to the competent graphic designer. The graphic designer was thus seen as a key to the conversion of analytical data into pictorial scenes which would be useful in developing background training environments.

It did not seem feasible to require the graphic designer to have in-depth knowledge in task analysis or other analytical techniques, so it was determined that a method be devised to assemble this data into word-picture descriptions. The background cues of the Low Angle Dive Bomb Task were used as the primary example to resolve whether a visual conversion process could be assembled.

The expanded surface task analysis contained two entry areas which were specifically cues oriented. Although all cues were listed and described for each sequence of a task, there was a natural dominance of visual cues, cuing referents, and cuing activities shown. Soon it was determined that the data contained in the expanded surface task analysis, though useful in a broad sense, did not contain sufficient detail to design a background environment which would enable the task to be performed. In order to design such an environment, it was first necessary to convert data into a word-picture of scene requirements. Continuing research defined four input areas that were considered essential to the development of word-pictures which contained sufficient depth to create useful task oriented backgrounds. These areas follow and will be explained in an example.

1. Visual Data Summarization	3. Geomorphic Considerations
2. Visual Data Check	4. Tactical Implications

Visual data summarization for the Low Angle Dive Bomb - The initial summarization of visual cues and referents for this task was made by a simple tally method. Specifically, all of the cues in the three cuing areas - sky, horizon, and ground - were listed and related to their particular cuing referents. Table 5.1. shows the results of this summary.

Table 5.1. Visual Data Summarization of the Low Angle Dive Bomb Task

Cues	Cuing Referents
Sky-	
Skytone	Color, Gradient
Lead Aircraft	Shape Size Perspective
Horizon-	
Skytone	Color, Gradient
Profile	Shape, Contour Horizontal Constant
Ground-	
Patterns	Shape, Contour Size, Contrast Perspective Vertical Construct
Target	Shape, Contour Size, Contrast Perspective
Landmarks	Shape, Contour Size, Contrast Perspective

This table shows the necessary basic cues involved in the task for the sky, horizon, and ground cuing areas. The cuing referents which have been determined from the cuing activities within the task, give the depth of visual information required to perform the task.

Visual Data Check for the Low Angle Dive Bomb - Because the visual cues and cuing referents are related to the cuing activities (such as detection, range, or tracking), a check was developed which consisted of two parts. The first part related cues which were specifically ownship oriented to the cuing activities in which they were involved. This check was performed by going through the expanded surface task analysis on a sequence by sequence basis and noting the various types of cuing activities for ownship related cues. The result of this organization can be seen in Table 5.2.

Table 5.2. Cues/Cuing Activities Check for the Low Angle Dive Bomb Task

Cues	Cuing Activity
Lead Aircraft to Ownship	Range, Tracking
Ownship to Target	Range, Tracking Detection, Identification Direction, Movement Location, Status
Ownship to Landmarks	Detection Identification Location

This table gives an indication of the kinds of cuing activities for each relationship and clearly shows the concentration of activities for these important cues. To the graphic designer, it meant that particular care must be taken to include referents which would make these cuing activities possible within the background environment.

In the second part, cuing activities were related to the general cuing referents as first described in Section 3. This check actually provided the graphic designer a clearer description or word-picture of the cuing referents involved for each activity provided by the analysis. Table 5.3. shows this information.

Geomorphic Considerations - The analysis information can determine what specific cues are used and how they are used in a task. The information, however, provides no guidance as to the basic natural characteristics of the earth's surface. This is of particular importance in air-to-ground tasks since it affects the types of landmarks, check points, and initial points which could be available to a pilot in a synthetic training environment. The basic natural characteristics of the surface environment were called geomorphic considerations. These considerations were defined as the character and arrangement of the earth's surface relative to layout features. An investigation into world geography indicated that at least five basic categories could be established. These categories and their descriptions are:

Table 5.3. Cuing Activity/Cuing Referents Check for the Low Angle Dive Bomb Task

Cuing Activity	Cuing Referents
Detection	A *shape* of perceptible *size* and contrast, some degree lighter or darker than the surrounding background.
Identification	A *shape* of perceptible *size*, *contrast*, *color*, and *contour* of distinguishable delineation within the outline shape of an object.
Movement	A *shape* of perceptible *size*, and *contrast* in positional change from another contrasting background cuing object or foreground (ownship) cues.
Direction	A *shape* of perceptible *size*, *contrast*, *contour*, and *perspective* relative to ownship position or location.
Range	A *shape* of relatable or changing *size*, increasing or decreasing *textural detail*, *contour*, or *color* relative to ownship or other background cues.
Tracking	A *shape* or *contrast* of alignable size which permits the cuing activities of *movement*, *direction*, and *range* to ownship referents and/or cuing devices.
Status	Specific instrument readout areas and cuing referents of ownship.
Location	*Shape*, *size*, *contrast*, *color*, and *contour* of specific layout: patterns, profiles, landmarks/checkpoints to ownship

1. Coastal - Land rising up from water
2. Plains - Flat lands
3. Uplands - Flat lands with mountainous periphery
4. Rolling Hills - Smooth, consistent and moderate changes in elevations
5. Mountains and Valleys - Rugged or smooth, abrupt, and extreme changes in elevation

Other features which are part of geomorphic concepts are weather, surface soil, vegetation, population, and industrial concentration. When all of these characteristics are addressed in terms of the cues and cuing referents determined by the analysis, a more clearly defined word-picture of the background environment emerges.

Tactical Implications - Tactical implications have been defined as the type of task to be trained relative to the terrain/tactical environment in which it should be trained. Thus, the tactical implications and the geomorphic considerations can be related to the extent determined by an analysis of task training requirements. Table 5.4. shows tactical implications of training and the possible relationship to geomorphic considerations.

With the definitions and examples for the geomorphic considerations and tactical implications complete, it was possible to organize the information in the remaining categories for the Low Angle Dive Bomb task. This task is considered a basic air-to-ground fighter maneuver and the description at the top of the analysis indicates that it was analyzed withi ontrolled range constraints. With this concept of training in mind, the following Geomorphic Considerations and Tactical Implications were adopted.

Table 5.4. Tactical Implication Examples

Tactical Task	Tactical Environment
Basic Fighter Maneuvers (Air/Air and Air/Ground)	Controlled Range
High/Low Ordnance Delivery	Controlled, Non-controlled range, enemy-type terrain
High/Low Air Combat Maneuvering	Non-controlled range or enemy-type terrain
Terrain Avoidance/ Low Ordnance Delivery	Non-controlled range or enemy-type terrain
Aggressor-Defender Experimental Maneuvering	Specific enemy-type terrain, defenses, weapons, and tactics
Experimental Low Level Ordnance Delivery	Specific enemy-type terrain, targets, defenses, and tactics

Geomorphic Considerations: To provide a range-type background environment with regular and irregular surface layout cues under less than perfect conditions.

1. Upland Geomorphic Category - flat lands with mountainous periphery (regular and irregular patterns and profiles)

2. Vegetation - cultivated and open uncultivated (regular and irregular patterns)

3. Population/Industrial - none

4. Weather - moderate (some regular cloudform and attenuating haze)

Tactical Implications: To provide a background environment to instruct the basic air-to-ground maneuver Low Angle Dive Bomb within a controlled range and contain:

1. Essential range landmark and check point cues

2. Essential range target cues

3. Lead aircraft

The second task selected for analysis and visual conversion process was the Acceleration Maneuver, formerly called the Low Yo-Yo. The same conversion process was followed in organizing analysis data into word-picture requirements for the Acceleration Maneuver data as was used for the Low Angle Dive Bomb task. The initial visual data summarization of cues for this task is shown in Table 5.5. It clearly shows the cuing referents required for the task within the Sky, Horizon, and Ground cuing areas.

Table 5.5. Visual Data Summarization for the Acceleration Maneuver

Cues	Cuing Referents
Sky-	
Skytone	Color and Gradient
Target	Size Shape Contour Contrast Perspective Wing Plane Fuselage Plane
Horizon-	
Skytone	Color and Gradient
Profile	Shape and Contour Horizontal Constant
Ground-	
Pattern	Shape, Size, and Contrast Vertical Construct

The cues/cuing activity check for the Acceleration Maneuver required a greater delineation between relationship of target to ownship and ownship to target. This was brought about because of the constant advantage being sought by the aggressor/hostile target.

The following is a discussion of this unique relationship. This relationship is also related to Table 5.6. which shows the Cues/Cuing Activities check. Table 5.7. contains the Cuing Activity/Cuing Referents check.

Table 5.6. Cues/Cuing Activities Check for the Acceleration Maneuver

Cues	Cuing Activity
Target to Ownship (i.e., what is the target doing which will effect my strategy and its outcome?)	Detection Identification Movement (rate) Direction Range
Ownship to Target (i.e., how am I positioning my craft to effect my strategy and its outcome?)	Status Tracking Range Direction Movement (rate)

Table 5.7. Cuing Activity/Cuing Referents Check for the Acceleration Maneuver

Cuing Activity	Cuing Referents
Detection	A shape of perceptible size and contrast, some degree lighter or darker than the surrounding background.
Identification	A shape of perceptible size, contrast, color, and contour of distinguishable delineation within the outline shape of the object.
Movement	A shape of perceptible size, and contrast in positional change from another contrasting background cue or foreground cue.
	. . . . . . OR . . . . . .

Table 5.7. Cuing Activity/Cuing Referents Check for the Acceleration Maneuver (continued)

Cuing Activity	Cuing Referents
Movement (cont'd)	A shape of perceptible size, contrast and contour, perspective, wingplane or fuselage plane in positional change to Ownship referents.
Direction	A shape of perceptible size, contrast, contour and perspective relative to Ownship position.
Range	A shape of relatable or changing size, increasing or decreasing texture, contour, color, or detail relative to Ownship and other background cues.
Tracking	A contrasting shape of alignable size which permits the cuing activities of movement, direction, and range to Ownship referents and/or cuing device.
Status	Specific instrument readout cues and cuing referents of Ownship.

Target to Ownship - The target to ownship relationship involves what the target is doing in terms of maneuvering which will effect the pilot's selected strategy and its results. This relationship involves a moving, noncooperative target. Moving, noncooperative targets are usually thought of as aggressor or hostile aircraft in the air-to-air combat arena. However, non-cooperative aggressor targets can also be encountered in air-to-ground weapons delivery involving motor vehicles, tanks, and large and small marine vessels. Moving targets may also be cooperative, such as a lead aircraft in a bombing run or a wingman. Thus, cooperative targets are usually thought of as friendly.

Ownship to Target - This relationship involves the positioning of ownship to effect the strategy and intended outcome selected by the pilot. The ownship to target positioning is involved in both air-to-air and air-to-ground weapons delivery. A large portion of air-to-ground delivery, however, requires only this singular position relationship between ownship to fixed target. Thus, with a fixed target delivery situation, the pilot is relieved of the noncooperative maneuvering aspects and is only concerned with, "How well am I positioning my craft to effect what I want to do?" in order to achieve the desired results.

Geomorphic Considerations and Tactical Implications - The Acceleration Maneuver is considered a basic fighter maneuver in the air-to-air domain of tasks. The description at the outset of the surface task analysis also indic ted that it was analyzed within the restraints of a controlled range. With this concept of training in mind, the following geomorphic considerations and tactical implications were adopted.

Geomorphic Considerations: To provide a range-type background environment with regular and irregular surface layout cues under less than perfect conditions.

1. Mountains and Valleys Category - Rugged and smooth shape and contour with abrupt changes in elevation (regular and irregular patterns and profiles)

2. Vegetation - Mostly uncultivated or barren

3. Population/Industrial - None

4. Weather - Fair, attenuating haze

Tactical Implications: To provide a background environment to instruct the basic air-to-air Acceleration Maneuver within a controlled range and contain:

1. Essential aerial target(s)

Thus, a maneuver is fully defined by four input areas: visual data summarization, visual data check, geomorphic considerations, and tactical implications. These can provide useful word-picture information to both the researcher and the graphic artist. A better understanding of the visual character of the task oriented background environment is provided which allows the design and pictorial development of scenes based on the interpretation of known cues, their referents, and cuing activities. The pictorial development of the background environment for a specific task or group of tasks is seen as the bridge between those who provide analytical data and training criteria, and those who are engaged in engineering the implementation of synthetic training devices. It should be noted that a complete understanding of the information contained in Section 2 is necessary for the understanding of the entire visual conversion process. Further, a high level of collaboration between the scientist and the graphic designer is critical to the successful accomplishment of the visual conversion process by which the word-pictures developed thus far are converted into actual visual scenes. This visualization methodology is found in the next section.

6. A VISUALIZATION METHODOLOGY

<u>Introduction</u> - The visual conversion process of the previous section allowed researchers to organize task analysis data concerning the cues, cuing referents, and cuing activities of a specific task into a meaningful format for the graphic designer. The addition of selected geomorphic considerations and tactical implications of the desired training situation completed the word-picture requirements for the Low Angle Dive Bomb task and the Acceleration Maneuver. This information, though general in nature, was useful in the actual design of task oriented background environments necessary to provide transferable instruction in a synthetic training device.

At this point one area still remained to be addressed. That was the area encompassed by the term, "realistic". Since pilots ultimately fly in the actual world, the major thrust in the design of visuals for synthetic training devices has been a continuing effort to simulate reality. Thus, in evaluating any visual system the question is usually asked, "How realistic is it?" rather than evaluating whether the cues and referents needed for the task related cuing activity are present in the system.

<u>The Level of Stylization</u> - The problem with the term, "realistic", is twofold. First, it implies that only the close emulation of the actual environment should be used for training

and secondly, it is a term with a meaning too broad to be qualified. For this reason the term, stylization, was adopted for this research since it is in accepted use by graphic designers and can be defined and categorized. Stylization has been defined as the portrayal of useful and essential visual elements of an object relative to the object's identification. Figure 6.1. shows the levels of stylization in five useful categories.

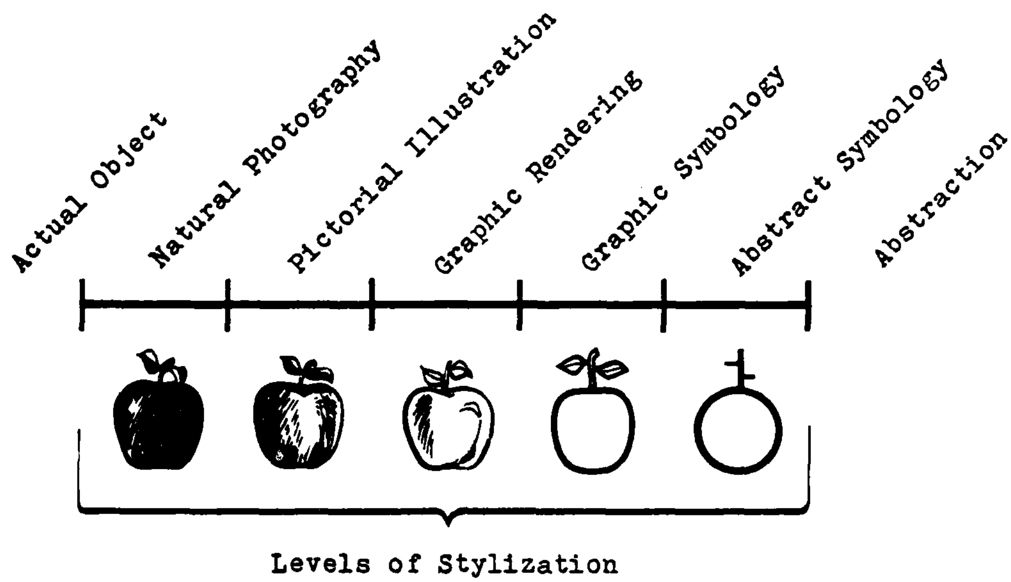


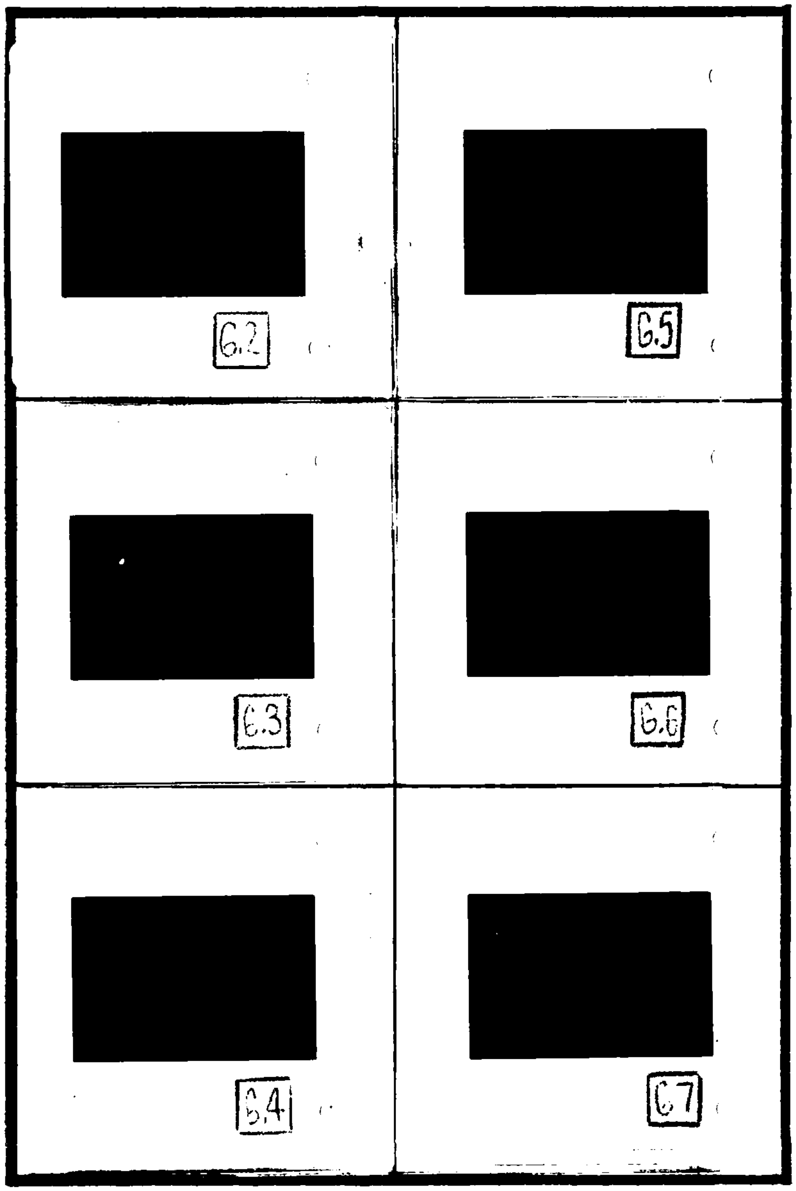
Figure 6.1. Five Levels of Stylization

The concept is illustrated with an apple object. The actual object can only convey the ultimate realism and thus becomes the standard reference for the properties of visual identification. The levels of stylization involve not only the removal of detail, but also the simplification of the visual elements or referents - notably those of shape, contour, and texture. With graphic symbology, for example, the portrayal can still be identified as an apple. With abstract symbology, however, the apple can only be identified as an apple if one is told that it represents an apple, since the object contains few referents that are visually relatable to the standard of the actual object. Thus, abstraction which occurs at the far right of the scale is defined as the use of visual elements or referents which do not portray any concept of an actual object or environment.

Identification in terms of the level of stylization is also one of the keys in determining the visual requirements of a synthetic training device. Since Gibson (1975) stated that visual perception is an act of attention, the question of portraying visual cues becomes one of determining what the pilot must recognize in the task so that this act of attention can take place. In Figure 6.1., the apple is the subject of attention: the stimuli or cue. Recognition of the cue has become one of determining that the representation has sufficient visual referents which allow it to be compared to the visual standard of the actual object and identified as an apple, not an orange. Recognition of other characteristics of the apple or any cue (such as kind, condition, or location) requires a level of stylization which includes the visual elements or cuing referents which <u>support those cuing activities</u>. Since the surface task analysis of a specific tactical task can furnish these activities, a level of stylization can be determined. Additional task information such as tactical implications and geomorphic considerations simply clarify cue characteristics and activities more completely.

The level of stylization plays a further role in the determination of visuals for a synthetic training device. With the analysis information for the training task in hand, it was possible to portray visual task oriented requirements at a number of useful levels of stylization which permitted evaluating those alternatives in terms of training efficiency and cost effectiveness. The remainder of this section has been devoted to the presentation of task oriented background environments and targets in various levels of stylization.

<u>Background Environment Development/Low Angle Dive Bomb Task</u> - An illustrative technique had to be found which would allow any visual cuing requirements to be depicted quickly and easily. Graphic designers chose the pastel chalk medium for this purpose because it is a permanent, versatile, dry medium with a full range of colors. In order to get a sense of relating the summarization and other word-picture data to a visualization methodology, a background environment from the air-to-ground data was built up in six stages. These stages show the required cues and referents being added step by step to the sky, horizon, and ground cuing areas until the scene was completed. Slide Figures 6.2 through



Slide Figures 6.2. through 6.7. Six Stage Background Environment Progression

6.7. show the progression of stages. It can be seen that when referents such as contour, perspective, and contrast which are called out at the left of each slide sketch are added, the end of space becomes more completely defined. Researchers then attempted to use the stylization scale in Figure 6.1 to categorize the level of stylization of the final sketch. Based on relating the illustrations which accompany each of the five levels of stylization, the background environment was easily categorized in the graphic rendering area of the scale.

This first attempt at a visual methodology showed researchers that the concept of relating word-pictures to sketches of background environments was possible, that the pastel chalk medium would be adequate to depict most background environment scenes, and that determining the level of stylization of a background could be categorized with a high degree of reliability. Working directly with all the analysis information, however, proved to be rather cumbersome and confining for the graphic designer. For this reason, it was determined that rather loosely defined initial rough sketches with descriptive notes should be made before proceeding to more finished visuals of the scene. The first try illustrations also suggested that an attempt should be made to explore levels of stylization in the areas of graphic and abstract symbology in order to evaluate their potential. As part of this effort, a U.S. Geological Survey topographic map was obtained which contained many of the geomorphic considerations stated earlier, namely the upland geomorphic category with flat lands and mountainous periphery - regular and irregular patterns and profiles. Figure 6.8. shows the topographic map and selected direction view. Slide Figure 6.9. shows this background environment using simplified size, shape, perspective, color, contrast, and contour referents. Slide Figure 6.10. shows a closer view of the mountains of the upland geomorphic category with the required cuing referents in a graphic symbology level of stylization. Slide Figure 6.11. shows essentially the same scene characteristics in an example of an abstract symbology level of stylization.

In evaluating these and many more developed background environment sketches for the Low Angle Dive Bomb task, researchers had to choose an environment which best suited the word-picture descriptions and the tactical implications of the task itself. Since the task was a basic attack maneuver situated in a controlled range environment, a rather conservative graphic symbology level of stylization was chosen for use as the background environment. Slide Figure 6.12. shows an alternative of this development and Slide Figure 6.13. shows the finalized background environment.

Surface patterns and profiles were chosen which would be useful in orienting a student on the downwind, base, and final delivery legs of the task at the initial phases of learning. Additional task oriented background environments were developed

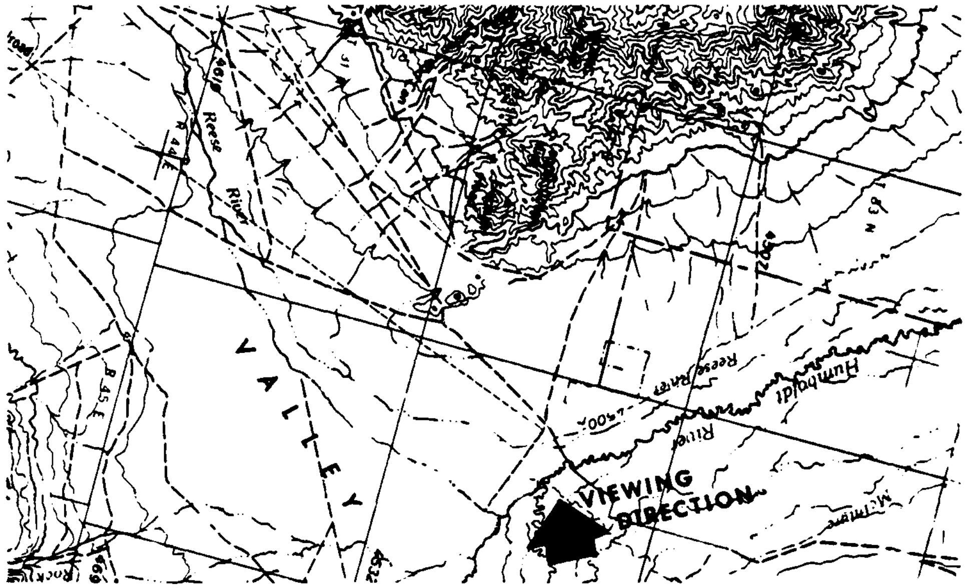
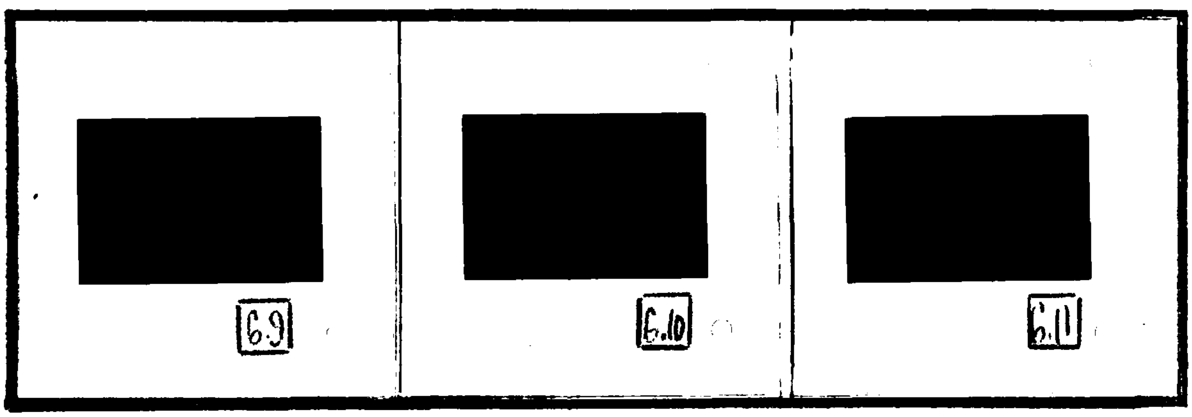


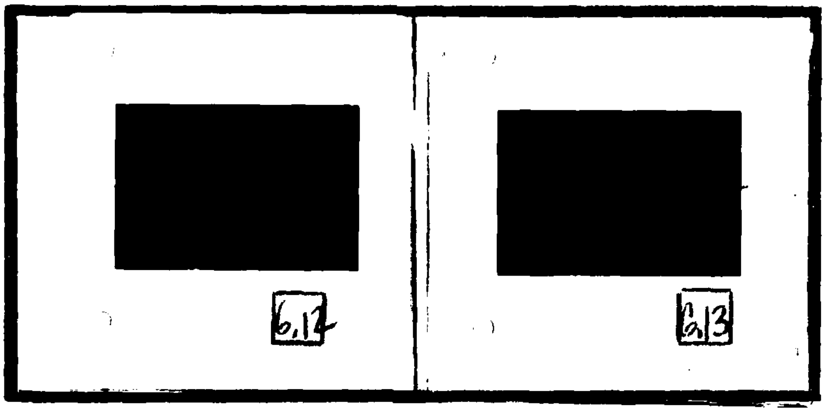
Figure 6.8. Portion of U.S. Geological Survey Topographic Map



Slide Figure 6.9. View of Topographic Map with Simplified Referents

Slide Figure 6.10. Mountain Periphery Detail as Graphic Symbology

Slide Figure 6.11. Upland Geomorphic Category as Graphic Abstraction



Slide Figure_6.12. Air-to-Ground Controlled Range Background Alternative

Slide Figure 6.13. Finalized Air-to-Ground Controlled Range Background

for the advanced learning phases of the Low Angle Dive Bomb. These environments have been incorporated into the following section.

Air-to-Ground Targets - Ground targets, though an integral part of surface layout of a background environment, have been discussed separately because of their specific tactical implications. The target types listed in Section 2. were reviewed. It was noted that although a great variety of targets existed, a large number of both strategic and tactical targets could be grouped as basically cylindrical or rectilinear type objects when viewed from an aircraft. Figure 6.14. shows some typical examples of these object shapes. Target objects such as these were generally found to exist in clusters of single shapes or as combinations of cylindrical or rectilinear shapes. Figure 6.15.

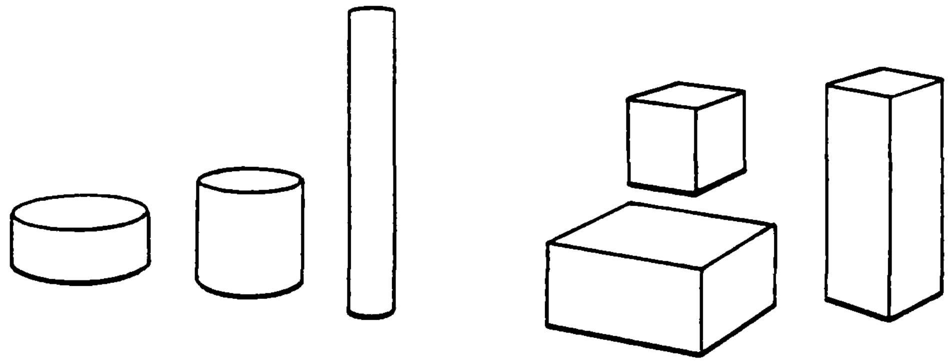


Figure 6.14. Basic Target Objects

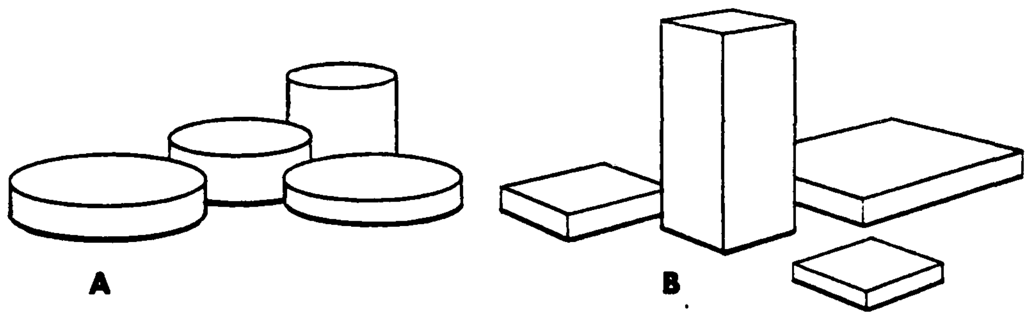


Figure 6.15. Clusters of Basic Target Objects

shows an example of shape clustering. These clusters of cylindrical and rectilinear objects with a minimum of size, shape, contour, and perspective cuing referents can easily be recognized as target cues such as storage or supply areas as shown in A, or urban structural complexes as shown in B of Figure 6.15.

Figure 6.16. shows a typical industrial complex of structures. It is made up of basic rectilinear and cylindrical shapes in a relationship of forms which characterize the industrial complex from an aerial vantage point. Again, only a minimum of shape, size, contour, and perspective cuing referents have been used to portray a specific target area. Thus, it does not appear to be necessary to include greater detail if training requires only locating, identifying, and delivering ordnance on a target within a tactical situation. Target object clusters and combinations have been incorporated in the non-range background environments depicted in the following section.

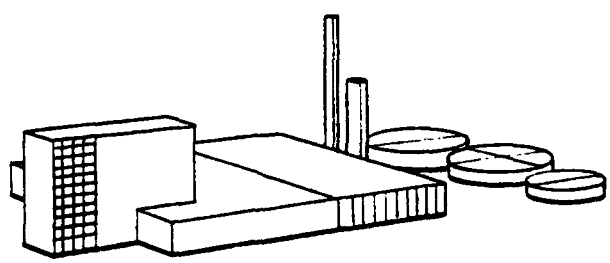


Figure 6.16. Industrial Complex Made up of Basic Object Shapes

Under range conditions of ordnance delivery, standard targets such as those shown in Figure 6.17. have been incorporated. They characterize some of the target cues found in actual range situations. These include not only a type of bull's-eye target cue, but also a run in line and foul line cues. Task oriented range background environments have incorporated these kinds of target cues and referents.

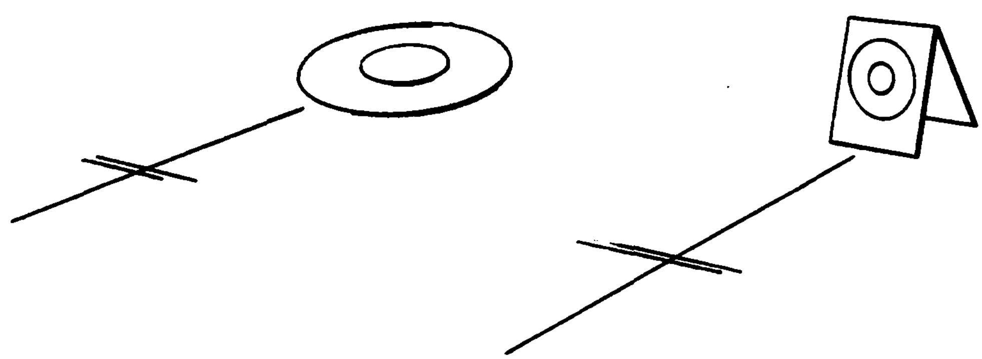
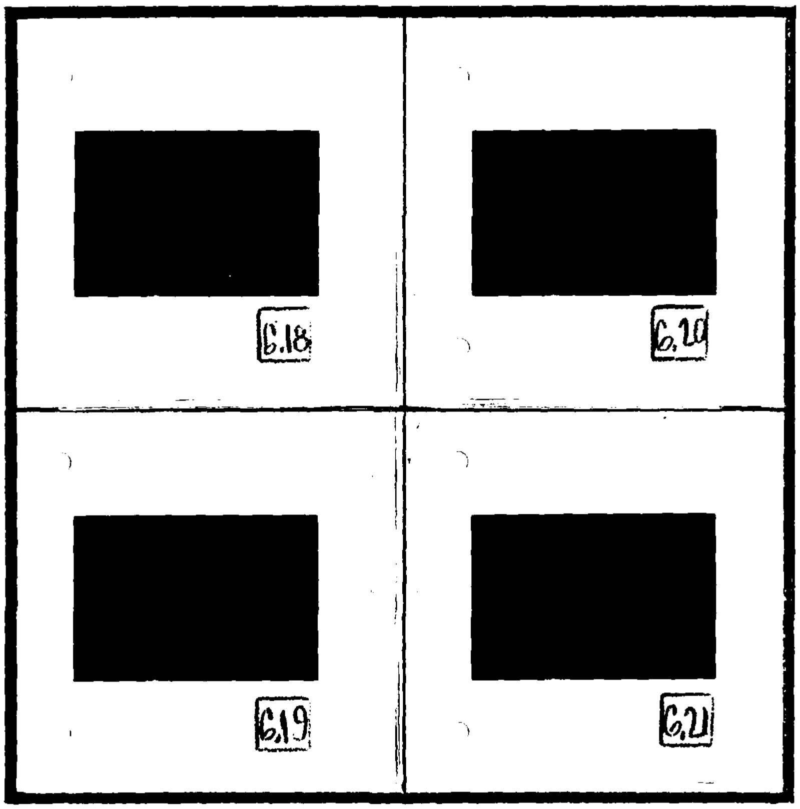


Figure 6.17. Typical Air-to-Ground Range Targets

Background Environment Development/Acceleration Maneuver - With many of the purely technical problems of background design in hand, it was possible to proceed directly to the design of the air-to-air environment. A review of the summarization and visual check data derived from the analysis of the air-to-ground task showed an expected change in visual emphasis. A new emphasis was quite naturally on the target and less on the ground cues, while the horizon cues and referents remained the same. The same approach was taken as developed earlier, that of working with the data in sketch form. Again, the geomorphic considerations and tactical implications of a basic range type situation were taken into consideration. A series of sketches was initiated. Four were chosen for further development and are shown in Slide Figures 6.18 through 6.21.



Slide Figures .18. thru 6.20. Air-to-Air Background Alternatives

Slide Figure 6.21. Finalized Air-to-Air Controlled Range Background

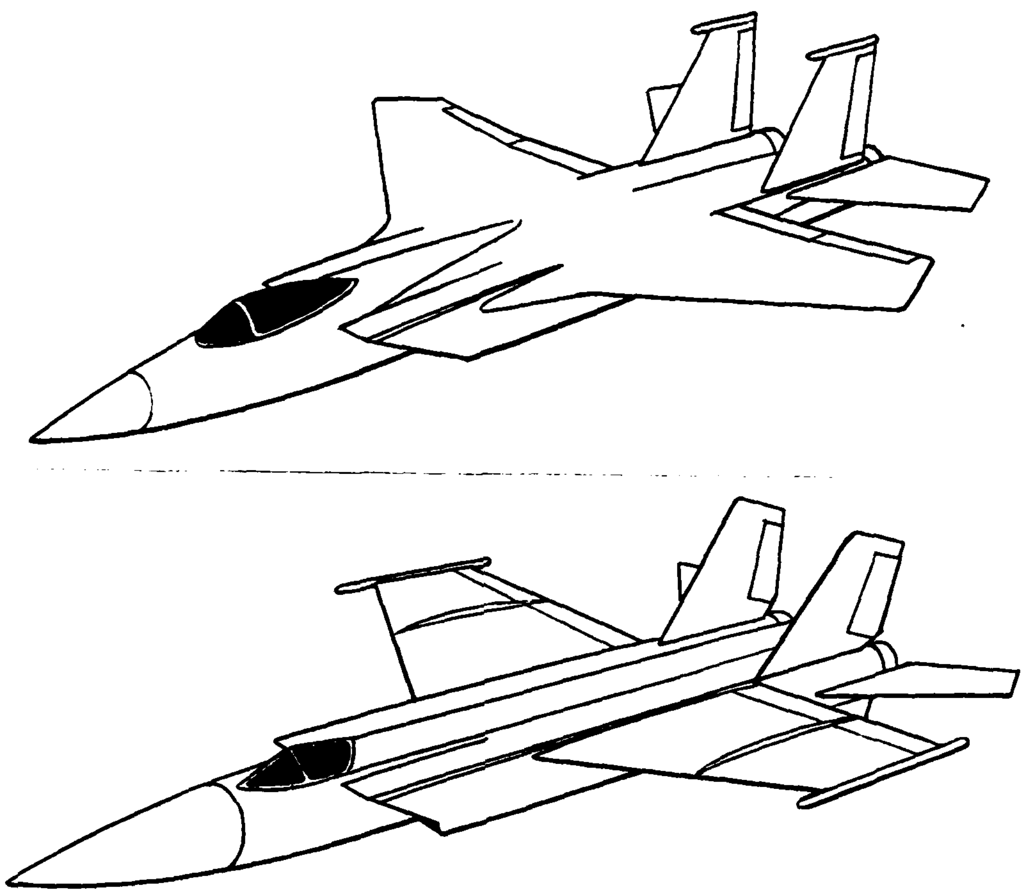
Note that a rather wide range of background alternatives was included. This range of alternatives was fostered because it was felt that an insufficient variety of visual ideas had been forthcoming when designing for the air-to-ground task. Slide Figure 6.21. was chosen as best fulfilling the task data requirements and information. The design was determined to be in the abstract symbology level of stylization. No specific criteria for background environment selection were developed other than comparing the illustrated visual concepts with a review of the analysis data which formed the word-picture of the task environment.

Aerial Targets - Analysis data showed the essential cuing referents needed for the cuing activities of the task. The instructional features of the learning plan presented in the following section indicated a requirement for a number of different identifiable hostile targets. Thus, the problem was one of recognition for identification purposes plus the cuing requirements for the task. The amount of contour which would directly effect the process of target identification was addressed first.

Two actual aircraft types of similar design were chosen. Their shapes were silhouetted in a typical three-quarter front perspective view. The silhouettes were placed together as shown in Figure 6.22. The two shapes look very much alike even at close comparison. Contour was added inside each shape where the

Figure 6.22. Silhouettes of Similar Aircraft Shapes

differences in form were most evident - notably at the cockpit, wings, and tail group. Figure 6.23. shows the result of this exercise. With this amount of contour, no doubt in terms of identification existed among those who had a knowledge of the two types. This exercise could not be considered comprehensive because distance and aspect angle play an important role; however, recognition emphasis appears to occur at cockpit, wings, and tail groups in the identification process.



• Figure 6.23. Contour Referents for Similar Aircraft Shapes

A brief survey of hostile aircraft types was made to determine basic aircraft shapes and suitable candidates as identifiable target aircraft. Figure 6.24. shows the three aircraft chosen for identification purposes. Again, contour detail was emphasized in the cockpit, wing, and tail group areas.

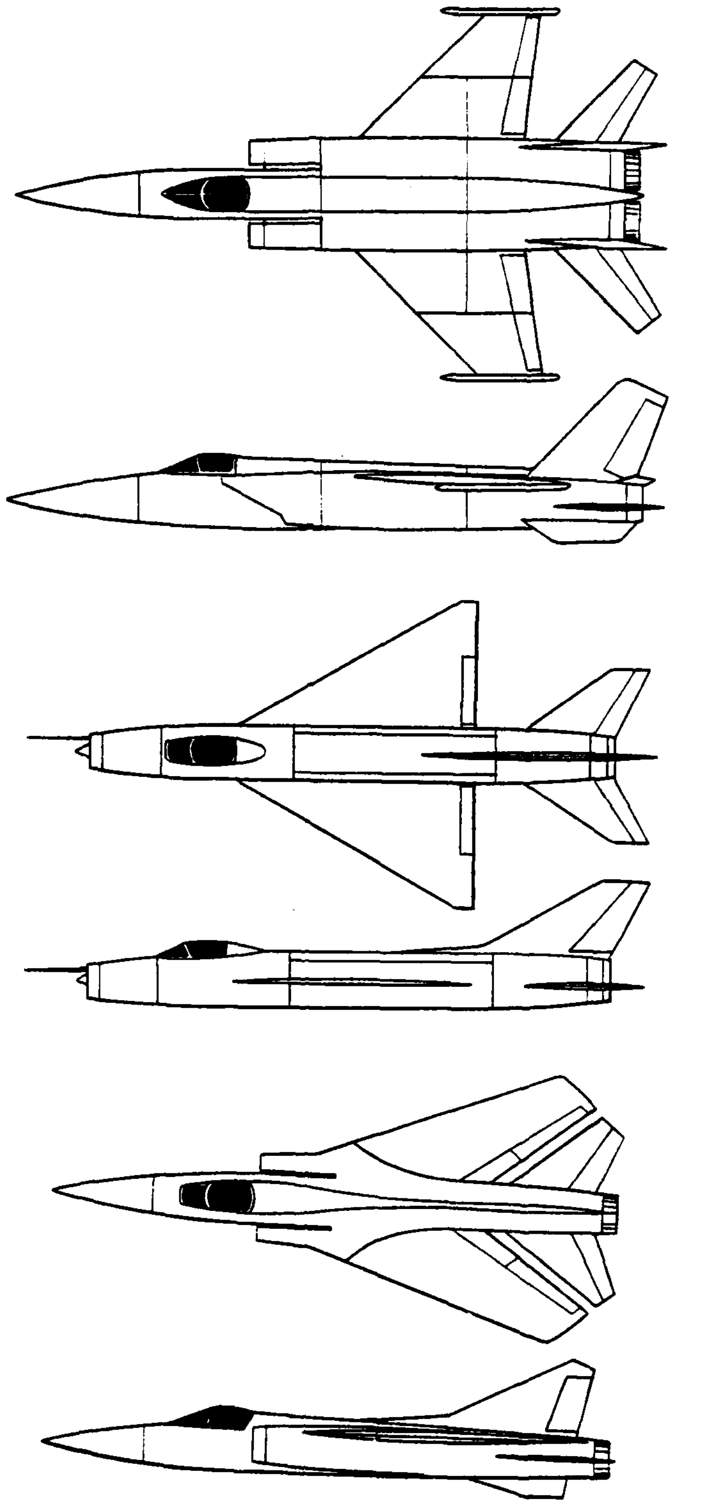


Figure 6.24. Candidate Target Aircraft

Tactical implications such as the basic nature of the task indicated that the major portion of the training task be conducted using a standard target rather than any specific aircraft type. A standard aerial target could characterize all modern fighter aircraft as much as possible. Figure 6.25. shows the plan view and side view of this standard target which was based on military aircraft found in Jane's (1979). The development emphasized size, shape, contour, the effects of changing perspective due to varying aspect angles, and the fuselage and wing plane referents in its

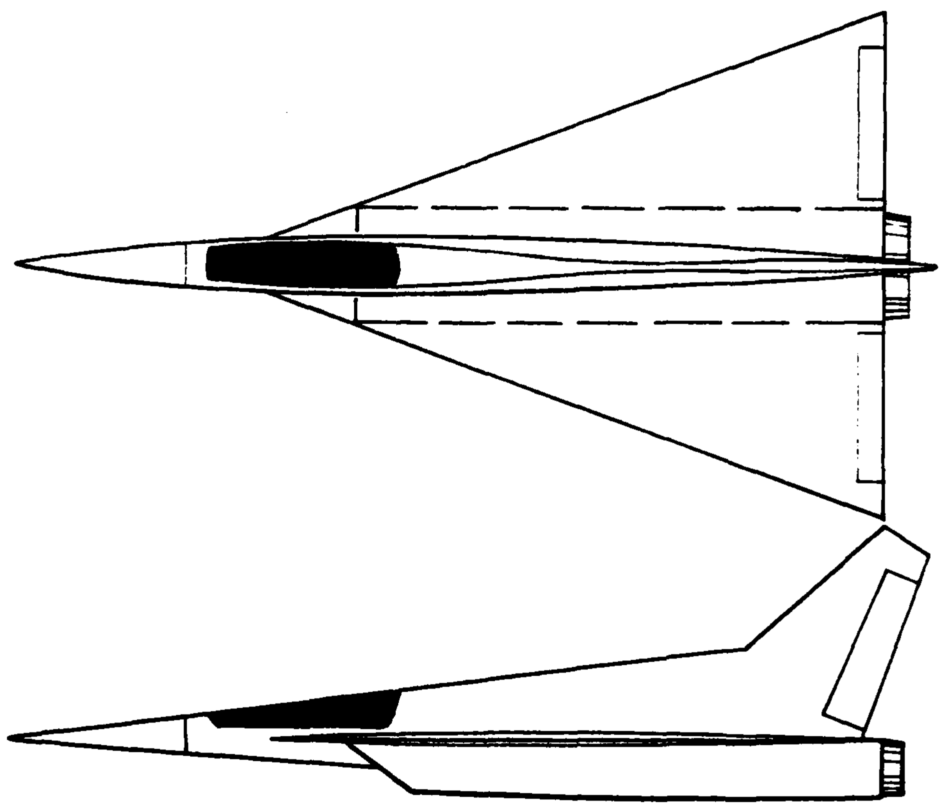


Figure 6.25. Plan View and Side View of Standard Aerial Target

design. Figure 6.26. shows the target in a number of typical aspect angles as seen from an ownship vantage point. A-A in the figure shows the wing plane and B-B shows the fuselage plane cuing referents.

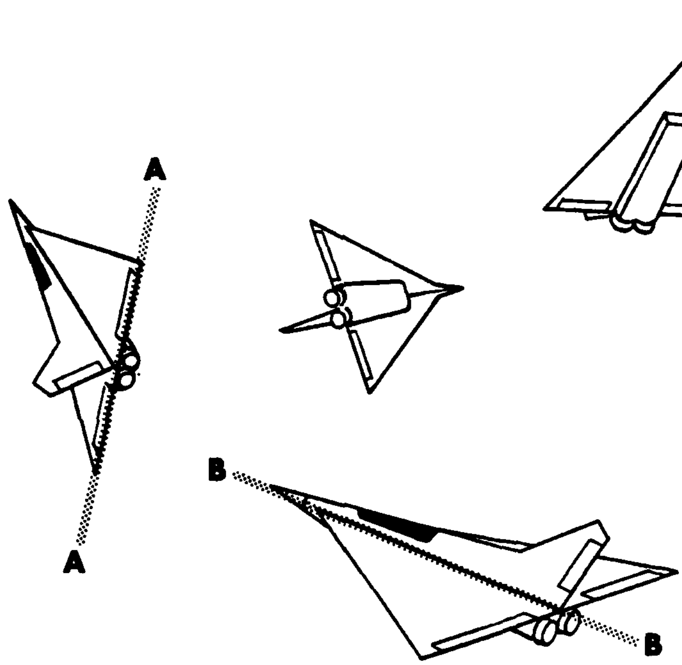


Figure 6.26. Typical Aspect Angles of Standard Aerial Target

The levels of stylization vary among the ground and aerial targets because of the differing identification requirements. Where a positive identification of a specific type is required, a graphic rendering level or a high degree of graphic symbology has been shown. Where only useful cues and referents are required, however, abstract symbology could be used. It does not seem incongruous that the levels of stylization be mixed as training situations required. Thus, a combination of graphic rendering, graphic symbology, and abstract symbology could be visually compatible in a single background environment if properly executed.

The visualization methodology marked the structural culmination of this research. The previous sections have thus established a framework which incorporated both the theory and practice of an experience-judgement approach to training. The learning plan in the following section is a result of this framework.

7. EXPERIENCE-JUDGEMENT LEARNING PLAN

Introduction - The instructional aspects of the experience-judgement learning theory developed in this research centered around a phased approach to training. The Instructional Review section showed that behavioral goals and their corresponding training event requirements could be tailored to such an approach. Implementation, however, would require a systematic structuring of training events under a closely controlled instructional environment. It is unlikely that such control could be achieved under actual flying conditions. However, a vicarious training situation as described earlier, using synthetic training devices could provide such an instructional environment. Further, vicarious training and instruction, when combined with actual flying, could provide highly optimized learning experiences and a rapid growth in specific judgement areas.

The Learning Plan - A learning plan was designed which focused on the use of the synthetic training device as an integral part of tactical flying instruction and training. This plan carefully related the training event requirements developed from task-related behavioral goals to appropriate instructional techniques and training device instructional features. A workable format was developed which allowed researchers to determine instructional features and techniques for each event within a learning phase. The result was a learning plan which integrated:

(1) tasks to be learned with (2) behavioral goals to be achieved within (3) a learning phases and events framework in (4) a synthetic instructional environment.

Development - In order to implement the phased approach to training described in this research, the synthetic training device milieu should consist of four components:

1. Task oriented background environment - specific task or task group related cues and referents (previously described)
2. Ownship environment - specific aircraft oriented foreground cues and performance cues (previously described)
3. Instructional features - specific device characteristics which interact directly with the student to create unique training events
4. Instructional techniques - specific manner in which instructional features are to be used for each training event

Instructional features have been defined as those device characteristics which allow the background and ownship environments to be controlled and manipulated to enhance or accentuate appropriate cues or cuing referents in order to create unique training event experiences. These features exist in both the visual and nonvisual categories. Emphasis has been placed on showing examples of visual features; however, the nonvisual aspects are, in many cases, as significant as the visuals. Thus, in instructional terms, the visual and nonvisual categories are seen as being interrelated in the synthetic training environment. For example, the use of graphic symbology such as directional arrows or reference lines which overlay the background environment and are manipulated to identify certain spacial cuing relationships is a purely visual feature. The use of slow motion, however, involves both the enhancement of visual movement and the temporal or nonvisual aspects of the cuing environment.

To complete the learning plan, instructional techniques were determined for the training events of each learning phase. Instructional techniques have been defined as the particular training methodology within a training plan which states the utilization of appropriate instructional features to achieve stated behavioral goals. In this research, the instructional techniques involved two headings: initialization and application of appropriate features for each training event. Initialization stated the specific starting conditions, while the application heading stated the type, description, sequencing, and integration of each feature to be used in order to obtain proper instruction.

Plan Format and Implementation - A form was designed that related the training event requirements, which stemmed from the behavioral goals established in the Instructional Review section, to instructional techniques needed to accomplish those requirements. Instructional features were then established from these techniques. The scope of this research allowed only a general description of the techniques and features; however, further detail could be easily attached to the format. As part of the format, five Slide Figures show the visually oriented instructional features for specific events. The event selection was based on an interest by researchers to take an actual look at the feature descriptions of those events.

The implementation of the learning plan format required both an analytical and intuitive approach. First, a number of sequential event requirements developed during the Instructional Review were studied to determine if similarities would allow some measure of grouping. The event or events were then studied to find the obvious instructional needs, and an initialization or starting point was established based on the task segment also established during the Instructional Review. The surface analysis task diagrams and analyses of cognitive components were useful in this regard. Next, the application was derived through an intuitive process based on the event requirements, behavioral goals, and personal flying experience of the researchers.

With the instructional techniques for a training event or group of events complete, researchers used as much creativity as possible to describe and relate instructional features to given techniques. No technical constraints were set. Thus, the sole criterion was to design features which would create the best vicarious instructional climate to accomplish the stated behavioral goals.

With the completion of a learning plan for each task, the instructional features were summarized. This summarization and a description of each feature can be found at the beginning of each learning plan. In review, the learning plan format for each task begins with a summary list of all the instructional features required for the instruction of the specific task for the convenience of the reader. Next, the learning phase and phase events are designated. The event requirement or requirements are listed. The instructional techniques and features are then shown in paragraph form, which will accomplish the event requirements.

The completed learning plan example of the Low Angle Dive Bomb task has been included in this section. A complete learning plan for the Acceleration Maneuver can be found in Appendix C.

Synthetic Training Device Instructional Techniques and Features - Low Angle Dive Bomb Task Example

A summary of training device instructional features:

1. Task oriented background range environment with lead aircraft - cues and referents determined through analysis which provides for all required cuing activity requirements.

2. Changeable task oriented nonrange background environments - cues and referents determined same as above.

3. Ownship environment - aircraft specific and task oriented foreground cues and referents, and performance cues.

4. Graphic symbology generation capability - the functional capacity to overlay the background environment with programmed, preprogrammed or manually manipulated linear visual displays.

5. Initialization, freeze, unfreeze and reinitialization capability - the functional capacity to begin a task from specific background and ownship parameters to stop or freeze, restart or unfreeze, and continue the task or begin the task again at the same specific parameters, or a new set of parameters.

6. Real time, slow time, or stop action modes - the functional capacity to perform task replay or computer programmed replay in real time (actual cuing tempo), slow time (controllable or programmed smoothly slowed cuing tempo), or stop action (controllable stop frame cuing tempo).

7. Computer replay flown ownship with synchronized programmed aural and graphic instruction - the functional capacity to present student with computer replay of preprogrammed ownship flown in the appropriate time mode with accompanying voice and graphic overlay instruction.

8. In-cockpit instant task/segment replay - the functional capability to permit full student/ownship task reenactment in selectable time modes.

9. Computer-perfect visual task/segment comparison of student performance - the functional capacity to graphically relate, in the cockpit, the student/ownship performance to computerized perfection of the same task/segment.

10. Instructor manipulation of graphic symbology - the functional capacity for the instructor to manually control specific linear visual displays.

11. Instructor control of student ownship - the manual remote control of ownship from the instructor's station.

12. Student/instructor aural communication - voice intercom capacity and instructor manual auditory display capacity.

1. Readiness Phase - Procedural Events

The Readiness Phase is involved in gaining knowledge and understanding of verbalizable concepts and principles about the performance of a task. Because the procedural events of this phase involve the understanding of the task, task goals, equipment systems, functions, and numerical values at the verbal level, material such as this can best be taught in a classroom or self-paced instructional atmosphere using audio/visual aids.

2. Awareness Phase - Cue Selection Events

Cue Selection Event Requirements

Recognize all useful landmark cues relative to wind drift on all task legs.

Recognize all useful landmark cues at roll in and roll out positions on all task legs.

Recognize proper pitch and bank angles for final approach with an understanding of wind on turn performance.

Recognize target position relative to proper dive angle from ownship position.

Recognize wind effects relative to crab angles required for compensation purposes.

Recognize proper slant range and dive parameters for ordnance release and how target appears when correct envelope is entered.

Instructional Techniques - The purpose of the events in this phase was to acquaint the student with the cues and specific cuing referents which will be used during the total task. It is essentially an introduction of where to look and how to look at useful cues. This in-cockpit experience is a reinforcement of data and procedures already learned in a learning center environment.

Initialization - Student is initialized on the downwind leg well in advance of turn to base at the correct parameters.

Application - The task is treated as a whole. The learning cycle begins on downwind and ends with a return to downwind. Task is computer flown with synchronized aural instruction and graphic enhancement in real time to establish concept and tempo. Slow time and freeze are used for detailed aural and graphic descriptive programmed instruction. Student and instructor interface for personalized instruction as necessary. Student will discuss and describe task information presented to the satisfaction of the instructor.

Instructional Features - Ownship ground track, ground target, lead aircraft, wind direction and velocity symbology, and landmark graphic designation. Programmed aural instruction with synchronized computer pilotage, real time, slow time, freeze, and reinitialization modes.

3. Initial Skill Development Phase - Demonstration Events

Demonstration Event Requirement

Show relationship between useful landmarks and ownship visual picture (slant range) to the target.

Instructional Techniques

Initialization - Student is initialized from freeze mode on downwind leg at correct parameters.

Application - At initialization, ownship is computer replay flown in real time to establish event tempo with programmed aural instruction. Task event is then replay flown with programmed aural and graphic instruction in slow time to show in detail and explain angular distances and visual picture at passing of designated landmark cues from the target.

Instructional Features - Ownship ground track, lead aircraft and spacing designation, useful landmarks, and relative angles to ownship graphically designated. Programmed aural and graphic instruction with synchronized computer replay pilotage, real time, slow time, freeze and reinitialization, student/instructor communication.

Demonstration Event Requirement

Show landmark/target relationship, and roll in visual picture and flight techniques for various wind and no-wind conditions.

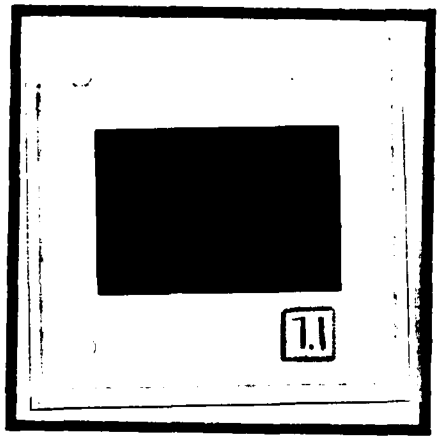
Instructional Techniques

Initialization - Student is initialized from freeze mode on downwind leg at correct parameters.

Application - At initialization, ownship is computer replay flown in real time to establish task tempo with programmed aural and graphic instruction. Event is then shown in slow time with continuing detailed aural and graphic instruction showing correct track, heading, landmark/target relationship relative to wind vector and velocities, roll in position, and bank angles.

Instructional Features - Ownship ground track, lead aircraft and spacing designated, wind vector and velocity symbology, landmarks graphically designated, bank angle and aerial track symbology. Programmed aural and graphic instruction synchronized with computer replay pilotage of ownship, wind dynamics, real time, slow time, freeze and reinitialization modes, and student/instructor communication. Slide Figure 7.1. shows the visual instructional features.

Ownship ground track, roll in and roll out landmark related symbology designated in white. Wind vector and velocity, lead aircraft, bank angle and aerial track symbology designated in gray.



Slide Figure 7.1. Roll in to Base-
Visual Instructional Features Example

<u>Demonstration Event Requirement</u>

Show roll out of ownship/target position visual picture and proper flight technique.

<u>Instructional Techniques</u>

Initialization - Student is initialized from freeze prior to base turn at correct parameters.

Application - At initialization, ownship is computer replay flown in real time with synchronized aural and graphic instruction to establish tempo. Event is then detailed in slow time with further aural/graphic instruction relating wind/position alternatives and roll in and roll out angles relative to specific situations. Stop action mode is used to assist in establishing firm visual picture at critical segments of the roll in and roll out progression.

<u>Instructional Features</u> - Ownship ground track, lead aircraft and spacing designated, wind vector and velocity symbology, appropriate landmark designation, aerial track symbology with bank angle. Programmed aural/graphic instruction with synchronized computer replay pilotage; wind dynamics; real time, slow time and stop action time modes; freeze; reinitialization; and student/instructor communication.

Demonstration Event Requirement

Show landmarks/target relationships and correction for wind and no-wind conditions for base leg.

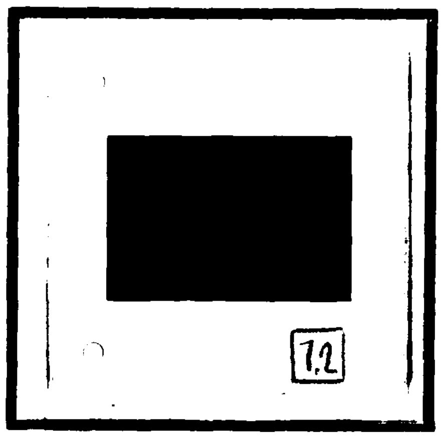
Instructional Techniques

Initialization - Student is initialized from freeze on base leg, beyond the turn at the correct parameters.

Application - At initialization, ownship is computer replay flown in real time with aural/graphic programmed instruction for task tempo. Reinitialization events are in slow time for detail with programmed aural/graphic instruction for various wind vector and velocity situations, aircraft spacing and their relationship to ground track, designated useful landmarks and target.

Instructional Features - Ownship ground track, lead aircraft and spacing designation, wind vector and velocity symbology, landmark designation, and relative angle to target symbology. Programmed aural/graphic instruction with synchronized computer replay pilotage, wind dynamics, real time and slow time modes, freeze, reinitialization, and student/instructor communication. Slide Figure 7.2. shows the visual instructional features.

Ownship ground track and roll in landmark related symbology designated in white. Wind vector and velocity, lead aircraft, and relative angle to target designated in gray.



Slide Figure 7.2. Base Leg - Visual Instructional Features Example

Demonstration Event Requirement

Show and relate roll in to slant range, target size and location to useful landmarks, and show proper roll in flight techniques.

Instructional Techniques

Initialization - Student is initialized from freeze on downwind leg, prior to roll in position at correct parameters.

Application - At initialization, ownship is computer flown in real time with programmed aural/graphic instructions to establish tempo under various pre-roll in and roll in wind and spacing conditions. Reinitialization events are in slow time to detail wind and spacing situations and roll in alternatives.

Instructional Features - Ownship ground track, aerial track, angular symbology from ownship to target, wind vector and velocity symbology, lead aircraft and graphic designation of landmarks. Programmed aural/graphic instruction with synchronized computer replay pilotage, wind dynamics, real time, slow time, freeze and reinitialization modes, and student/instructor communication.

Demonstration Event Requirements

Show and relate roll in progression of bank and dive angles to target visual picture.

Show roll out and dive progression to target and sighting device.

Instructional Techniques

Initialization - Student is initialized from freeze on downwind, prior to final approach at correct parameters.

Application - The two event requirements are first taken separately and then shown together as a smooth motion. At initialization, ownship is computer replay flown with synchronized programmed aural/graphic instruction to establish task tempo. Reinitialization in slow time for detailed programmed aural/graphic instruction relative to roll in and roll out progression and tempo. Stop action and freeze are used to describe visual picture detail and provide build-up of correct visual picture to the student.

Instructional Features - Ownship ground track, ownship aerial track with bank and dive angle symbology. Programmed aural/graphic instructions with synchronized computer replay pilotage; wind dynamics; real time, slow time and stop action time modes; freeze; reinitialization; and student/instructor communication. Slide Figure 7.3. shows the visual instructional features.

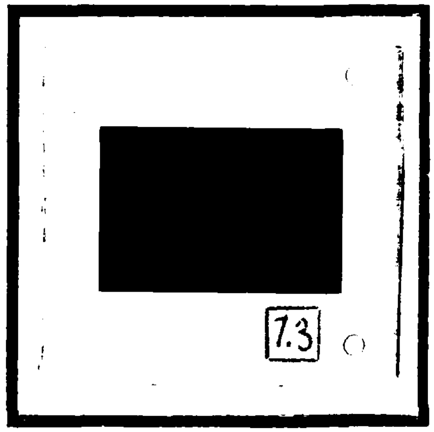
Demonstration Event Requirement

Show variable wind force conditions and their effect on tracking and visual and sight pictures.

Instructional Techniques

Initialization - Student is initialized from freeze on final dive, beyond roll out at correct parameters.

Ownship ground track and roll in point designated in white. Wind vector and velocity, aerial track, dive and bank angles in gray.



Slide Figure 7.3. Roll in to Final - Visual Instructional Features Example

Application - At initialization, ownship is computer replay flown and pilot is presented with target/pipper tracking solution progression with programmed aural/graphic instruction. Segment is shown in real time to establish tempo, and in slow time to show in detail the various wind conditions visually, and the effect of crab angles on the no wind condition approach to target.

Instructional Features - Ownship ground track, wind vector and velocity symbology, ownship to target angular displacement graphics, and ordnance sight symbology. Programmed aural instruction with synchronized computer replay pilotage; wind dynamics; real time, slow time, stop action, freeze and reinitialization modes; and student/instructor communication.

Demonstration Event Requirements

Show target to sight/pipper relationship relative to range, dive angle, and airspeed with proper technique.

Show progression of proper target to pipper movement visual picture, relative to correct dive angle and airspeed.

Instructional Techniques

Initialization - Student is initialized from freeze on final approach beyond roll out at correct parameters.

Application - The two events are taken together. At initialization, ownship is computer replay flown with programmed aural/graphic instruction. Pilot is presented with ground and aerial track with dive angle, their relationships to one another, and the target/pipper combination under no wind and various wind conditions. Segment is shown in real time for tempo, slow time for detailed explanation, and stop action for critical visual picture analysis prior to ordnance release. Perform ordnance release and projected ordnance impact point.

Instructional Features - Ownship ground track, ownship aerial track, angular relationship symbology between target and ownship, wind vector and velocity symbology, and projected ordnance impact point. Programmed aural/graphic instruction, synchronized computer replay pilotage, wind dynamics, real time, slow time, stop action time, freeze, reinitialization, and student/instructor communication.

Demonstration Event Requirement

Show target size and dive angle with WSO altitude and airspeed calls as critical to pull off target with pull-up flying techniques.

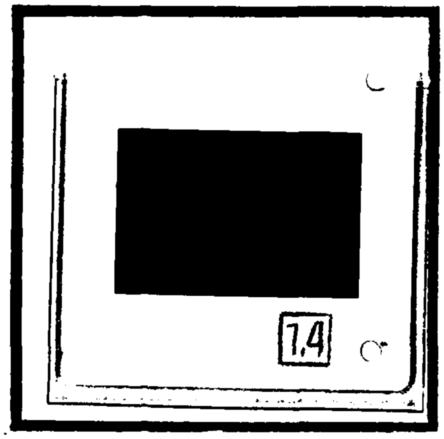
Instructional Techniques

Initialization - Student initialized from freeze on final approach beyond roll in at correct parameters.

Application - At initialization, relate tracking and ordnance release, and concentrate on pullout activity. Stress and relate target size and shape to critical airspeed and altitude calls by WSO, all using ownship computer flown in real time with programmed aural instruction. Use slow time for detailed relationship description.

Instructional Features - Graphic target designation and weapons sight symbology. Programmed aural instruction with synchronized computer replay pilotage; WSO airspeed and altitude calls; real time, slow time, freeze and reinitialization modes; and student/ instructor communication. Slide Figure 7.4. shows the visual instructional features.

Ownship ground track and weapons release point designated in white. Wind vector and velocity, crab angle and sight/pipper symbology in gray.



Slide Figure 7.4. Final Dive - Visual Instructional Features Example

Demonstration Event Requirement

Show relationship of ownship climbing turn to altitude, spacing position estimates, and proper climb out flight techniques.

Instructional Techniques

Initialization - Student is initialized from freeze beyond ordnance release point in correct parameters.

Application - At initialization, ownship is computer flown with synchronized programmed aural and graphic instruction presenting best rates of climb for best repositioning on downwind leg relative to target and designated landmarks under wind and no wind conditions. Segment is presented in real time and slow time for detailed explanation of procedures and flight techniques.

Instructional Features - Ownship ground track, ownship aerial track, and lead aircraft with landmarks designated. Programmed aural instruction synchronized with computer pilotage and graphic presentation, real time, slow time, freeze, reinitialization, and student/instructor communication.

3. Initial Development Phase - Imitation Events

Imitation Event Requirement

Attempt final dive and tracking to target and ordnance release.

Instructional Techniques

Initialization - Student is initialized from freeze on final beyond roll out at the correct parameters.

Application - Appropriate demonstration event is first shown as a refresher. At segment initialization, student flies ownship in real time with minimum graphic assistance except for projected ordnance impact point at instructor's discretion. Segment instant replay performance versus computer-perfect comparison used as critique information for student and instructor. Additional symbology may be employed as remedial instruction at instructor's discretion.

Instructional Features - Projected ordnance impact point, ordnance impact plot, in-cockpit instant segment replay with student versus computer-perfect performance graphically displayed, and instructor manipulated symbology. Real time task performance, real time, slow time, stop action instant segment replay, freeze and reinitialization modes, WSO airspeed and altitude calls, and instructor control of student ownship.

Imitation Event Requirement

Attempt roll in and dive to final approach.

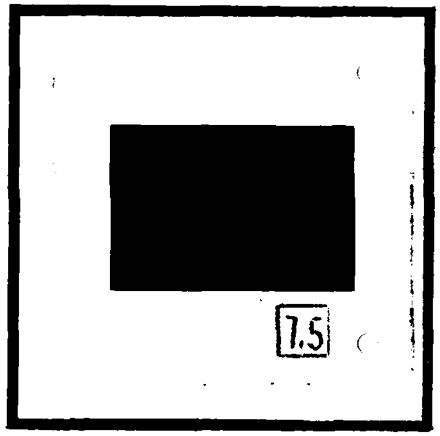
Instructional Techniques

Initialization - Student is initialized from freeze on mid-downwind position prior to final roll in, at correct parameters.

Application - Appropriate demonstration event is first shown as a refresher. At segment initialization, student flies ownship without graphic symbology assistance in real time. Segment instant replay performance and computer-perfect comparison may be used as critique information for student and instructor. Additional symbology can be used as remedial instruction including the presentation of programmed demonstration event material at the discretion of the instructor.

Instructional Features - In-cockpit segment instant replay, computer-perfect segment comparison, instructor manipulated symbology. Real time, slow time, stop action instant replay, freeze, reinitialization, student/instructor communication and instruction, and instructor manipulated control of student ownship. Slide Figure 7.5. shows the visual instructional features.

Ownship ground track, weapons release point, sight/pipper, and alpha numerics designated in white. Computer-perfect ground track, weapons release point, sight/pipper, and alpha numerics designated in gray.



Slide Figure 7.5. Final Dive -
In-cockpit Instant Replay Example

Imitation Event Requirement

Attempt proper downwind and base turn.

Instructional Techniques

Initialization - Student is initialized from freeze on downwind at correct parameters.

Application - Appropriate demonstration event is first shown as a refresher. At segment initialization, student flies ownship in real time without graphic assistance. Segment in-cockpit instant replay and computer-perfect performance comparison are used for critique by student and instructor. Instructor manipulated graphic symbology, student ownship control, and personalized aural instruction should be used.

Instructional Features - In-cockpit instant segment replay, computer-perfect performance comparison, and instructor manipulated symbology. Real time, slow time, stop action, instant replay, freeze and reinitialization modes; student/instructor communication and instruction; and instructor control of student ownship.

Imitation Event Requirement

Attempt off target pull-up and correct reposition on downwind for next delivery.

Instructional Techniques

Initialization - Student is initialized from freeze just beyond ordnance release.

Application - At initialization, student flies ownship in real time without graphic assistance. Segment in-cockpit replays and computer-perfect performance comparisons are used by student and instructor for instruction and critique. Instructor manipulated graphic symbology and personalized aural instruction should be used in conjunction with replays. Programmed computer flown instruction from these specific demonstration events should be used for remedial or refresher instruction.

Instructional Features - In-cockpit instant segment replay with student versus computer-perfect performance graphically displayed, and instructor manipulated symbology. Real time task performance; real time, slow time, stop action instant replay, freeze and reinitialization modes; student/instructor communication and instruction; and instructor control of student ownship.

3. Initial Skill Development Phase - Primary Rehearsal Events

Primary Rehearsal Event Requirement

Rehearse task segments *I, II, and III together, segments IV and V together and segments VI and VII together.

FOOTNOTE:

* Task segments were discussed in Section 4.

Rehearse and concentrate on segment VI with the addition of segment VII. Demonstrate and rehearse segments under varying wind conditions.

Rehearse segments IV, V, and VI together using varying wind conditions and with different background environments and targets.

Rehearse segments IV, V, and VI from another air-to-ground task.

Demonstrate and rehearse any task segments on a remedial basis as needed.

Instructional Techniques

Initialization - Student is initialized from freeze at the beginning of the task segments specified for rehearsal.

Application - All stated rehearsal events may be applied at the discretion of the instructor. At the initialization, student flies ownship without graphic symbology assistance in real time. Instant in-cockpit replay is used for instruction, and performance is critiqued by student and instructor. Replay performance may be compared with computer-perfect performance and instructor may show additional alternatives. Replay may be seen in real time, slow time, or stop action time modes. Instructor may utilize symbology to designate or stress specific cues or referents. Computer replay programmed demonstrations or instructor demonstrations may be used for remedial instruction.

Instructional Features - Changeable background environments and targets; lead aircraft; instructor manipulated graphic symbology; instant in-cockpit task/segment replay; freeze and reinitialization; instant replay in real time, slow time, or stop action time; computer flown ownship with synchronized aural and graphic instruction; student/instructor communication and instruction; instructor control of student ownship.

4. Advanced Skill Development Phase - Reorganization Events

Reorganization Event Requirements

Rehearse task segments IV, V, and VI until all doubt of concepts, rules, procedures and performance/techniques are replaced by smooth consistent performance.

Rehearse segments I through VII and ensure accuracy in all segments with the introduction of wind and aircraft spacing variables.

Instructional Techniques

Initialization - Student is initialized from freeze at the beginning of task segments specified for rehearsal.

Application - Concentration should first be given to rehearsal of segments IV, V, and VI together under a variety of wind conditions and initialization points. The entire task, or segments I thru VII, should be alternated with the IV, V, VI approach and delivery sub-task. The complete task should contain all the procedures and situations which can occur under range conditions including all communication and WSO input. Instant in-cockpit replay should be used by the student and instructor to critique the performance. Student performance may be compared with computer-perfect performance under a variety of task situations and conditions. All instructional features may be used at the discretion of the instructor for remedial instruction and the presentation of useful performance alternatives.

Instructional Features - Instant in-cockpit replay, computer-perfect graphic comparison, graphic ordnance plot, instructor manipulated symbology, student/instructor communication and instruction, and verbal range officer and WSO input.

4. Advanced Skill Development Phase - Secondary Rehearsal Events

Secondary Rehearsal Event Requirements

Rehearse Low Angle Dive Bomb task interspersed with other learned air-to-ground tasks to determine if visual picture concepts and procedures have become fixed for this task.

Rehearse task in changed range settings, with single or multi-aircraft attack.

Instructional Techniques

Initialization - Student is initialized from freeze at segment I.

Application - In both events, student flies ownship under a variation of situations and conditions. Instructor must deliver all pertinent range officer and WSO communications. Interspersed other air-to-ground ordnance deliveries will require procedures similar to actual conditions. Instant in-cockpit replay of task will provide critique information for student and instructor. Student performance may be compared with computer-perfect performance at the instructor's discretion. The only task oriented graphic symbology required is the bomb plot, although instructor may use all symbology at his discretion.

Instructional Features - Instant in-cockpit replay, computer-perfect graphic comparison, ordnance plot, student/instructor communication and instruction, and WSO's verbal range input.

Secondary Rehearsal Event Requirement

Rehearse task in tactical target and terrain environment.

Instructional Techniques

Initialization - With the departure from the range background environment, initialization should occur over a known landmark for task orientation. There may be a number of suitable initialization points and these should be pre-briefed to the student.

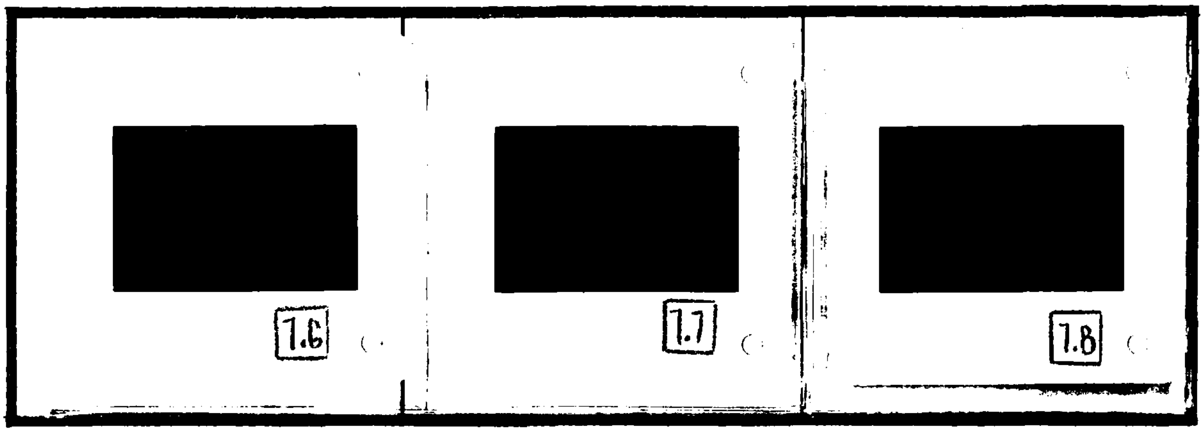
Application - Student flies ownship from pre-briefed initialization point along a short pre-briefed route to a specific target using the Low Angle Dive Bomb as method of ordnance delivery. Ownship may fly as single attacker or as part of an instructor flown two aircraft formation. Ownship may fly lead or wing position at the discretion of the instructor. Instructor must perform all required task communication. Instant in-cockpit replay is used as performance critique material for both student and instructor. The only graphics required is the ordnance plot on target although the instructor may use manipulated graphic symbology as required for critique or instruction. Real time, slow time, and freeze may be used during instant replay. Student performance may be compared to computer-perfect task performance.

Instructional Features - Instant in-cockpit replay, computer-perfect graphic comparison, graphic ordnance delivery plot, instructor manipulated graphic symbology, student/instructor communication and instruction, and verbal WSO or lead aircraft communication. Slide Figures 7.6 through 7.8 show the visual instructional features.

5. Inventive Phase - Adaptive Events

Adaptive Event Requirement

Attempt ordnance delivery from near outside task parameters at various task segment initialization points.



Slide Figures 7.6, 7.7. and 7.8. Non-controlled/
Tactical Background Environments

Instructional Techniques

Initialization - Student is initialized from freeze at pre-briefed point or landmark if not in sight of target.

Application - Student flies ownship first in familiar range background environment initialized at various predetermined near out-of-parameter conditions (too high, too fast, in high winds or unknown turbulent winds) as lead aircraft or wingman. As student becomes proficient, unfamiliar range background environment and targets should be presented under similar non-ideal conditions. Instant in-cockpit task replay is used by student and instructor to critique performance. Student performance should be compared with computer-perfect performance. Instructor should point out techniques which will allow the student to negotiate the difficult parameters. The instructor may demonstrate techniques and show critical performance areas of the task. Instructor will also perform all required task communication.

Instructional Features - Instant in-cockpit task replay, computer-perfect graphic comparison, graphic ordnance delivery plot, and instructor manipulated graphic symbology, instructor manipulated student ownship and lead aircraft, student/instructor communication and instruction, and verbal WSO or lead aircraft communication.

Adaptive Event Requirement

Attempt ordnance delivery under unusual terrain, weather conditions, target defenses, or target conditions.

Instructional Techniques

Initialization - Student is initialized from freeze at pre-briefed landmark and parameters.

Application - Student flies ownship to perform task over uniquely difficult surface pattern and contour. Delivery parameters are narrow due to a combination of target placement, target defenses, surface layout winds and visual attenuation. Student is briefed and oriented as to location prior to initialization. Instant in-cockpit replay is used by student and instructor to critique task performance. Student performance should be graphically compared with computer-perfect performance flying techniques and procedures. Useful cues and referents should be shown and explained so the student may gain skill experience and judgement. Instant replay and computer-perfect performance should be run in real time and slow time so that all visual cues and analyses of critical task areas can be assimilated. Instruction should also show outside-the-cockpit view of task performance which shows ownship, ground track, aerial track, and surface layout.

Instructional Features - Instant in-cockpit task replay, computer-perfect task performance, ordnance delivery plot, and instructor manipulated graphic symbology, instructor manipulated student ownship, instructor manipulated lead/wing aircraft, student/instructor communication and instruction, and verbal WSO or other aircraft communication.

Summary - The learning plans for the two tasks were the culmination of a multistep process to determine an experience-judgement approach to tactical flying training. The lists of instructional features, which resulted from the instructional techniques, have been shown to be similar. Basic differences exist, however, in the kinds of background environments to be presented and the types of target related cues and referents to be used for the two tasks. The manner in which such features as graphic symbology were employed is also somewhat different. The

Slide Figures which have been incorporated into the learning plans, suggest only some of the visual enhancement possibilities for an appropriate synthetic training device. The Slide Figures are general in nature and a detailed visualization of the instructional features of these tasks would require at least one or two illustrations for each training event. In some cases the animation of an entire event sequence, in perhaps a number of visual alternatives, would not only be useful but necessary to determine the best features. This animation process could also be accompanied by alternative voice instruction and other non-visual features.

The tasks chosen to work with in this research are basic and rather simple in terms of a fighter pilot's total task/skill repertoire. Thus, the resulting instructional techniques and features were also somewhat simple in requirement. With a systemized approach such as this now in place, however, it should be possible to go on to more complex tasks with a higher degree of confidence regarding useful results. The integrated relationship of the scientist, engineer, and graphic designer suggests that a wide range of instructional techniques and instructional features can be forthcoming. These two learning plans should be thought of as just the beginning.

CONCLUDING STATEMENT

> "If I were faced with the problem of improving training, I should not look for much help from the well-known learning principles like reinforcement, distribution of practice, response familiarity, and so on. I should look instead at the technique of task analysis and at the principles of component task achievement, intertask transfer, and the sequencing of subtask learning to find those ideas of greatest usefulness in the design of effective training" (Gagne, 1962, p. 90).

The experience-judgement approach provided one means of meeting the alternative techniques suggested by Gagne. Through the integrated application of many areas, tactical training concepts for fighter pilots were developed. Based on a theory of how pilots perform, a task analysis methodology led to training goals and training requirements including the specification of the visual environment. These goals and requirements provided the basis for the rational design of synthetic device features.

The approach, however, is not yet complete. Only two relatively simple tactical maneuvers out of many complex fighter maneuvers have been analyzed. The role of input made by instructors also remains to be determined. An engineering conversion methodology and implementation plan procedure must be developed in order to identify hardware requirements which will meet current technology. Above all, this approach must be validated to ensure that it is logical and that it can deal with all training needs.

These still unanswered areas lead to the need for additional efforts which will take this conceptual approach and add those components so that courseware and hardware specifications can be developed. Along with software requirements, these specifications can be used to form plans which will describe everything that is needed to build the training environment. Experimental tryouts of training plans then could be conducted to determine their effectiveness.

The experience-judgement approach appears feasible wherever experience and judgement must be gained without long on the job training. The theory of how pilots operate is not exclusive to those complex tasks alone. Many positions such as tank commanders, submarine captains and nuclear power plant control room operators all require the development of similar types of judgement skills which must be sharply honed and available from the first day of action. The analysis techniques and functional methodologies structured in this research also have general applicability to a broad range of training where critical tasks have predominately visual input to the operator. Thus, the start made here to define how judgement is acquired can have both general application and far-reaching results.

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GLOSSARY

Aerial Layout - that group of sky cues and corresponding referents which extend up from the horizon.

Aerial Target - a craft capable of flight, designated as an object of search or attack.

Anticipate - the mental activity which occurs prior to a particular portion or segment of a task and triggers the decision process for a number of subsequent task sequences.

Anticipation Point - the position in a task where an alternative task or task segment may be selected.

Aural Cues - forms of physical energy which act as stimuli to the ear.

Background Cues - those cues away from the pilot and the aircraft which comprise the end of space.

Behavioral Goals - the explicit statements of what is to be learned in order to accomplish a task.

Checkpoint - a conspicuous object or prominent surface feature which has been designated as a specific location reference or action point.

Cloudform - an obscured area imposed over the skytone.

Cognitive Requisites - the critical judgemental factors which are essential to the performance of a particular action sequence of the expanded surface analysis.

Color - the light energy spectrum which is visible to the eye.

Contact Flying - flight which occurs under Visual Flight Rules (VFR) and where the major portion of visual information is from background cues. (Also see Background Cues.)

Contour - the visual delineation characteristics within the outline shape or boundary of a form.

Contrast - the comparison of the intensity levels of light energy as they are reflected from the surface of forms.

Control Cues - stimuli which can be sensed by the body limbs or extremities through the control devices of the aircraft.

Cues - forms of physical energy which are perceptible by the human sensory system and interpretable by the brain.

Cuing Activity - the useful purpose by which the pilot utilizes specific cues and referents to achieve task goals.

Cuing Referents - the useful visual elements and symbologies contained within a cuing form.

Detail - the visual emergence of an individual part or parts from a larger structure or area.

Detection - the determination of the presence or existence of a specific cuing object, such as a target.

Direction - the position of a specific set of useful cues relative to the actual clock and elevation position of the viewer.

Experience - the skill or understanding which is the result of practice, participation, or of living through something.

Foreground Cues - those visual cues and referents which are made up of portions of the aircraft within the pilot's field of view.

Fuselage Plane - an imaginary line drawn fore and aft through the fuselage of an aircraft.

Geomorphic Considerations - the character and arrangement of the earth's surface relative to specific layout features.

Good Judgement - the exercise of the judgemental process in which the decision or decisions made result in the valid outcome of the task performance. (Also see Judgement.)

Gradient - the rate of change taking place on useful cuing referents of a variable nature in perceptible degrees or stages.

Horizontal Constant - the real or imaginary line referent of the earth's profile.

Identification - the use of the visual and cognitive processes to recognize the usefulness of a cue.

Initial Point (IP) - a conspicuous object or prominent surface feature which has been designated as a specific tactical action starting point.

Instructional Features - those device characteristics which allow the background and ownship environments to be controlled and manipulated to enhance or accentuate appropriate cues or cuing referents to create unique training experiences.

Instructional Techniques - the particular training methodology with a training plan which states the utilization of appropriate instructional features to achieve stated behavioral goals.

Judgement - the process of discovering an objective or intrinsic relationship between two or more objects, facts, experiences, or concepts. (Also see Spacial Judgement and Organizational Judgement.)

Landmark - a prominent pattern or profile feature which serves the pilot as a guide to location. (Also see Pattern and Profile.)

Learning - the change in human disposition or capability which persists over a period of time, and which is not simply ascribable to the process of growth.

Location - the estimation or determination of the course of ownship.

Long Term Memory - information which was acquired and stored in the brain prior to the performance of a task.

Mental Action - the cognitive process initiated by perceived stimulus cues and preceding the motor action.

Motion Cues - stimuli which can be sensed by the body receptors as a result of aircraft movement onset.

Motor Action - the physical output resulting in movement of aircraft controls.

Movement - the relative and/or actual degree of displacement between a specific set of cues as compared over an interval of time.

Organizational Judgement - the synthesis of learned knowledge and perceived information in order to make decisions or form conclusions about real time flying situations.

Ownship Environment - foreground and performance cuing areas which relate the pilot and aircraft to the background cues. (Also see Foreground Cues and Performance Cues.)

Pattern - the clustering of similar physical parts or materials in a specific area with a definable boundary shape.

Performance Cues - those visual and non-visual cues and referents which constitute the aerodynamic energy management and equipment capability represented by the cockpit.

Perspective - linear perspective is the visual alteration of boundary shapes and contours of objects as a result of differing distances and viewing angles.

Profile - the visible changes in the elevation of the earth's surface.

Range - the amount of space between a set of useful cues.

Shape - the visible outline or edge characteristics of a form or area.

Short Term Memory - information which was obtained during a task and retained for a minimum duration.

Size - the relative magnitude of a shape or contour characteristic within a shape.

Skytone - the vertical light gradation of a sky area free of cloudform.

Spacial Judgement - the synthesis of perceived information which is used to estimate real time flying situations.

Status - the estimation or conclusion of the performance condition of ownship.

Stylization - the portrayal of useful and essential visual elements of objects/cues relative to their identification.

Surface Layout - that group of ground cues and corresponding referents which describe the earth's outer surface.

Tactical Implications - the type of task to be trained relative to the terrain/tactical environment in which it should be trained.

Texture - the characteristic structure of a surface given it by the physical size, shape, density, arrangement, and proportion of its individual parts.

Tracking - the alignment of ownship with another object within established parameters.

Training Event - the instructional activity needed to achieve the stated behavioral goals within a particular learning phase.

Vertical Construct - the imaginary perpendicular referent from the horizontal constant. (Also see Horizontal Constant.)

Vicarious Experience - the emotional involvement in the performance of a task as it occurs in a synthetic medium or device.

Visual Cues - forms of physical energy which act as stimuli to the eye.

Visual Elements - the physical properties of cues which visually describe their surface form.

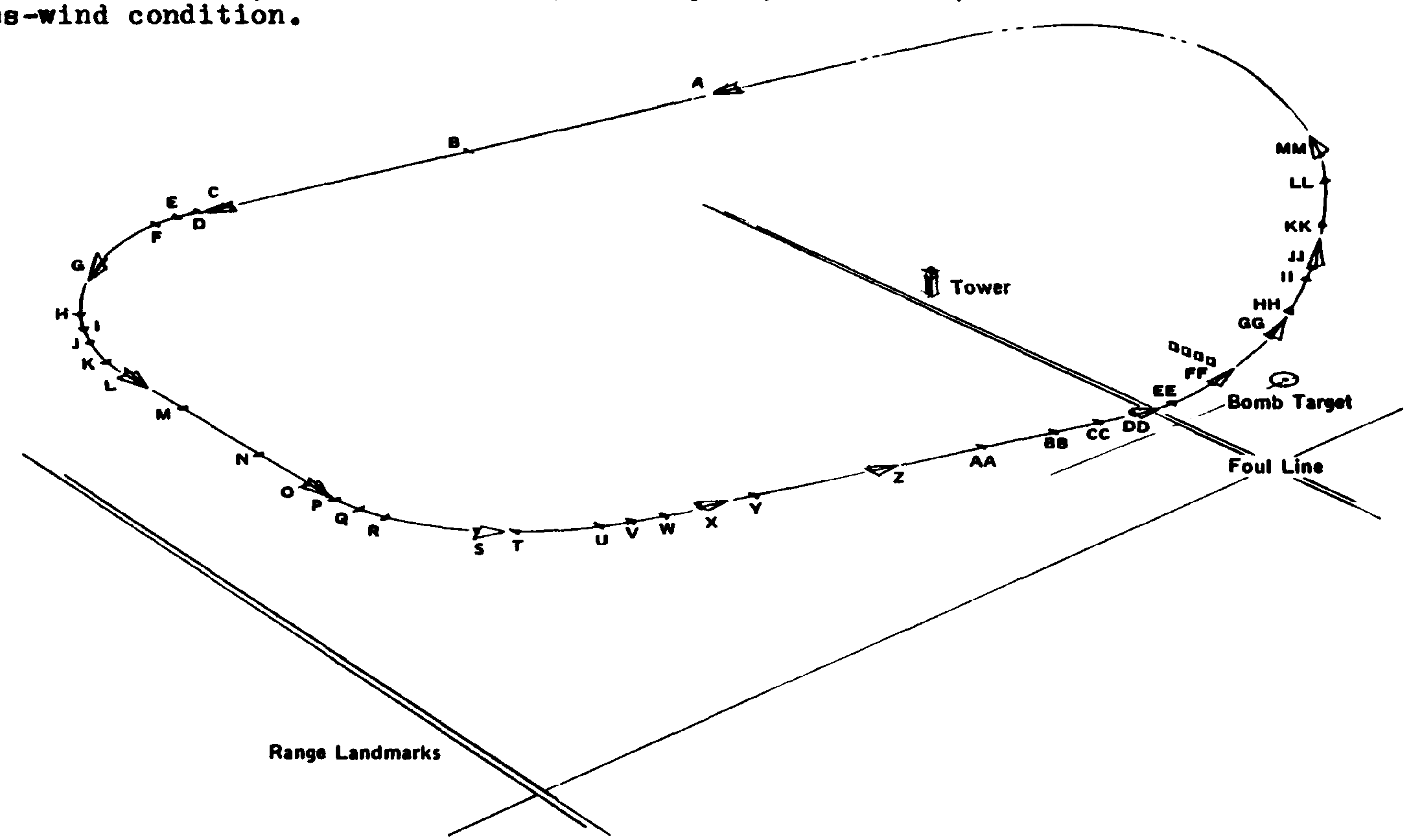
Wing Plane - an imaginary line drawn through from wing tip to wing tip of an aircraft.

Word-Picture - a written data format which contains sufficient essential visual descriptions to permit the visualization of task related background environments.

APPENDIX A. SURFACE TASK ANALYSES

LOW ANGLE DIVE BOMB DELIVERY/Controlled Range

SITUATION - Established on downwind, straight and level, 3,500 feet AGL, 400 kts., weapons select switches set and confirmed with WSO, second aircraft, first pass, new event, cross-wind condition.



TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
A.	Sequence Goal: ESTABLISHED ON DOWNWIND TO TARGET			
	Visual Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (attitude) & Direction		
	Ground		Determines proper spacing from lead & distance from target	
	*Target-(shape, size, contrast, contour, perspective) to ownship	Range, Direction & Location		
	*Patterns-(shape, size, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction	Sustains level flight	
	*Landmarks-(shape, size, contour, contrast, perspective) to ownship	Identification & Location		Maintains required aileron & stabilator control
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish target location from terrain features and lead aircraft

Angular Concepts - Recognition of relative geometry of target and position in pattern relative to lead aircraft

Organizational Judgement

Data - range procedures, altitude, airspeed and weapons system procedures

Strategy - initial selection of bomb pattern and ranking possible alternatives, rules of thumb to achieve bombing accuracy

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
B.	Sequence Goal: TO CONTINUE DOWNWIND			
	Visual- Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape, contour - Horizontal Constant) to ownship	Movement (attitude) & Direction	Determines base roll in position approaching	
	Ground			
	*Target-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Range & Location relative to ownship	Sustains level flight	
	*Patterns-(shape, size, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		Maintains required aileron and stabilator control
	*Landmarks-(shape, size, contour, contrast, perspective) to ownship	Location		
	Ownship			
	*Flight Instr.-airspeed & altitude readout values	Status		
	Aural-Normal aircraft sounds	Stable Reference Info.		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish base leg roll in position from terrain features

Angular Concepts - to estimate position for roll in relative to desired dive angle and geometry of the range pattern

Organizational Judgement

Data - range procedures, proper pattern, altitude & airspeed, weapons system procedures

Strategy - planning and selection of concepts regarding base leg roll in

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
C.	Sequence Goal: TO PREPARE FOR TURN TO BASE			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (attitude) & Direction	Anticipates roll in to base leg	
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range & Location relative to ownship	Sustains level flight	
	*Patterns-(shape, size, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		Maintains required aileron and stabilator control
	*Landmarks-(shape, size, contour, contrast, perspective) to ownship	Location		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish base leg position from terrain features & position relative to target

Angular Concepts - to estimate position to start turn into base relative to wind and desired dive angle

Organizational Judgement

Data - range procedures, airspeed, altitude & weapons system

Strategy - comprehension of alternative pattern if base leg choosen is not correct for environment considerations

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING*REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
D.	Sequence Goal: TO START ROLL IN TO BASE			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (attitude) & Direction	Determines position to roll in to base & maintain proper spacing	
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range & Location relative to ownship		Coordinates aileron & rudder movement with stabilator pressure
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Aural-Normal aircraft sound	Stable Reference Info.		
	communication (lead cleared in hot by range officer)	Tactical Information		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish base leg position from terrain features and range landmarks

Angular Concepts - to estimate position and roll in rate to start turn

Organizational Judgement

Data - range procedures, pattern, airspeed and altitude

Strategy - decision to start turn to maintain desired location in pattern

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
E.	Sequence Goal: TO CONTINUE ROLL IN			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (roll in rate, turn rate) & Direction		
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range & Location relative to ownship		
	*Patterns-(size, shape, contrast, contour, perspective) to ownship	Movement & Direction	Determines satisfactory roll rate and need for power	
	*Landmarks-(shape, size, contrast, contour, perspective) to ownship	Location		Maintains coordinated aileron & rudder pressure, increased stabilator pressure, adjusts throttle
	Aural-Change in aircraft sound	Control Feedback		
	Control-Increased aileron, stabilator, & rudder pressure	Adjustment Feedback		
	Motion-Positive g onset, pitching up and rolling	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish that roll in rate is at the required rate to make turn as desired

Angular Concepts - to estimate roll in rate to be as required to produce needed turn rate

Organizational Judgement

Data - range procedures, pattern knowledge

Strategy - decision that roll in rate is satisfactory

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
F.	Sequence Goal: TO STOP ROLL IN			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (roll rate & turn rate) & Direction	Determines proper bank attitude approaching	
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range & Location relative to ownship		Coordinates aileron & rudder pressure, maintains stabilator pressure
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	*Landmarks-(shape, size, contrast, contour, perspective) to ownship	Location		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Constant aileron & rudder, increased stabilator pressure, throttle advance	Adjustment Feedback Discrete Feedback		
	Motion-Increasing positive g, pitching up, and rolling	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish that sufficient bank angle & turning rate approaching to make turn

Angular Concepts - to recognize that proper turn rate and bank angle is approaching

Organizational Judgement

Data - range procedures

Strategy - comprehension that roll must be stopped to achieve proper turn rate

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
G.	Sequence Goal: TO ESTABLISH TURN TO BASE			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (bank angle, turn rate) & Direction	Determines need to communicate (position & fuel to range officer)	
	Ground			
	*Target-(size, shape, contrast contour & Perspective) to ownship	Range & Location relative to target		
	*Patterns-(shape, size, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction	Sustains turn	
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		Activates mic. button, communicates, maintains required aileron & stabilator control
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Neutral aileron & rudder, constant stabilator pressure	Support Feedback		
	Motion-Constant positive g, pitch and roll stabilized	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish that turn rate is satisfactory in placing base leg at desired position from target

Angular Concepts - to recognize significance of proper base leg relative to target

Organizational Judgement

Data - range procedures, pattern, airspeed, altitude, and communication requirements

Strategy - comprehension of proper turn rate base leg accomplished & initial planning of next segment

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
H.	Sequence Goal: TO PREPARE TO ROLL OUT			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(shape, size, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (bank angle & turn rate) & Direction		
	Ground		Anticipates roll out to base	
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range & Location relative to ownship	Sustains turn	
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		Maintains required aileron & stabilator control
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Aural-Normal aircraft sounds communication	Stable Reference Info.		
	Control-Aileron & stabilator pressure, mic. switch function	Support Feedback Discrete Feedback		
	Motion-Constant positive g, pitch & roll constant	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish position to start roll out

Angular Concepts - to recognize the importance of required base leg geometry relative to target

Organizational Judgement

Data - range procedures

Strategy - comprehension of follow through task segments following completion of roll out

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
1.	Sequence Goal: TO START ROLL OUT Visual — Sky *Skytone-(color & gradient) *Lead Aircraft-(shape, size, perspective) to ownship	Range & Tracking in pattern		
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour -Horizontal Constant) to ownship	Movement (bank angle & turn rate) & Direction	Determines position to roll out to base for spacing and distance from target	
	Ground *Target-(shape, size, contrast contour, perspective) to ownship	Range & Location relative to ownship		
	*Patterns-(shape, size, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		Coordinates aileron & rudder with stabilator movement
	*Landmarks-(shape, size, contrast, contour, perspective) to ownship	Location		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Aileron & stabilator pressure	Adjustment Feedback		
	Motion-Constant positive g, pitch & roll constant	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish lead aircraft position and relative target position

Angular Concepts - to recognize significance of changes in target perspective and changes in geometry of range landmarks

Organizational Judgement

Data - range procedures, pattern altitude & airspeed, weapons delivery procedures/slant range as a function of base leg position

Strategy - decision to start roll out to complete the turning task from downwind to base

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
J.	Sequence Goal: TO CONTINUE ROLL OUT			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(shape, size, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (roll out rate & turn rate) and Direction	Determines satisfactory roll rate & need to reduce power	
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range & Location relative to ownship		
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		Maintains coordinated aileron & rudder pressure, relaxes stabilator pressure, adjusts power
	*Landmarks-(shape, size, contrast, contour, perspective) to ownship	Location		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Increased aileron, stabilator, & rudder pressure	Adjustment Feedback		
	Motion-Decreasing positive g, pitch & roll constant	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish proper spacing between lead and ownship & roll out rate sufficient to effect roll out on desired point

Angular Concepts - to recognize significance of changes in target angular relationship to ownship and position to lead aircraft

Organizational Judgement

Data - range procedures, pattern altitude, airspeed, weapons delivery

Strategy - comprehension that roll out must be completed on point that will place base leg at required distance from target

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
K.	Sequence Goal: TO STOP ROLL Visual Sky *Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon *Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (roll out rate & turn rate) and Direction	Determines wings level approaching	
	Ground *Target-(size, shape, contrast, contour, perspective) to ownship	Range & Location relative to ownship		Moves aileron & rudder, relaxes stabilator pressure
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	*Landmarks-(shape, size, contrast, contour, perspective) to ownship	Location		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Constant aileron & rudder pressure, throttle reduction	Support Feedback		
	Motion-Decreasing positive g, pitch decreasing, rolling	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish wings level position and turn rate stopped

Angular Concepts - to estimate target relative position is correct for position in pattern

Organizational Judgement

Data - range procedures

Strategy - comprehension that roll out on base segment is complete & planning for next segment

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
1.	Sequence Goal: TO ESTABLISH LEVEL FLIGHT ON BASE LEG			
	Visual Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Location in pattern		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (attitude) & Direction	Determines need to adjust altitude & airspeed for proper spacing	
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Location & Range relative to ownship		Decreases stabilator pressure, and adjusts throttle
	*Pattern-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Detection, Identification & Location		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Increased aileron & rudder, decreased stabilator pressure	Adjustment Feedback		
	Motion-Normal g, pitch & roll stabilized	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish wings level position from visual elements

Angular Concepts - to estimate position on base leg is correct relative to target and dive angle requirements

Organizational Judgement

Data - range procedures

Strategy - comprehension that base leg to target distance relationship is important to achieve necessary dive angle

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TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
M.	Sequence Goal: TO CONTINUE BASE LEG			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (attitude) & Direction		
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range & Location relative to ownship	Determines proper altitude, airspeed & spacing approaching	
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		Increases stabilator pressure
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Identification & Location		
	Ownship			
	*Flight Instr.-(airspeed & altitude readout values)	Status		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Increased stabilator pressure, throttle reduction	Adjustment Feedback		
	Motion-Normal g, pitching down	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish wings level from visual elements

Angular Concepts - to recognize relationship of ownship position on base relative to target range (distance from base leg)

Organizational Judgement

Data - range procedures

Strategy - determination that base leg portion of task has been accomplished

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
N.	Sequence Goal: TO CONTINUE BASE LEG			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern	Determines proper altitude, airspeed & track; need to trim & communicate (position to range officer)	
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (attitude) & Direction		
	Ground			Activates mic. button, communicates, adjusts trim & relaxes stabilator pressure
	*Target-(shape, size, contrast, contour, perspective) to ownship	Range, Direction & Location relative to ownship		
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Ownship			
	*Flight Instr.-(altitude & airspeed readout values)	Status		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Increased stabilator pressure	Adjustment Feedback		
	Motion-Positive g, pitch stabilized	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the amount of crab required to maintain track on base leg

Angular Concepts - to estimate ownship position correct to achieved required dive angle on final

Organizational Judgement

Data - range procedures, communication procedures, aircraft trim procedures

Strategy - comprehension of subsequent task segment for roll in to final dive heading

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
0.	Sequence Goal: TO PREPARE TURN TO FINAL			
	Visual Sky/Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement(attitude) & Direction		
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range, Direction and Location relative to ownship	Anticipates roll in and dive	
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location	Sustains level flight	Maintains required aileron and stabilator pressure
	Aural-Normal aircraft sound, communication (clearance from range officer)	Stable Reference Info. Tactical Information		
	Control-Neutral stabilator pressure, mic. switch function	Support Feedback Discrete Feedback		
	Motion-Normal g	Support Reference Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish relative position of target to initiate roll in to final

Angular Concepts - to estimate the point to initiate roll in on target

Organizational Judgement

Data - range procedures, dive bomb techniques

Strategy - comprehension of roll in techniques to achieve proper azimuth for final approach

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
P.	Sequence Goal: TO START ROLL IN AND DIVE			
	Visual Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (roll in & turn rate) & Direction		
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range, Direction & Location relative to ownship	Determines position to roll in to final & need for power	
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Direction & Motion		Coordinates aileron & rudder movement, maintains stabilator pressure, moves throttle
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Aural-Normal aircraft sound Control-Aileron & stabilator control Motion-Normal g	Stable Reference Info. Support Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish rate of aircraft movement

Angular Concepts - to recognize positional relationships of target relative to ownship

Organizational Judgement

Data - range procedures, dive bomb pattern techniques, fire control system procedures

Strategy - comprehension of roll in principles

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
Q.	Sequence Goal: TO CONTINUE ROLL IN AND DIVE Visual Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (roll in rate, turn rate & attitude change) & Direction	Determines satisfactory roll rate & need to begin to establish dive	
	Ground *Target-(size, shape, contrast, contour, perspective) to ownship *Patterns-(size, shape, contrast, contour, perspective) to ownship	Range, Direction, Movement & Location to ownship Movement & Direction		Maintains coordinated aileron & rudder pressure, relaxes stabilator pressure
	Aural-Change in aircraft sound	Control Feedback		
	Control-Increased aileron & rudder pressure, constant stabilator pressure, throttle advance	Adjustment Feedback		
	Motion-Positive g onset, rolling	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish roll in rate is correct to produce projected turn rate

Angular Concepts - to recognize significance of ownship geometry relative to target & final run in track location

Organizational Judgement

Data - range procedures, dive bomb pattern techniques, fire control procedures

Strategy - comprehension of roll in task segment principles

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
R.	Sequence Goal: TO STOP ROLL IN AND DIVE			
	Visual Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (bank angle turn rate, dive angle) & Direction	Determines proper roll and dive attitude achieved	Coordinates aileron & rudder pressure, maintains stabilator pressure
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction (target picture) to ownship		
	*Patterns-(size, shape, contrast contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Constant aileron & rudder pressure, decreased stabilator pressure	Support Feedback		
	Motion-Positive g, pitching down, rolling	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the rate of turn and dive angle approaching relative to target

Angular Concepts - to estimate and recognize the significance of the proper turn rate & dive angle approaching, relative to ownship position from target

Organizational Judgement

Data - range procedures, dive bomb pattern techniques, fire control system procedures

Strategy - decision to stop roll in and dive

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
S.	Sequence Goal: TO ESTABLISH DIVING TURN Visual Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (bank angle, turn rate, dive angle) & Direction	Sustains descending turn	
	Ground *Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction (target picture) relative to ownship		Maintains required aileron & stabilator control
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Neutral aileron & rudder pres., constant stabilator pressure	Support Feedback		
	Motion-Positive g, pitch & roll stabilized	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish turn rate & dive angle as satisfactory

Angular Concepts - to recognize significance of positional relationships such as range & angle, and dive angle to target

Organizational Judgement

Data - dive bomb techniques and numbers, fire control system procedures

Strategy - comprehension of next task segment in maneuver

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
T.	Sequence Goal: TO PREPARE TO ROLL OUT ON FINAL			
	Visual — Sky/Horizon *Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (bank angle, turn rate, dive angle) & Direction	Anticipates roll out to final dive	
	Ground *Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction (target picture) relative to ownship		Maintains required aileron & stabilator control
	*Pattern-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Aileron, stabilator & rudder pressure	Support Feedback		
	Motion-Positive g, pitch & roll constant	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the relative movement of target

Angular Concepts - to estimate and recognize significance of relative position of ownship velocity vector to target/range and size of target

Organizational Judgement

Data - dive bomb pattern techniques, fire control system procedures

Strategy - comprehension of roll out principles to avoid pendulum effect, etc.

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
U.	Sequence Goal: TO START ROLL OUT AND MAINTAIN DIVE			
	Visual Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (roll out rate, turn rate, dive angle) & Direction	Determines proper position to roll out to final with satisfactory dive angle	
	Ground *Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement and Direction (target picture)		
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Moveme.. & Direction		Coordinates aileron and rudder, maintains stabilator pressure
	Ownship *Sight-(combining glass/reticle) to target shape	Range & Tracking		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Positive g, pitch & roll constant	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish relative movement of target position to ownship

Angular Concepts - to recognize significance of sight position relationship and the tracking movement towards target

Organizational Judgement

Data - dive bomb pattern techniques, fire control systems procedures

Strategy - comprehension of target & sight tracking in accordance with rules and principles of dive bomb maneuver

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
V.	Sequence Goal: TO CONTINUE ROLL OUT AND MAINTAIN DIVE			
	Visual — Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (roll out rate, turn rate, dive angle) & Direction		
	Ground *Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement and Direction (target picture)	Determines satisfactory roll out rate & need to reduce power	
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		Maintains coordinated aileron & rudder pressure, constant stabilator pressure, moves throttle
	Ownship *Sight-(combining glass/reticle) to target shape	Tracking & range		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Increased aileron & rudder pressure, constant stabilator pressure	Support Feedback		
	Motion-Positive g, pitch constant, rolling	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish required amount of dive and track relative to target

Angular Concepts - to recognize significance of sight position relationship & its movement towards target

Organizational Judgement

Data - dive bomb pattern techniques, fire control system procedures

Strategy - comprehension of target & sight tracking rules and principles

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
W.	Sequence Goal: *TO STOP ROLL AND MAINTAIN DIVE*			
	Visual — Sky/Horizon			
	*Skytone-(color & gradient)	Movement (dive angle/ attitude) & Direction		
	*Profile-(shape & contour-Horizontal Constant) to ownship			
	Ground		Determines wings level	
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction		Moves aileron & rudder, maintains stabilator pressure
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	Ownship			
	*Sight-(combining glass/reticle) *to* target shape and size	*Tracking & Range*		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Constant aileron & rudder, constant stabilator pressure, throttle reduced	Support Feedback Adjustment Feedback		
	Motion-Decreasing positive g, pitch constant, rolling	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish desired sight position relative to target location

Angular Concept - to recognize significance of target position relative to sight position

Organizational Judgement

Data - dive bomb pattern techniques, fire control system procedures

Strategy - comprehension of final task segment

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
X.	Sequence Goal: TO BECOME ESTABLISHED ON FINAL APPROACH TO THE TARGET			
	Visual Sky/Horizon			
	*Skytone-(color & gradient)	Movement (dive angle & attitude) & Direction		
	*Profile-(shape & contour-Horizontal Constant) to ownship		Determines proper airspeed, altitude, and dive angle approaching; and need for trim	
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction		Adjusts trim, maintains stabilator pressure
	*Patterns-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		
	Ownship			
	*Sight-(sight reticle) to ownship	Range & Tracking		
	*Flight Instr.-ADI, altitude, airspeed readout values	Status		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Increased aileron & rudder, constant stabilator pressure	Adjustment Feedback		
	Motion-Normal g, pitch & roll stabilized	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish target and adjust tracking for wind correction

Angular Concepts - recognize significance of sight track rate for correct position at weapons release

Organizational Judgement

Data - dive bomb pattern procedures, & fire control system procedures

Strategy - planning for final release task

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
Y.	Sequence Goal: TO PREPARE FINAL APPROACH AND PULL-UP			
	Visual Sky/Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (dive angle & attitude) & Direction	Anticipates delivery & pull-up	
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction	Sustains level dive	
	*Patterns-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		Maintains required aileron and stabilator control
	Ownship			
	*Sight-(reticle) to target shape,size	Range & Tracking		
	Aural-Change in aircraft sound	Control Feedback		
	communication - WSO (dive angle, A/S & altitude)	Support Systems Info.		
	Control-Neutral aileron, rudder & stabilator pressure, trim switch function	Support Feedback Discrete Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish movement of sight reference is consistent with range value

Angular Concepts - to recognize significance of sight/target tracking geometry

Organizational Judgement

Data - dive bomb pattern procedures, fire control system procedures

Strategy - comprehension of weapons release principles

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
2.	Sequence Goal: TO START FINAL APPROACH	TO TARGET		
	Visual Sky/Horizon			
	*Skytone-(color & gradient)	Movement (dive angle & attitude) & Direction		
	*Profile-(shape & contour -Horizontal Constant) to ownship		Determines need for crab delivery & to refine dive angle	
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction		Increases required rudder, stabilator & aileron pressure
	*Profile-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		
	Ownship			
	*Sight-(pipper) to target shape, size	Range & Tracking		
	*Flight Instr.-altitude, airspeed readout values	Status		
	Aural-Change in aircraft sound	Control Feedback		
	comm.-WSO (dive angle, A/S, alt)	Support Systems Info.		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish sight tracking reference, position track with target

Angular Concepts - to recognize significance of sight/pipper size with target range information

Organizational Judgement

Data - dive bomb pattern procedures, tracking procedures, fire control systems procedures

Strategy - comprehension that delivery position must change and final approach correction

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
AA.	Sequence Goal: TO CONTINUE FINAL APPROACH			
	Visual — Sky/Horizon *Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (dive angle & attitude) & Direction		
	Ground *Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction	Determines dive refinement & proper crab approaching	
	*Patterns-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		Relaxes required rudder, stabilator & aileron pressure
	Ownship *Sight-(pipper) to target shape,size	Range & Tracking		
	Aural-Change in aircraft sound comm.-WSO (dive angle, A/S,alt.)	Control Feedback Support Systems Info.		
	Control-Increased aileron, rudder & stabilator pressure Motion-Normal g	Adjustment Feedback Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish that crab correction is adjusting target/pipper relationship

Angular Concepts - to estimate the significance of sight/pipper relationship geometry with target position

Organizational Judgement

Data - dive bomb pattern procedures, tracking procedures, fire control system procedures

Strategy - decision that correction has produced required rate of ownship to target position relationship

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
BB.	Sequence Goal: TO CONTINUE FINAL APPROACH			
	Visual Sky/Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (dive angle & attitude) & Direction		
	Ground		Determines proper dive solution	
	*Target-(size, shape, contrast, contour, perspective) to ownship	Range, Movement & Direction		Maintains aileron, stabilator & rudder pressure
	*Patterns-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		
	Ownship			
	*Sight-(pipper) to target shape,size *Flt. Instru.-ADI, A/S, altitude	Range & Tracking Status		
	Aural-Change in aircraft sound comm.-WSO (dive angle, A/S,alt.)	Control Feedback Support System Info.		
	Control-Aileron, rudder, & stabilator pressure	Support Feedback		
	Motion-Normal g, pitch constant	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the alignment of pipper reference with target

Angular Concepts - to recognize significance of approaching relationship of sight/pipper for weapons release

Organizational Judgement

Data - dive bomb pattern procedures, tracking procedures, fire control system procedures

Strategy - comprehension of bomb release criteria

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
CC.	Sequence Goal: TO CONTINUE FINAL APPROACH			
	Visual Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour -Horizontal Constant) to ownship	Movement (dive angle & attitude) & Direction	Determines proper tracking solution approaching	
	Ground *Target-(size, shape, contrast, contour, perspective) to ownship	Movement, Direction & Range	Sustains level dive	
	*Patterns-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		Maintains required aileron, stabilator & rudder pressure
	Ownship *Sight-(pipper) to target size,shape	Range & Tracking		
	Aural-Normal aircraft sound comm.-WSO(dive angle, A/S, alt.)	Stable Reference Info. Support System Info.		
	Control-Aileron, rudder, & stabilator pressure	Support Feedback		
	Motion-Normal g, pitch constant	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish sight/pipper tracking towards target

Angular Concepts - to recognize significance of sight/pipper approaching size relationship with target circle

Organizational Judgement

Data - dive bomb pattern procedures, tracking procedures, fire control system procedures

Strategy - Determination that release parameter goals are approaching

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
DD.	Sequence Goal: TO CONTINUE FINAL APPROACH			
	Visual — Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour -Horizontal Constant) to ownship	Movement (dive angle & attitude) & Direction		
	Ground			
	*Target-(size, shape, contrast, contour, perspective) to ownship	Movement, Direction & Range	Determines proper tracking solution (pipper/target relation)	
	*Patterns-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		
	Ownship		Sustains level dive	
	*Sight-(pipper) to target size,shape	Range & Tracking		Maintains required aileron, stabilator & rudder pressure
	Aural-Normal aircraft sound comm.-WSO(dive angle, A/S, alt.)	Stable Reference Info. Support Systems Info.		
	Control-Aileron, stabilator & rudder pressure Motion-Normal g	Support Feedback Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish sight/pipper tracking movement towards target

Angular Concepts - to recognize significance of sight/pipper approaching size relationship with target circle

Organizational Judgement

Data - dive bomb pattern procedures, tracking procedures, fire control system procedures

Strategy - Determines that release parameter goals are approaching

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
EE.	Sequence Goal: TO RELEASE ORDNANCE			
	Visual Sky/Horizon			
	*Skytone-(color & gradient)	Movement (dive angle & attitude) & Direction		
	*Profile-(shape & contour-Horizontal Constant) to ownship		Determines pickle position	
	Ground		Sustains level dive	
	*Target-(size, shape, contrast, contour, perspective) to ownship	Movement, Direction & Range		Maintains aileron, stabilator & rudder pressure; activates pickle button
	*Patterns-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		
	Ownship			
	*Sight-(pipper) to target	Range & Tracking		
	Aural-Normal aircraft sound	*Stable Reference Info.*		
	comm.-WSO (calls pickle alt.)	Support Systems Info.		
	Control-Minimum aileron, stabilator & rudder pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish that proper sight/target picture is reached

Angular Concepts - to recognize target & sight picture relationship

Organizational Judgement

Data - dive bomb pattern, tracking & fire control procedures

Strategy - decision to release ordnance and initiate recovery task segment

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
FF.	Sequence Goal: TO START OFF TARGET PULL-UP			
	Visual Sky/Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (dive angle & attitude) & Direction	Determines need to initiate smooth g pull	
	Ground			Moves stabilator and rudder
	*Target-(size, shape, contrast, contour, perspective) to ownship	Movement, Direction & Range		
	*Patterns-(size, shape, contrast, contour, texture, perspective - Vertical Construct) to ownship	Movement & Direction		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Minimum aileron, stabilator & rudder pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish range of target and recovery altitude required

Angular Concepts - to estimate size of target and ground contour, and texture to initiate dive recovery

Organizational Judgement

Data - range procedures

Strategy - comprehension of weapons release & execution of recovery segment

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
GG.	Sequence Goal: TO CONTINUE PULL-UP Visual Sky			
	*Skytone-(color & gradient)	Detection		
	*Lead Aircraft-(size, shape, contrast, perspective) to ownship	Range & Direction, Location & Tracking in pattern	Determines satisfactory pitch movement rate & need for power	
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour -Horizontal Constant) to ownship	Movement (attitude rate change) & Direction		Maintains stabilator pressure & throttle movement
	Ground *Patterns-(size, shape, contrast, contour, texture, perspective) to ownship	Direction & Movement		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Detection, Identification & Location		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Increased stabilator & rudder pressure	Adjustment Feedback		
	Motion-Positive g onset, pitching up	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the rate of pitch movement satisfactory to clear ground

Angular Concepts - to recognize significance of rate of pitch movement relative to ownship and the ground

Organizational Judgement

Data - dive bomb pattern recovery procedures & aircraft g limits

Strategy - comprehension of dive recovery approaching and planning following task segment

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
III.	Sequence Goal: TO STOP PULL-UP TO CLIMBING TURN			
	Visual — Sky			
	*Skytone-(color & gradient)	Range, Direction,		
	*Lead Aircraft-(size, shape, perspective) to ownship	Location & Tracking in pattern		
	Horizon		Determines proper pitch attitude approaching	
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (attitude rate change) & Direction		Relaxes stabilator pressure
	Ground			
	*Patterns-(size, shape, contrast, contour, texture, perspective) to ownship	Direction & Movement		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Aural-Change in aircraft sound	Control Feedback		
	Control-Constant stabilator & rudder pressure,	Support Feedback		
	throttle advance	Discrete Feedback		
	Motion-Increasing positive g, pitching up	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish proper pitch attitude approaching and to start climbing turn

Angular Concepts - to recognize significance of maintaining proper distance from lead aircraft

Organizational Judgement

Data - pattern procedures, and aircraft g limits

Strategy - Decision to execute next task segment

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
11.	Sequence Goal: TO PREPARE TRANSITION TO CLIMBING TURN			
	Visual — Sky			
	*Skytone-(color & gradient) *Lead Aircraft-(size, shape, perspective) to ownship	Range, Direction, Location & Tracking in pattern	Anticipates climbing turn	
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (attitude rate change) & Direction	Sustains level climb	Maintains required aileron, stabilator & rudder control
	Ground *Patterns-(size, shape, contrast, contour, texture, perspective) to ownship	Direction & Movement		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Decreased stabilator pressure	Adjustment Feedback		
	Motion-Decreasing positive g, pitch stabilized	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish pitch rate of ownship to lead aircraft

Angular Concepts - to estimate positional relationship of lead aircraft relative to start of turn and turn rate

Organizational Judgement

Data - pattern procedures, airspeeds & altitudes

Strategy - decision to execute climbing turn with confirmation of ownship position in pattern

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
JJ.	Sequence Goal: TO START ROLL IN TO CLIMBING TURN Visual Sky *Skytone-(color & gradient) *Lead Aircraft-(size, shape, perspective) to ownship Horizon *Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship Ground *Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship *Landmarks-(size, shape, contrast, contour, perspective) to ownship Ownship *Flight Instr.-(A/S & alt. readout values) Aural-Normal aircraft sound Control-Decreased stabilator pressure Motion-Decreasing positive g, pitch constant	Range & Tracking in pattern Movement (attitude, roll in rate, turn rate) & Direction Movement & Direction Location Status Stable Reference Info. Adjustment Feedback Control Output Feedback	Determines desired pitch attitude & position to begin roll, need for trim	Coordinates aileron & rudder movement, adjusts trim & relaxes stabilator pressure

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish pitch is satisfactory to initiate roll in to climbing turn

Angular Concepts - to estimate the position to begin roll in based on ownship geometry to lead aircraft and bomb pattern

Organizational Judgement

Data - range pattern procedures

Strategy - planning of follow-on task segments, based on accuracy of last delivery score

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
KK.	Sequence Goal: TO CONTINUE ROLL IN CLIMBING TURN			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (climb attitude, roll rate, turn rate) & Direction	Determines proper pitch attitude & satisfactory roll rate/turn for proper spacing	
	Ground			
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		Maintains coordinated aileron & rudder pressure, maintains stabilator pressure
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Increased aileron & rudder, decreased stabilator pressure, trim switch function	Adjustment Feedback Discrete Feedback		
	Motion-Constant positive g, pitch constant, rolling	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish roll in rate required for ownship range position

Angular Concepts - to recognize the significance of spacial position (altitude & lead aircraft angle off)

Organizational Judgement

Data - range procedures

Strategy - comprehension of initial turn to remain in pattern is correct

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
11.	Sequence Goal: TO STOP ROLL IN CLIMBING TURN			
	Visual Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern	Determines desired pitch attitude & proper bank angle approaching	
	Horizon			
	*Skytone-(color & gradient)			Coordinates aileron & rudder movement, maintains stabilator pressure
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (climb attitude bank angle, turn rate) & Direction		
	Ground			
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Ownship			
	*Flight Instr.-flight & engine readout values	Status		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Constant aileron, rudder & stabilator pressure	Support Feedback		
	Motion-Constant positive g, pitch constant, rolling			

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish sufficient roll and turn from visual elements

Angular Concepts - to recognize significance of leading aircraft position, range and altitude relative to ownship position

Organizational Judgement

Data - range pattern procedures

Strategy - comprehension that climbing turn to remain in pattern is satisfactory and planning follow-on task

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
MM.	Sequence Goal: TO ESTABLISH CLIMBING TURN			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	Range & Tracking in pattern		
	Horizon			
	*Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (climb attitude bank angle, turn rate) & Direction	Determines need for trim, comm.-WSO (calls bomb plot)	Adjusts trim & relaxes stabilator pressure
	Ground			
	*Patterns-(size, shape, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction		
	*Landmarks-(size, shape, contrast, contour, perspective) to ownship	Location		
	Aural-Normal aircraft sound comm.-WSO	Stable Reference Info. Support Systems Info.		
	Control-Neutral aileron & rudder, constant stabilator pressure	Support Feedback		
	Motion-Constant positive g, pitch constant, roll stabilized	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish desired spacing relative to lead aircraft

Angular Concepts - to recognize significance of position in pattern relative to lead aircraft and closure rate

Organizational Judgement

Data - range pattern procedures, airspeeds & altitudes

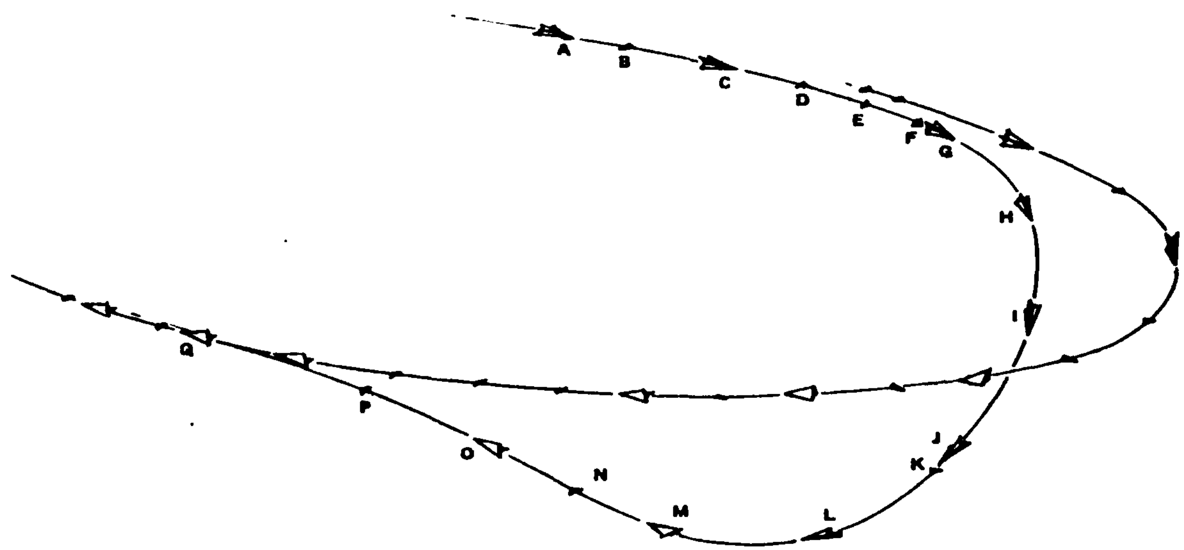
Strategy - comprehension of downwind leg planning upon completion of climbing turn

One v One LOW YO-YO AND COUNTER LOW YO-YO

(Like Aircraft, Missile Shot, Controlled Range)

SITUATION - Attacker in approximately 5:30 position, 12,000 feet out, co-airspeed and altitude.

SITUATION - Defender in a turn at high cruise.



TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
A.	Sequence Goal: TO SIGHT TARGET AND PREPARE FOR ATTACK			
	Visual — Sky *Skytone-(color & gradient) *Target-(size, shape & contrast) to ownship	Detection of target	Anticipates attack	
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement & Direction	Sustains level flight	Maintains required aileron & stabilator control
	Ground *Patterns-(shape, size, contrast & perspective - Vertical Construct) to ownship	Direction		
	Aural-Normal aircraft sound Control-Aileron, stabil. & rudder pres. Motion-Normal g	Stable Reference Info. Support Feedback Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish target shape and relative speed and direction

Angular Concepts - to estimate spacial relationship of target to ownship

Organizational Judgement

Data - target information

Strategy - comprehension of attack situation & initial development of an attack plan with alternatives

TASK NO. 1a   TASK Low Yo-Yo (attacker), Controlled Range   DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
B.	Sequence Goal: TO START ATTACK Visual Sky *Skytone-(color & gradient) *Target-(size, shape, contrast, contour) to ownship	Identification of target		
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour -Horizontal Constant) to ownship	Movement (rate) & Direction (of target to ownship)	Determines need for armament set up and closure with target, need to call "Tally Ho" to WSO	
	Ground *Patterns-(size, shape, contrast & perspective - Vertical Construct) to ownship	Direction & Movement		Communicates, activates Master Arm switch, moves throttle, increases stabilator pressure, activates pinkie switch
	Aural-Normal aircraft sound Control-Aileron & stabilator pressure Motion-Normal g	Stable Reference Info. Support Feedback Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - distinguishes closure rate of target and relative target position

Angular Concepts - to estimate relative target geometry for initial attack phase

Organizational Judgement

Data - knowledge of target visual characteristics, alert procedures, & fire control system procedures

Strategy - confirmation of enemy and attack plan selection

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
C.	Sequence Goal: TO CONTINUE ATTACK AND	START OFFENSIVE TURN		
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(shape, size, contrast, wing plane contour, perspective) to ownship	Movement & Direction of target		
	Horizon			
	*Skytone-(color & gradient)	Movement & Direction (of ownship relative to target)	Determines target's turn	
	*Profile-(shape & contour-Horizontal Constant) to ownship			Coordinates aileron & rudder with stabilator movement
	Ground			
	*Patterns-(size, shape, contrast & perspective - Vertical Construct) to ownship	Direction		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Comm.-WSO (lock-on)	Tactical Information		
	Control-Increased stabilator pressure,	Adjustment Feedback		
	throttle advance to AB,	Discrete Feedback		
	pinkie switch function,	Discrete Feedback		
	master arm switch			
	Motion-Normal g, acceleration	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish roll rate and subsequent turn rate from visual elements

Angular Concepts - to recognize the significance of target turn and matching ownship action

Organizational Judgement

Data - weapons system procedures and operation

Strategy - comprehension that attack plan requires closure and matching turn behind target

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
D.	Sequence Goal: TO CONTINUE OFFENSIVE TURNING ATTACK			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(shape, size, contrast, wing plane contour, perspective) to ownship	Movement & Direction (roll & turn of target) Range	Determines satisfactory roll rate, communication-WSO	
	Horizon			Maintains coordinated aileron & rudder, increased stabilator pressure
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (roll and turn rate of ownship relative to target) & Direction		
	Ground			
	*Patterns-(size, shape, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship			
	*Sight-(analog bar)	Range of target		
	Aural -Change in aircraft sound Comm.-WSO (target range)	Control Feedback Support Systems Info.		
	Control-Increased aileron, stabilator & rudder pressure	Support Feedback		
	Motion-Positive g onset, pitching up, rolling	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the amount of roll rate to match target aircraft from wing plane contour

Angular Concepts - to recognize the significance of matching or exceeding target roll rate

Organizational Judgement

Data - fire control system procedures & range procedures

Strategy - comprehension of offensive turning attack plan

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
E.	Sequence Goal: TO ESTABLISH OFFENSIVE	TURNING ATTACK		
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane contour, perspective) to ownship	Movement, Direction & Range of target		
	Horizon		Determines proper bank attitude approaching & stagnated position	
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (turn rate, bank angle) & Direction of ownship		
	Ground			Coordinates aileron & rudder movement, maintains stabilator pressure
	*Patterns-(size, shape, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship			
	*Sight-(analog bar)	Range of target		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Comm.-WSO (target range)	Tactical Information		
	Control-Constant aileron & rudder pres, increased stabilator pressure	Support Feedback		
	Motion-Increasing positive g, pitching up, rolling	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish that target's turn and bank have been matched by ownship

Angular Concepts - to recognize the significance of matching turning angles and zero closure rate

Organizational Judgement

Data - weapons systems procedures

Strategy - determination that goal to match target turn and bank have been met

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
F.	Sequence Goal: TO MAINTAIN TURNING ATTACK/PREPARE LOW YO-YO			
	Visual — Sky *Skytone-(color & gradient) *Target-(size, shape, contrast, wing plane contour, perspective) to ownship	Movement, Direction & Range of target	Anticipates Low Yo-Yo to close	
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (turn rate, bank angle of ownship) Direction	Sustains turn	Maintains required aileron & stabilator control
	Ground *Patterns-(shape, size, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship *Sight-(analog bar)	Range of target		
	Aural-Normal aircraft sound Comm.-WSO (target range)	Stable Reference Info. Tactical Information		
	Control-Neutral aileron & rudder pres. constant stabilator pressure	Support Feedback		
	Motion-Constant positive g, pitch & roll stabilized			

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the match of ownship turn and bank with target

Angular Concepts - to recognize relationship geometry between ownship and target to accomplish Low Yo-Yo alternate plan

Organizational Judgement

Data - weapons system procedures, WSO call procedures

Strategy - comprehension of principles and rules of Low Yo-Yo maneuver

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
G.	Sequence Goal: TO START YO-YO BY ALTERING TURN			
	Visual Sky			
	*Skytone-(color & gradient) *Target-(size, shape, contrast, wing and fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target	Determines target lead point & need to pull inside target aircraft	
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour-Horizontal Constant) to ownship	Movement (turn rate) & Direction of ownship		Coordinates aileron & rudder pressure with stabilator movement
	Ground *Patterns-(size, shape, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship *Sight-(analog bar)	Range of target		
	Aural-Normal aircraft sound	Support Reference Info.		
	Comm.-WSO (target range)	Tactical Information		
	Control-Aileron & stabilator pres.	Support Feedback		
	Motion-Constant positive g, constant pitch & roll	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish target image relative to target lead position

Angular Concepts - to recognize the significance of target lead point geometry to commence Yo-Yo

Organizational Judgement

Data - weapons systems procedures, meaning of WSO's procedural call

Strategy - comprehension of principles of Low Yo-Yo and planning of this follow-on task segment

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
H.	Sequence Goal: TO ESTABLISH TURN AND START DESCENT			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast wing plane & fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target		
	Horizon		Determines proper lead point (bank) achieved & need to unload g to acquire acceleration	
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (pitch attitude & bank angle) and Direction of ownship		
	Ground			Coordinates aileron & rudder pressure, moves stabilator
	*Patterns-(size, shape, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship			
	*Sight-(analog bar)	Range of target		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Comm.-WSO (target range)	Tactical Information		
	Control-Increased aileron, rudder & stabilator pressure	Adjustment Feedback		
	Motion-Increased positive g, pitching up, rolling	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish proper lead point, range and relative position to target

Angular Concepts - to recognize the significance of small change in angular position of target to indicate that changing ownship position is needed

Organizational Judgement

Data - weapons system procedures

Strategy - comprehension of satisfactory initial start and planning of next segment is required

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
1.	Sequence Goal: TO CONTINUE DESCENT IN ESTABLISHED TURN			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane & fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target	Determines satisfactory pitch movement & bank attitude	
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (pitch attitude & bank angle) & Direction of ownship		Relaxes stabilator pressure, maintains constant aileron & rudder pressure
	Ground			
	*Patterns-(shape, size, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship			
	*Sight-(analog bar)	Range of target		
	Aural-Change in aircraft sound	Control Feedback		
	Comm.-WSO (target range)	Tactical Information		
	Control-Aileron & rudder pressure, decreased stabilator pressure	Adjustment Feedback		
	Motion-Decreasing positive g, pitching down, roll stabilized			

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish pitch movement and bank attitude relative to target is satisfactory

Angular Concepts - to recognize the significance of relative change in ownship geometry to target aircraft

Organizational Judgement

Data - weapons system procedures, WSO procedural calls

Strategy - comprehension that task sequence is satisfactory thus far and planning is required for follow-on

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
J.	Sequence Goal: TO ESTABLISH DESCENDING	TURN		
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane & fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target	Determines proper pitch & bank attitude achieved	
	Horizon			
	*Skytone-(color & gradient)			Coordinates aileron & rudder pressure with constant stabilator pressure
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (pitch attitude bank angle) & Direction of ownship		
	Ground			
	*Patterns-(size, shape, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship			
	*Sight-(analog bar)	Range of target		
	*Flight Instr.-(cross-check of read-out values)	Status		
	Aural-Change in aircraft sound	Control Feedback		
	Comm.-WSO (target range)	Tactical Information		
	Control-Decreased stabilator pressure, constant aileron & rudder pres.	Adjustment Feedback		
	Motion-Unloaded g, pitching down, constant roll	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the degree of descending turn (satisfactory to meet selected target position)

Angular Concepts - to recognize the significance of change in relative angular position of target (meets strategy requirements)

Organizational Judgement

Data - weapons systems procedures, aircraft system numbers

Strategy - comprehension of maneuver principles, and plan next sequence portion (to turn and pull up)

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
K.	Sequence Goal: TO PREPARE FOR TURNING	PULL-UP		
	Visual — Sky *Skytone-(color & gradient) *Target-(size, shape, contrast, wing plane & fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target	(Sufficient energy, lead & altitude separation approaching)	
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour -Horizontal Constant) to ownship	Movement (pitch, bank attitude) & Direction of ownship	Anticipates smooth g pull & missile delivery	
	Ground *Patterns-(shape, size, contrast, perspective - Vertical Construct) to ownship	Direction	Sustains turning descent	
	Ownship *Sight-(analog bar)	Range of target		Maintains required aileron & stabilator control
	Aural-Change in aircraft sound	Control Feedback		
	Comm.-WSO (target range)	Tactical Information		
	Control-Neutral aileron & rudder pres., constant stabilator pressure	Adjustment Feedback		
	Motion-Unloaded g, pitch stabilized, roll constant	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish sufficient energy lead & altitude separation relative to target aircraft

Angular Concepts - to recognize significance of critical angular position relative to target approaching

Organizational Judgement

Data - weapons system procedures

Strategy - decision to execute next portion of attack task segment

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
L.	Sequence Goal: TO START TURNING PULL-UP			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane & fuselage plane contour perspective) to ownship	Movement, Direction & Range		
	Horizon		Determines position to initiate pull back into target's plane	
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement (pitch & bank attitude) & Direction of ownship		Moves stabilator, coordinates aileron & rudder pressure
	Ground			
	*Patterns-(size, shape, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship			
	*Sight-(analog bar)	Range of target		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Comm.-WSO (target range)	Tactical Information		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Unloaded g, constant pitch & roll	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish the proper sight picture of visual elements in relation to approaching pull-up

Angular Concepts - to recognize the significance of spacial geometry position to execute turning pull-up

Organizational Judgement

Data - weapons system procedures, aircraft system numbers

Strategy - planning next task portion of Yo-Yo and possible alternatives

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
M.	Sequence Goal: TO CONTINUE TURNING PULL-UP			
	Visual — Sky *Skytone-(color & gradient) *Target-(size, shape, contrast, wing plane & fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target	Determines satisfactory g (pitch rate) movement & bank attitude (lead)	
	Horizon *Skytone-(color & gradient) *Profile-(shape & contour -Horizontal Constant) to ownship	Movement (pitch attitude change, bank angle) Direction of ownship		Maintains constant stabilator pressure
	Ground *Patterns-(size, shape, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship *Sight-(analog bar)	Range of target		
	Aural-Change in aircraft sound Comm.-WSO (target range)	Control Feedback Tactical Information		
	Control-Increased aileron, rudder & stabilator pressure	Adjustment Feedback		
	Motion-Positive g onset, constant roll	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish change in target's perspective

Angular Concepts - to recognize the significance of pitch rate of ownship relative to target's angle

Organizational Judgement

Data - weapons system procedures, aircraft system

Strategy - comprehension of target position in parameters with plan

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
N.	Sequence Goal: TO ESTABLISH CLIMB RATE AND ALTER TURN			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane & fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target		
	Horizon		Determines proper g loading achieved & need to change bank to refine lead point	
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (pitch & bank attitude) & Direction of ownship		Coordinates aileron & rudder pressure, relaxes stabilator pressure
	Ground			
	(none)			
	Ownship			
	*Sight-(analog bar)	Range of target		
	Aural-Change in aircraft sound	Control Feedback		
	Comm.-WSO (target range)	Tactical Information		
	Control-Constant stabilator pressure	Support Feedback		
	Motion-Constant positive g, pitching up, constant roll	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish visual detail to refine lead point

Angular Concepts - to recognize significance of proper g loading to turn geometry based on target/ownship relationship

Organizational Judgement

Data - target's performance numbers, weapons system procedures

Strategy - planning and determination of execution of final task segment (attack)

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
0.	Sequence Goal: TO START TURNING ATTACK			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane & fuselage plane contour perspective) to ownship	Movement, Direction & Range of target		
	Horizon			
	*Skytone-(color & gradient)		Determines lead point to arrive at missile parameters	
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (turn rate, bank angle & relative attitude of target) & Direction to ownship		Coordinates aileron & rudder pressure, increased stabilator pressure
	Ground			
	(none)			
	Ownship			
	*Sight-(analog bar)	Range of target		
	Aural-Change in aircraft sound	Control Feedback		
	Comm.-WSO (target range)	Tactical Information		
	Control-Increased aileron & rudder pressure with decreased stabilator pressure	Adjustment Feedback		
	Motion-Decreasing positive g, pitching up, rolling	Control Output Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish target's wing plane movement as a change in turn

Angular Concepts - to recognize the significance of tighter turn to lead point and angular relationship between target and ownship

Organizational Judgement

Data - knowledge of missile range parameters and range calls by WSO

Strategy - comprehension of missile launch criteria as related to final Yo-Yo attack segment

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
P.	Sequence Goal: TO CONTINUE TURNING ATTACK AND BEGIN TRACKING			
	<u>Visual</u> Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane & fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target	Determines proper missile parameters approaching	
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour-Horizontal Constant) to ownship	Movement & Direction (bank angle, turn rate & attitude) relative to ownship & target		Maintains required variable aileron, rudder & stabilator pressure
	Ground			
	(none)			
	Ownship			
	*Sight-(reticle) to target	Tracking		
	<u>Aural</u>-Change in aircraft sound Comm.-WSO (target range)	Control Feedback Tactical Information		
	<u>Control</u>-Aileron & rudder pressure, increased stabilator pressure	Adjustment Feedback		
	<u>Motion</u>-Increased positive g, pitching up, rolling	Control Output Feedback		

COGNITIVE REQUISITES

<u>Spacial Judgement</u>

Discrimination - to distinguish target's relative constant visual elements with ownship

Angular Concepts - to recognize significance of approaching geometry which is placing target in required launch position

<u>Organizational Judgement</u>

Data - weapons systems procedures

Strategy - comprehension of following phase of attack strategy

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
Q	Sequence Goal: TO PREPARE TURNING ATTACK AND EXPEND ORDNANCE			
	Visual Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane & fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target	Determines inside missile parameter & proper tracking solution to fire	
	Horizon			
	*Skytone-(color & gradient)	Movement & Direction rate of ownship		
	*Profile-(shape & contour-Horizontal Constant) to ownship			Maintains required variable aileron, stabilator & rudder control, activates trigger
	Ground			
	(none)			
	Ownship			
	*Sight-(pipper) to target (analog bar)	Tracking Range of target		
	Aural-Change in aircraft sound	Control Feedback		
	Comm.-WSO (target tracking)	Tactical Information		
	Control-Aileron, rudder & stabilator pressure	Adjustment Feedback		
	Motion-Constant positive g, pitch stabilized, constant roll	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish target's relative constant visual elements with ownship

Angular Concepts - to recognize the significance of spacial geometry between target and ownship is reaching point of missile launch

Organizational Judgement

Data - weapons systems procedures, knowledge of missile launch envelope and launch procedures

Strategy - planning of post launch alternatives (break or gun shot)

TASK NO. 1a TASK Low Yo-Yo (attacker), Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
H.	Sequence Goal: TO CONTINUE TRACKING TARGET AIRCRAFT			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Target-(size, shape, contrast, wing plane, fuselage plane contour, perspective) to ownship	Movement, Direction & Range of target	Determines need to tighten turn to stay with target and need to call "Fox 2"	
	Horizon			
	*Skytone-(color & gradient)	Movement (rate) of ownship		
	*Profile-(shape & contour-Horizontal Constant) to ownship			Increases stabilator pressure, activates mic. button, communicates
	Ground			
	*Patterns-(size, shape, contrast, perspective - Vertical Construct) to ownship	Direction		
	Ownship			
	*Sight-(pipper) to target (analog bar)	Tracking Range of target		
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Aileron, stabilator & rudder pressure	Support Feedback		
	trigger (missile function)	Discrete Feedback		
	Motion-Constant positive g, constant pitch & roll	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement

Discrimination - to distinguish target's relative constant visual elements with ownship

Angular Concepts - to recognize the significance of firing envelope spacial relationship

Organizational Judgement

Data - weapons systems procedures, & range procedures

Strategy - comprehension of principles of gun shot or break as follow-on alternatives

APPENDIX B. ANALYSES OF COGNITIVE COMPONENTS

Training Events & Behavioral Goals
by Learning Phases

Table B-1 Analysis of Cognitive Components Format
Acceleration Maneuver

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
A.	Anticipates attack	Planning	Organiz. Judg. (Strategy)	To sight target and prepare for attack		
	Sustains level flight	Estimating	Spacial Judg. (Angular Concept)			
B.	Determines need for armament set up - closure on target and "Tally-Ho" call	Remembering	Organiz. Judg. (Data and Strategy)	To start attack	1. To detect target and identify it as hostile	
C.	Determines target's turn	Distinguish	Spacial Judg. (Discrimination)	To continue attack by starting offensive turn	2. To recognize an attack situation & select plan to convert to a win advantage	I
D.	Determines satisfactory roll rate	Estimating	Spacial Judg. (Angular Concept)	To continue offensive turning attack	3. To remember attack facts and procedures 4. To recognize when attack plan is a no-win situation	
E.	Determines proper bank attitude approaching and stagnated position	Estimating Concluding	Spacial Judg. (Angular Concept) Organiz. Judg. (Strategy)	To establish offensive turn		
F.	Anticipates Low Yo-Yo	Planning	Organiz. Judg. (Strategy)	To maintain attack and prepare for Yo-Yo	5. To convert to a win attack by adopting 2nd plan	
	Sustains turn	Estimating	Spacial Judg. (Angular Concept)			II

Table B-1 Analysis of Cognitive Components Format Acceleration Maneuver (Cont'd)

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
G.	Determines target's lead point and need to pull inside target	Predicting Evaluating	Spacial Judg. (Angular Concept) Organiz. Judg. (Data)	To start Yo-Yo by altering turn		
H.	Determines proper lead achieved and need to acquire acceleration	Concluding Evaluating	Organiz. Judg. (Strategy) (Data)	To establish turn and start descent	6. To remember Acceleration Maneuver facts and procedures 7. To predict target lead point	II
I.	Determine satisfactory pitch and bank attitude	Estimating	Spacial Judg. (Angular Concept)	To continue descent in established turn	8. To estimate ownship flight path relative to lead point and target	
J.	Determine proper pitch and bank attitude achieved	Concluding	Organiz. Judg. (Strategy)	To establish descending turn		
K.	Anticipates smooth g pull and missile delivery	Planning	Organiz. Judg. (Strategy)	To prepare for pull up	9. To distinguish lead point/target relative to out-of-plane angles of ownship	
L.	Determine position to initiate pull back into target's plane	Estimating	Spacial Judg. (Angular Concept)	To start turning pull up	10. To remember weapons launch facts and procedures	III
M.	Determines satisfactory g loading	Estimating	Spacial Judg. (Angular Concept)	To continue turning pull up		

Table B-1 Analysis of Cognitive Components Format
Acceleration Maneuver (Cont'd)

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
N.	Determines proper g loading achieved and need to refine lead point	Concluding Evaluating	Organiz. Judg. (Strategy)	To establish climb rate and alter turn		III
O.	Determines lead point to arrive at missile parameters	Estimating	Spacial Judg. (Angular Concept)	To start turning attack	11. To estimate closure angles relative to target lead point and ownship	
P.	Determines proper missile parameters approaching	Estimating	Spacial Judg. (Angular Concept)	To continue turning attack and start tracking	12. To establish final closure angles relative to target/lead point and ownship	
Q.	Determines inside missile parameters and proper tracking solution to fire	Concluding Remembering	Organiz. Judg. (Data and Strategy)	To prepare for turning attack and expend ordnance	13. To recognize correct launch envelope and target/ownship angles	
R.	Determines need to tighten turn (to stay with target and calls "Fox 2"	Estimating Remembering	Spacial Judg. (Angular Concept) Organiz. Judg. (Data)	To continue tracking		

Table B-2 Analysis of Cognitive Components Format
Low Dive Bomb Task

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
A.	Determines proper spacing from lead & distance from target	Concluding	Organiz. Judg. (Strategy)	To be established downwind to target		I
	Sustains level flight	Estimating	Spacial Judg. (Angular Concept)		1. To remember attack facts and procedures	
B.	Determines base roll in position approaching	Predicting	Spacial Judg. (Angular Concept)	To continue downwind	2. To estimate downwind leg track	
	Sustains level flight	Estimating	Spacial Judg. (Angular Concept)			
C.	Anticipates roll in to base leg	Planning	Organiz. Judg. (Strategy)	To prepare for turn to base		II
	Sustains level flight	Estimating	Spacial Judg. (Angular Concept)			
D.	Determines position to roll in to base & maintain proper spacing	Concluding	Organiz. Judg. (Strategy)	To start roll in to base	3. To estimate roll in position to base leg	
					4. To roll in to base leg	
E.	Determines satisfactory roll rate & need for power	Estimating Remembering	Spacial Judg. (Angular Concept) Organiz. Judg. (Data)	To roll in to turn to base	5. To communicate position to range officer	
F.	Determines proper bank attitude approaching	Concluding	Organiz. Judg. (Strategy)	To stop roll in		

Table B-2 Analysis of Cognitive Components Format
Low Dive Bomb Task (cont'd)

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
G.	Sustains turn & determines need to communicate (position & fuel to range officer)	Estimating	Spacial Judg. (Angular Concept)	To estimate turn to base leg		
		Remembering	Organiz. Judg. (Data)			
H.	Anticipates roll out to base	Planning	Organiz. Judg. (Strategy)	To prepare for roll out		
	Sustains turn	Estimating	Spacial Judg. (Angular Concept)			
I.	Determines proper position out to base for proper spacing & distance from target	Concluding	Organiz. Judg. (Strategy)	To start roll out	6. To estimate roll out position 7. To roll out on base leg track 8. To remember base leg facts & procedures 9. To recognize base leg track 10. To communicate position to range officer	III
J.	Determines satisfactory roll rate & need to reduce power	Estimating	Spacial Judg. (Angular Concept)	To continue roll out		
		Remembering	Organiz. Judg. (Data)			
K.	Determines wings level approaching	Estimating	Spacial Judg. (Angular Concept)	To stop roll		
L.	Determines need to adjust altitude & airspeed for proper spacing	Concluding	Organiz. Judg. (Strategy)	To establish level flight on base leg		

Table B-2 Analysis of Cognitive Components Format
Low Dive Bomb Task (cont'd)

SEQ.	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
M.	Determines proper altitude & air-speed & spacing approaching	Concluding	Organiz. Judg. (Strategy)	To continue base leg		
N.	Determines proper altitude, airspeed & track; need to trim & communicate (position to range officer)	Concluding Remembering	Organiz. Judg. (Strategy) Organiz. Judg. (Data)	To continue base leg		
O.	Anticipates roll in & dive	Planning	Organiz. Judg. (Strategy)	To prepare turn to final		
	Sustains level flight	Estimating	Spacial Judg. (Angular Concept)			
P.	Determines posi-tion to roll in to final & need for power	Concluding Remembering	Organiz. Judg. (Strategy) Organiz. Judg. (Data)	To start roll in and dive	11. To remember final approach facts & procedures 12. To estimate roll in position to final approach 13. To roll in to final/dive 14. To estimate bank & dive angle	IV
Q.	Determines satis-factory roll rate & need to begin dive	Estimating Remembering	Spacial Judg. (Angular Concept) Organiz. Judg. (Data)	To continue roll in & dive		
R.	Determines proper roll & dive atti-tude achieved	Concluding	Organiz. Judg. (Strategy)	To stop roll in to dive		
S.	Sustains descending turn	Evaluating	Organiz. Judg. (Strategy)	To establish div-ing turn		

Table B-2 Analysis of Cognitive Components Format
Low Dive Bomb Task (cont'd)

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
T.	Anticipates roll out to final dive	Planning	Organiz. Judg. (Strategy	To prepare to roll out on final		
U.	Determines proper position to roll out to final with satisfactory dive angle	Concluding	Organiz. Judg. (Strategy)	To start roll out & maintain dive		
V.	Determines satisfactory roll out rate & need to reduce power	Estimating Remembering	Spacial Judg. (Angular Concept) Organiz. Judg. (Data)	To continue roll out & maintain dive	15. To estimate roll out position & dive angle to target 16. To roll out with proper estimated airspeed & altitude & dive angle to target	V
W.	Determines wings level	Estimating	Spacial Judg. (Angular Concept)	To stop roll & maintain dive		
X.	Determines proper airspeed, altitude & dive angle approaching; & need for trim	Concluding	Organiz. Judg. (Strategy)	To become established on final approach to target		
Y.	Anticipates delivery & pull up	Planning	Organiz. Judg. (Strategy)	To prepare final approach & pull up		
Z.	Determines need for crab delivery & to refine dive angle	Diff'ntiate	Spacial Judg. (Discriminating)	To start final approach to target		

Table B-2 Analysis of Cognitive Components Format
Low Dive Bomb Task (cont'd)

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
AA.	Determines dive refinement & proper crab approaching	Evaluating	Organiz. Judg. (Strategy)	To continue final approach		VI
BB.	Determines proper dive solution	Concluding	Organiz. Judg. (Strategy)	To continue final approach		
CC.	Determines proper tracking solution approaching	Distinguish	Spacial Judg. (Discrimination)	To continue final approach	17. To remember weapons system facts, procedures & off target pull up	
DD.	Determines proper tracking solution (pipper/target relationship	Distinguish Concluding	Spacial Judg. (Discrimination) Organiz. Judg. (Strategy)	To continue final approach	18. To consider/estimate wind forces on final approach	
EE.	Determines pickle position	Concluding	Organiz. Judg. (Strategy)		19. To control aircraft tracking to sight/pipper system	
	Sustains level dive	Estimating	Spacial Judg. (Angular Concept)	To release ordnance	20. To recognize correct bomb release envelope, sight picture, and release ordnance	
FF.	Determines need to initiate smooth g pull up	Concluding	Organiz. Judg. (Strategy)	To start off target pull up	21. To pull up off target	
GG.	Determines satisfactory pitch movement & need for power	Concluding Remembering	Organiz. Judg. (Strategy) Organiz. Judg. (Data)	To continue pull up		
HH.	Determines proper pitch attitude approaching	Concluding	Organiz. Judg. (Strategy)	To stop pull up to climbing turn		

Table B-2 Analysis of Cognitive Components Format
Low Dive Bomb Task (cont'd)

SEQ	MENTAL ACTION	DECISION FUNCTION	JUDGEMENT	SEQUENCE GOAL	BEHAVIORAL GOAL	TASK SEG.
II.	Anticipates climbing turn	Planning	Organiz. Judg. (Strategy)	To prepare transition to climbing turn		
	Sustains level climb	Estimating	Spacial Judg. (Angular Concept)			
JJ.	Determines desired pitch attitude & position to begin roll, & need for trim	Concluding	Organiz. Judg. (Strategy)	To start roll in to climbing turn	22. To remember off target/preattack facts and procedures	VII
KK.	Determines proper pitch attitude & satisfactory roll rate/turn for proper spacing	Concluding	Organiz. Judg. (Strategy)	To continue roll in to climbing turn	23. To begin reposition of aircraft for next delivery	
		Estimating	Spacial Judg. (Angular Concept)			
LL.	Determines desired pitch attitude & proper bank angle approaching	Concluding	Organiz. Judg. (Strategy)	To stop roll in		
MM.	Determines need for trim & communication (WSO calls bomb plot)	Concluding	Organiz. Judg. (Strategy)	To establish climbing turn		
		Remembering	Organiz. Judg. (Data)			

Table B-3 Training Events and Behavioral Goals by Learning Phases for the Low Angle Dive Bomb Attack

Readiness Phase - Procedural Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Acquire knowledge of altitude, airspeed, dive angle, weapons, weapons select, and range information	1. To remember Low Dive Bomb attack facts and procedures
Acquire knowledge of communication facts and terminology	5. & 10. To communicate position to range officer
Acquire knowledge of range information - airspeed, altitude, heading and spacing	8. To remember base leg facts and procedures
Acquire knowledge of weapons system and set up, dive angle, airspeed, WSO information calls	11. To remember final approach procedures
Acquire knowledge of armament capabilities, safety considerations and limitations and pull up considerations - proper altitude, g loading, bank angle	17. To remember weapons system facts, procedures and off target pull up
Acquire knowledge of event sequences, airspeed, altitude facts and range data	22. To remember off target/ pre-attack facts and procedures

Awareness Phase - Cues Selection Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Recognize landmarks relative to wind drift	2. To estimate downwind leg track
Recognize specific landmark/ target characteristics at approximate roll in position	3. To estimate roll in position
Recognize proper heading and landmark/target relationship	6. To estimate roll out position

Table B-3 Training Events and Behavioral Goals by Learning Phases for the Low Angle Dive Bomb Attack (cont'd)

Awareness Phase - Cues Selection Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Recognize landmarks and positional relationship of base leg to target	9. To recognize base leg track
Recognize landmarks and surface characteristics relative to target as approximate roll in position	12. To estimate roll in position for final dive
Recognize proper pitch and bank angle for final approach with understanding of wind on turn performance	14. To estimate bank and dive angle
Recognize target position relative to proper dive angle from ownship position	15. To estimate roll out position and dive angle to target
Recognize wind effects relative to crab angles required for compensation purposes	18. To consider/estimate wind forces on final approach
Recognize proper slant range and dive parameters for weapons release and how target appears when correct envelope is entered	20. To recognize correct bomb release envelope, sight picture, and altitude to release ordnance

Initial Skill Development Phase - Demonstration Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Show relationship between useful landmarks and ownship visual picture (slant range) from the target	2. To estimate downwind leg track
Show landmark/target relationship and roll in visual picture and flight techniques for various wind and no wind conditions	3. To estimate roll in position to base leg 4. To roll in to base

Table B-3 Training Events and Behavioral Goals by Learning Phases for the Low Angle Dive Bomb Attack (cont'd)

Initial Skill Development Phase - Demonstration Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Show roll out ownship/target position visual picture and proper flight techniques	6. To estimate roll out position 7. To roll out on base leg track
Show landmark/target relationship and correction for wind and no wind conditions	9. To recognize base leg track
Show and relate roll in to slant range, target size and location to possible useful landmarks and proper roll in flight techniques	12. To estimate roll in position to final approach 13. To roll in to final/ dive
Show and relate roll in progression of bank and dive angle to target visual picture	14. To estimate bank and dive angle
Show roll out and dive progression of ownship to target and sighting device	15. To estimate roll out position and dive angle to target
Show variable wind force conditions and their effect on tracking and visual/sight picture	18. To consider/estimate wind force on final approach
Show target to sight/pipper relationship relative to range, dive angle, and airspeed with proper flight techniques	19. To control aircraft tracking with sight/pipper system
Show progression of proper target to pipper movement visual picture relative to correct dive angle and airspeed	20. To recognize correct bomb release envelope
Show target size and dive angle with WSO altitude and airspeed calls as critical to pull off target with pull up flying techniques	21. To pull off target

Table B-3 Training Events and Behavioral Goals by Learning Phases for the Low Angle Dive Bomb Attack (cont'd)

Initial Skill Development Phase - Demonstration Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Show relationship of ownship climbing turn to altitude, spacing position estimates, and proper climb out flight technique	23. To begin reposition of aircraft for next event

Initial Skill Development Phase - Imitation Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Attempt final dive and tracking to target and ordnance release	18. To consider/estimate wind forces on final approach 19. To control aircraft tracking with sight/pipper system 20. To recognize correct bomb release envelope and release ordnance
Attempt roll in and dive to final approach	12. To estimate roll in position to final approach 13. To roll in to final/dive 14. To estimate bank and dive angle. 15. To estimate roll out position and dive angle to target 16. To roll out with proper estimated airspeed, altitude, and dive angle to target

Table B-3 Training Events and Behavioral Goals by Learning Phases for the Low Angle Dive Bomb Attack (cont'd)

Initial Skill Development Phase - Imitation Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Attempt proper downwind parameter and base turn	2. To estimate downwind leg track 3. To estimate roll in position to base leg 4. To roll in to base leg 6. To estimate roll out position 7. To roll out on base leg track
Attempt off target pull up and correct reposition on downwind for next delivery	9. To recognize base leg track Objectives 18, 19, and 20 plus 21. To pull up off target 23. To begin reposition of aircraft for next delivery 2. To estimate downwind track 3. To estimate roll in position to base leg

Initial Skill Development Phase - Primary Rehearsal Events

EVENT REQUIREMENTS	SEGMENT GOALS
Rehearse task segments I, II, and III together. Segments IV and V together and segments VI and VII together	To develop and chain basic skills of the task
Rehearse and concentrate on segment VI with the later addition of segment VII. Demonstrate and rehearse various wind conditions	To develop basic delivery skills

Table B-3 Training Events and Behavioral Goals
by Learning Phases for the Low Angle Dive Bomb Attack (cont'd)

Initial Skill Development Phase - Primary Rehearsal Events

EVENT REQUIREMENTS	SEGMENT GOALS
Rehearse segments IV, V, & VI together using variable winds and different terrain landmarks	To develop adaptive variability within the task
Rehearse segments IV, V, & VI from any air-to-ground task to this task (e.g.,High Dive Bomb)	To develop weapons transition capability between delivery task events
Instruct and demonstrate any remedial requirements from earlier phase events as needed	To develop and/or maintain all cognitive and skill concepts

Advanced Skill Development Phase - Reorganization Events

EVENT REQUIREMENTS	SEGMENT GOALS
Rehearse segments IV, V, & VI until all doubt of concepts, rules, procedures & performance/ techniques are replaced by smooth consistent performance	To establish ownship on final approach, deliver ordnance, and pull off target
Rehearse segments I thru VII, and insure accuracy in all segments with the introduction of wind & aircraft spacing variables	To perform total task

Advanced Skill Development Phase - Secondary Rehearsal Events

EVENT REQUIREMENTS	MANEUVER GOALS
Rehearse Low Dive Bomb task interspersed with other learned air-to-ground tasks to determine if visual pictures for this task have become fixed	To perform total task in relation to other air-to-ground delivery events
Rehearse task in changed range setting, single ship or multi-aircraft attack	To convert task skills to other terrain situations

Table B-3 Training Events and Behavioral Goals by Learning Phases for the Low Angle Dive Bomb Attack (cont'd)

Advanced Skill Development Phase - Secondary Rehearsal Events

EVENT REQUIREMENTS	MANEUVER GOALS
Rehearse task in tactical target and terrain environments	To convert task skills to tactical situations

Inventive Phase - Adaptive Events

EVENT REQUIREMENTS	MANEUVER GOALS
Attempt ordnance delivery from near outside task parameters at various task segment initialization points	To convert to successful task completion from unusual approach circumstances
Attempt ordnance delivery under unusual terrain, weather conditions, target defenses, or target conditions	To convert to task success in predicted or unpredictable tactical or environmental circumstances

Table B-4 Training Events and Behavioral Goals by Learning Phases for the Acceleration Maneuver

Readiness Phase - Procedural Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Acquire knowledge of physical and performance characteristics of threat aircraft	1. To identify target as hostile
Acquire knowledge of air-to-air offensive tactics, weapons and launch parameters	2. To remember attack facts and procedures
Acquire knowledge of maneuver parameters and attack geometry	6. To remember Acceleration Maneuver facts and procedures
Acquire knowledge of missile system capabilities and limitations	10. To remember weapons launch facts and procedures

Awareness Phase - Cues Selection Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Recognize specific cuing shape and contours in various attitudes under different lighting conditions	1. To detect target and identify it as hostile
Recognize spacial relationships and various geometry requirements between target and ownship	2. To recognize an attack situation
Recognize unsuccessful attack geometry between ownship and target	4. To recognize a no-win situation
Recognize spacial relationships and performance parameters effecting lead point prediction	7. To predict target lead point 8. To estimate ownship flight path relative to lead point and target

Table B-4 Training Events and Behavioral Goals by Learning Phases for the Acceleration Maneuver (cont'd)

Awareness Phase - Cues Selection Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Recognize the dynamic spacial relationship concerning closure cues between ownship and target	11. To estimate closure angles relative to target lead point and ownship 12. To establish final closure angles relative to target, lead point and ownship
Recognize target cues in relation to sight/radar symbology and ownship angles	13. To recognize correct launch envelope and target versus ownship angles

Initial Skill Development Phase - Demonstration Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Show proper maneuver alternatives for attack engagement	2. To recognize an attack situation and select plan to convert to win advantage
Show stagnation situations from various angles, positions and circumstances	4. To recognize when attack plan is a no-win situation
Show Acceleration Maneuver as solution to stagnated position from various angles	5. To convert to a win attack by adopting 2nd plan
Show how to determine target lead point from various attitudes and airspeeds	7. To predict lead point
Show flight path/lead point relationship	8. To estimate ownship flight path relative to lead point and target
Show out-of-plane acceleration task portion	9. To distinguish lead point and target relative to out-of-plane angles of ownship

Table B-4 Training Events and Behavioral Goals by Learning Phases for the Acceleration Maneuver (cont'd)

Initial Skill Development Phase - Demonstration Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Show pull up and return into target plane, proper closure and improper closure angles	11. To estimate closure angles relative to target
Show closure rates and angles to target relative to lead point and ownship	12. To establish closure angles
Show proper launch envelope and common mistakes in correct envelope and angle assessment at launch	13. To recognize correct launch envelope

Initial Skill Development Phase - Imitation Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Attempt to engage targets from various aspects and conditions	1. To detect target and identify it as hostile 2. To recognize an attack situation and select plan to convert to win advantage 4. To recognize when attack plan is a no-win situation
Attempt to predict target lead as demonstrated	7. To predict target lead point 8. To estimate ownship flight path relative to lead point and target
Attempt out-of-plane acceleration with turn to predicted lead and pull up, and target closure	9. To distinguish lead point relative to target and out-of-plane angles of ownship 11. To estimate closure angles

Table B-4 Training Events and Behavioral Goals by Learning Phases for the Acceleration Maneuver (cont'd)

Initial Skill Development Phase - Imitation Events

EVENT REQUIREMENTS	BEHAVIORAL GOALS
Attempt tracking into plane of target, continue tracking to launch envelope and missile launch	12. To establish final closure angles relative to target/lead point and ownship 13. To recognize correct launch envelope relative to target and ownship angles
Attempt the prediction of target lead as demonstrated	7. To predict target lead point
Attempt out-of-plane acceleration and turn to predicted lead point	9. To distinguish lead point of target relative to out-of-plane angles of ownship
Attempt pull up and closure on target	11. To estimate closure
Attempt tracking into plane of target and Attempt target tracking to launch envelope and missile launch	12. To establish final closure angles

Initial Skill Development Phase - Primary Rehearsal Events

EVENT REQUIREMENTS	SEGMENT GOALS
Rehearse task segments I, II, and III separately	To develop and chain basic skills of the task
Rehearse and concentrate attention and demonstrations on task segment II	To develop the basic acceleration skill portion
Rehearse segments III, then II	To develop smooth transition of out-of-plane to tracking and launch task
Rehearse segments II and III with target at various starting aspects, airspeeds, and distance out	To develop a sense of adaptive variability within the task and task segments

Table B-4 Training Events and Behavioral Goals by Learning Phases for the Acceleration Maneuver (cont'd)

Initial Skill Development Phase - Primary Rehearsal Events

EVENT REQUIREMENTS	SEGMENT GOALS
Rehearse and demonstrate any remedial requirements from Readiness and Awareness Phases	To develop or maintain all cognitive concepts and rules

Advanced Skill Development Phase - Reorganization Events

EVENT REQUIREMENTS	SEGMENT GOALS
Rehearse and specialize initiation from multi-threat environment, with emphasis on picking the most easily convertible target and rejecting less favorable or targets impossible to convert.	Segment I - To Engage, size up target and ownship relationship in situational context and determine strategy
Rehearse acceleration segment by varying parameters of target and ownship relationships	Segment II - To Convert, employ strategy and alternatives to gain favorable ownship position
Rehearse getting ownship in target's plane and using alternative weapons most suitable to situation	Segment III - To Track & Fire, establish ownship in target's plane within specific weapons parameters and effectively expend ordnance
Rehearse all segments until all doubt of angular concepts, procedures, or techniques have been replaced by smooth performance	

Advanced Skill Development Phase - Secondary Rehearsal Events

EVENT REQUIREMENTS	MANEUVER GOALS
Rehearse complete task with target threats of varying flight characteristics from all aspects	To perform the task starting from simple to complex target aspect angles and velocities through the entire range of ownship characteristics to the weapons firing

APPENDIX C. TRAINING TECHNIQUES AND FEATURES

Synthetic Training Device Instructional Techniques and Features - Acceleration Maneuver

A summary of training device instructional features:

1. Task oriented background environment with instructor selectable aerial targets - cues and referents determined through analysis which provide for all required cuing activities. Selectable aerial targets contain identification level cues and referents.

2. Instructor flown aerial target - functional capacity to manually control standard target from instructor station.

3. Computer replay flown aerial target - functional capacity to preprogram flight parameters of a specific target for later replay in variable time modes.

4. Ownship environment - aircraft specific task oriented foreground cues and referents, and performance cues.

5. Graphic symbology generation capability - the functional capacity to overlay the background environment with programmed, preprogrammed or manually manipulated linear visual displays.

6. Initialization, freeze, unfreeze, and reinitialization capability - the functional capacity to begin a task from specific background and ownship parameters to stop, or freeze, restart or unfreeze, and continue the task or begin the task again at the same specific parameters or a new set of parameters.

7. Real time, slow time or stop action modes - the functional capacity to perform task replay or computer programmed replay of ownship in real time (actual cuing tempo), slow time (controllable or programmed smoothly slowed cuing tempo), or stop action (controllable stop frame cuing tempo).

8. Computer replay flown ownship and target with programmed synchronized aural and graphic instruction - the functional capacity to present student with computer replay of preprogrammed ownship flown in appropriate time mode with accompanying voice and graphic overlay instruction.

9. In-cockpit instant task/segment replay - the functional capability to permit full student/ownship task reenactment in selectable time modes.

10. Computer-perfect visual task/segment comparison of student performance - the functional capacity to graphically relate, in the cockpit, the student/ownship performance to computerized perfection of the same task/segment.

11. Instructor manipulation of graphic symbology - the functional capacity for the instructor to manually control specific linear visual displays.

12. Instructor control of student ownship - the manual remote control of ownship from the instructor's station.

13. Student/instructor aural communication - voice intercom. Capacity and instructor manual auditory display capacity.

1. Readiness Phase - Procedural Events

The Readiness Phase is involved in gaining knowledge and understanding verbalizable concepts and principles about the performance of a task. Because the procedural events of this phase involve the understanding of the task, task goals, equipment systems, functions, and numerical values at the verbal level, material such as this can best be taught in a classroom or self-paced instructional atmosphere using audio/visual aids.

2. Awareness Phase - Cues Selection Events

Cue Selection Event Requirement

Recognize specific cuing shapes and contours in various attitudes under different lighting conditions.

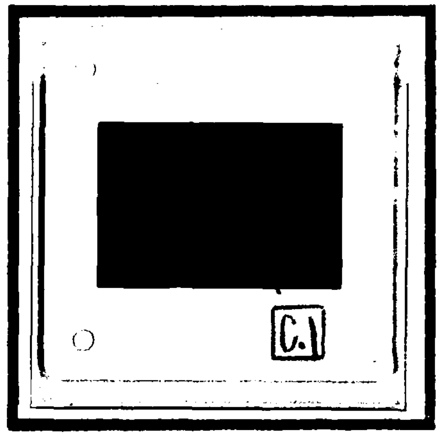
Instructional Techniques

Initialization - Student is presented various targets at preselected positions and attitudes. Many and varied initial conditions should be presented.

Application - At initialization, targets are presented for detection and identification. A different initial condition is selected for each successive target presentation. Targets are removed after proper identification. Instructor can point out undetected targets to student.

Instructional Features - Selectable targets in varying attitudes and lighting conditions; instructor manipulated pointer symbology; programmed initialization with instructor options for target selection, range, position, attitude, lighting; and student/instructor aural communication. Slide Figure C.1. shows the visual instructional features.

Standard aerial targets are shown in various attitudes, aspect angles, and lighting conditions.



Slide Figure C.1. Selectable Aerial Targets Example

Cue Selection Event Requirement

Recognize spacial relationships and various geometry requirements between target and ownship.

Instructional Techniques

Initialization - Student is initialized in various conditions from the target, from which successful attacks can be achieved.

Application - At initialization, programmed graphic symbology shows timed sequential flight path of both ownship and target to final launch position with synchronized aural instruction. Reinitialization shows computer flown ownship with synchronized aural instruction attack on target in real time and slow time.

Instructional Features - Graphic symbology generation capability, programmed synchronized aural instruction to graphic presentation, computer flown ownship in real time and slow time modes, student/instructor communication.

Cue Selection Event Requirement

Recognize unsuccessful attack geometry between ownship and target.

Instructional Techniques

Initialization - Student is initialized from freeze in various positions relative to target from which turn in plane results in stagnated position.

Application - At initialization ownship and target are computer replay flown in real time with synchronized aural instruction presenting how remaining in target's plane results in stagnation under certain conditions. Graphic symbology is used to show relatively constant aspect angle.

Instructional Features - Graphic symbology of aspect angles, computer replay flown ownship and target with synchronized aural instruction in real time and slow time modes, student/instructor communication.

Cue Selection Event Requirement

Recognize spacial relationship and performance parameters effecting lead point prediction.

Instructional Techniques

Initialization - Student is initialized from freeze at various ownship positions relative to target including variable airspeed and g levels.

Application - At initialization ownship and target are computer replay flown with synchronized aural instruction and graphic symbology identifying proper lead point in real and slow time. Reinitialize to illustrate effects of various ownship airspeeds and g levels on initial target lead point.

Instructional Features - Graphic symbology showing project target lead points, computer replay flown ownship and target with synchronized programmed aural instruction in real time and slow time modes, and student/instructor communication.

Cue Selection Event Requirement

Recognize the dynamic spacial relationship concerning closure cues between ownship and target.

Instructional Techniques

Initialization - Student is initialized from freeze at various ownship positions relative to target.

Application - At initialization, ownship and target are computer replay flown with programmed synchronized aural instruction and graphic symbology presenting closure angles, aspect angles, and range changes during the attack.

Instructional Features - Graphic symbology showing ownship track, closure, and aspect angle; computer replay flown ownship and target synchronized aural instruction; and student/instructor communication.

Cue Selection Event Requirement

Recognize target cues in relationship to sight/radar symbology and ownship angles.

Instructional Techniques

Initialization - Student is initialized from freeze with target in various launch envelope positions (e.g., at edge of both range and angle, at the heart of the envelope, and near the edge of envelope/range).

Application - At initialization, computer replay flown ownship and target present maximum and minimum acceptable range and angles with graphic symbology to illustrate and highlight angles with synchronized aural instruction, relative to sight and/or radar display.

Instructional Features - Graphic symbology highlighting target range and angles, programmed aural and graphic instruction synchronized with computer replay flown ownship, real time, slow time, and student/instructor communication.

3. Initial Skill Development Phase - Demonstration Events

Demonstration Event Requirement

Show proper maneuver alternatives for attack engagement.

Instructional Techniques

Initialization - Student is initialized from freeze in various aspects behind target from which a successful attack can be achieved.

Application - At initialization, ownship is computer replay flown in real time to give general familiarization of basic attack profiles. Several different initialization points should be presented to show modification of the task. Replay is shown in real time and slow time with synchronized aural and graphic instruction.

Instructional Features - Graphic symbology showing target and ownship track; programmed aural and graphic instruction with synchronized computer replay flown ownship and target; real time, slow time, freeze, and reinitialization modes; and student/instructor communication.

Demonstration Event Requirement

Show stagnation situations from various angles, positions, and circumstances.

Instructional Techniques

Initialization - Student is initialized from freeze in various positions relative to target from which turn in plane results in stagnated position.

Application - At initialization, ownship and target are computer replay flown in real time and slow time to illustrate where no advantage to ownship is achieved by remaining in target's plane. This information is presented in synchronized, programmed aural instruction.

Instructional Features - Computer replay flown target, programmed aural instruction with synchronized real time and slow time computer replay flown ownship and target. Freeze, unfreeze, and reinitialization modes; and student/instructor communication.

Demonstration Event Requirement

Show Acceleration Maneuver as solution to stagnated position from various angles.

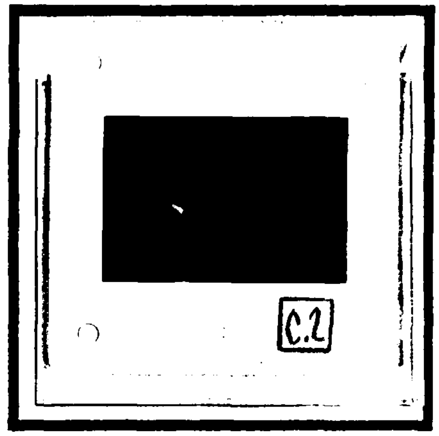
Instructional Techniques

Initialization - Student is initialized from various positions relative to target in same situation as in previous event.

Application - At initialization, student is presented with graphic symbology which shows Acceleration Maneuver ownship path relative to target. Ownship is then computer replay flown against various targets demonstrating the effectiveness of the Acceleration Maneuver in real time and slow time with synchronized, programmed aural instructions.

Instructional Features - Graphic symbology showing target and ownship flight paths of maneuver, programmed aural instruction with synchronized real time and slow time computer flown replay of ownship and target. Freeze, unfreeze, and reinitialization modes and student/instructor communication. Slide Figure C.2. shows the visual instructional features.

Projected target flight path is shown in increments. Acceleration Maneuver, also presented in increments, shows the closure relationships between the two flight paths.



Slide Figure C.2. Acceleration Maneuver Flight Path as a Solution to Stagnation Example

Demonstration Event Requirements

Show how to determine target lead point from various attitudes and airspeeds

Show flight path/lead point relationships.

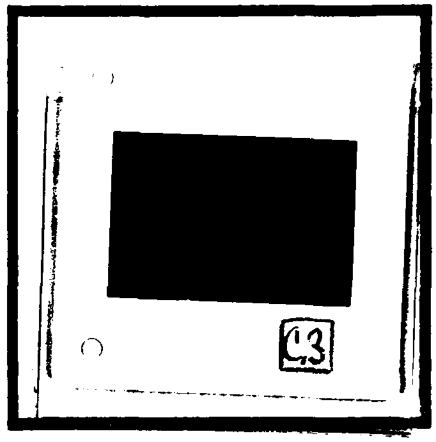
Instructional Techniques

Initialization - Student is initialized from freeze, from various positions relative to target at different ownship attitudes and airspeeds.

Application - At initialization, ownship and target are computer replay flown including graphic symbology showing desired target lead point relative to each situation in real time and slow time with programmed synchronized aural instruction.

Instructional Features - Graphic symbology of target lead point for various target/ownship engagement situations, lead point and flight paths updated throughout demonstration, computer replay flown ownship and target synchronized to graphic and programmed aural instruction in real time and slow time. Freeze, unfreeze, and reinitialization capability; and student/instructor communication. Slide C.3. shows the visual instructional features.

Target projected flight path and lead point is shown in gray. Acceleration Maneuver of ownship flight path and projected closure point is shown in white.



Slide Figure C.3. Target Lead Point Versus Ownship Flight Path Example

<u>Demonstration Event Requirement</u>

Show out-of-plane acceleration task portion. Show pull-up and return to target plane, proper closure and improper closure angles.

<u>Instructional Techniques</u>

Initialization - Student is initialized from freeze in stagnated target plane position.

Application - At initialization, ownship and target are computer replay flown in real time and slow time showing lead point and initial out-of-plane flight path with synchronized aural instruction. This is followed by initialization to pull up and return to target plane portion of attack. Ownship and target are computer replay flown in real time and slow time showing changing lead point and converging target and ownship flight paths (angle off, aspect angle and range) with synchronized aural instruction. Entire out-of-plane task portion is then presented together in ownship/target replay with programmed synchronized aural instruction.

<u>Instructional Features</u> - Graphic symbology of target lead point; target flight path and ownship flight path; computer replay flown ownship and target with synchronized aural instruction in real time and slow time modes; freeze, unfreeze, and reinitialization modes; and student/instructor communication.

Demonstration Event Requirement

Show closure rate and angles to target relative to lead point and ownship

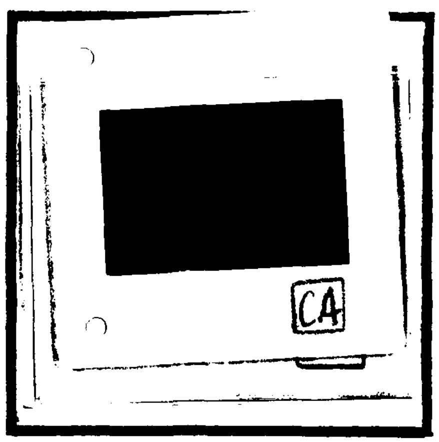
Instructional Techniques

Initialization - Student is initialized from freeze, from pull-up position to target.

Application - At initialization, ownship and target are computer replay flown in real time and slow time with synchronized graphic and aural instruction emphasizing varying closure rates and angles relative to lead point.

Instructional Features - Graphic symbology of target and ownship flight paths and lead point for various closure variables; computer replay of ownship and target in real and slow time with synchronized aural and graphic instruction; freeze, unfreeze, and reinitialization modes; and student/instructor communication. Slide Figure C.4. shows the visual instructional features.

View of target as ownship begins to pull back into target's plane. View shows projected ownship flight path and target/ownship sight relationship.



Slide Figure C.4. Ownship Closure Angle Relative to Projected Flight Path Example

Demonstration Event Requirement

Show proper launch envelope, and common mistakes in determining correct envelope and angle assessment at launch.

Instructional Techniques

Initialization - Student is initialized from freeze in pull-up position from target inside launch conditions.

Application - At initialization, ownship and target are computer replay flown in real time and slow time with synchronized graphic and aural programmed instruction to illustrate edge of firing envelope for various situations and types of weapons. Instructor and programmed material are used to emphasize correct technique and correction of common firing errors.

Instructional Features - Graphic symbology of flight paths and firing angles; weapons firing path; instructor manipulated symbology; computer replay flown ownship and target; with programmed synchronized instruction in real time, slow time, freeze, unfreeze, and reinitialization modes; and student/instructor communication.

3. Initial Skill Development Phase - Imitation Events

Imitation Event Requirement

Attempt to engage targets from various aspects and conditions.

Instructional Techniques

Initialization - Student is initialized from freeze in various conditions from the target, from which successful attacks can be achieved.

Application - Appropriate demonstration event is shown as a refresher. At initialization, student flies ownship to duplicate flight path of demonstration in real time with no graphic assistance. Each attack engagement is imitated individually. Instructor critiques student performance using graphic student ownship flight path symbology with slow time, stop action segment instant replay and freeze to instruct in actual conditions of range, closure, velocity and aspect angle.

Instructional Features - In-cockpit instant replay; ownship and target's flight path; instructor manipulated graphics; real time, slow time, stop action instant replay, freeze, unfreeze, and reinitialization modes; and student/instructor communication.

Imitation Event Requirements

Attempt to predict target lead as demonstrated.

Attempt out-of-plane acceleration with turn and pull-up and target closure.

Attempt tracking into plane of target, continue tracking to launch envelope and missile launch (or gun shot).

Instructional Techniques

Initialization - Student is initialized from freeze in various conditions from target, from which successful attacks can be achieved.

Application - Appropriate demonstration events are shown as refreshers. Student flies ownship for each attack engagement in real time without graphic assistance. Each engagement is initialized individually. Imitation is critiqued by student and instructor using instant in-cockpit replay with graphic symbology showing ownship flight path, weapons flight path, and computer-perfect flight path. Replay can be in real time, slow time, stop action and freeze with instructor manipulated graphics to emphasize correct ownship/target relationship. Instructor may also fly student ownship as appropriate.

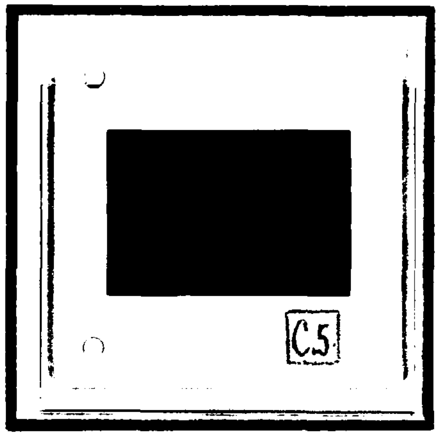
Instructional Features - In-cockpit instant replay; computer-perfect comparison symbology of flight paths and weapons launch path; instructor manipulated graphic symbology; real time, slow time, stop action instant replay, freeze, unfreeze, reinitialization; instructor manipulated ownship; and student/instructor communication. Slide Figure C.5. shows the visual instructional features.

3. Initial Skill Development Phase - Primary Rehearsal Events

Primary Rehearsal Event Requirement

Rehearse task segments I, II, and III separately.

Task critique as seen from ownship showing computer-perfect lead point and flight path in gray and student ownship lead point and flight path in white. Arrow shows common error. Comparative airspeed, altitude, and g values are shown in the upper right.



Slide Figure C.5. In-cockpit Computer-perfect/ Ownship Task Comparison Example

<u>Instructional Techniques</u>

Initialization - For segment I, initialize student from freeze in various conditions from target. For segment II, initialize at start of out-of-plane maneuver. For segment III, initialize at pull-up position from target.

Application - Student is initialized in all events sequentially and flies ownship without graphic assistance. In-cockpit instant replay in real time, slow time, stop action and freeze are used by instructor to critique performance. Instructor may also use control of student ownship and manipulated graphics as instruction aids. Student flight path may also be compared to computer-perfect flight for specific segments.

<u>Instructional Features</u> - In-cockpit instant replay, instructor manipulated graphics; computer-perfect versus ownship flight path comparison; instant replay in real time, slow time, stop action and freeze; instructor control of student ownship; and student/ instructor communication.

<u>Primary Rehearsal Event Requirements</u>

Rehearse and concentrate attention and demonstrations on task segment II.

Rehearse segment III and then segment II.

Rehearse segments II and III with target at various starting aspects, airspeeds, and distance out.

Rehearse and demonstrate any remedial requirements from previous phases.

Instructional Techniques and Features - All instructional techniques and features for these training events are the same as those shown immediately above.

4. Advanced Skill Development Phase - Reorganization Events

Reorganization Event Requirement

Rehearse Acceleration Maneuver by varying parameters of target and ownship relationship to determine maneuver limitations.

Instructional Techniques

Initialization - Student is initialized from freeze in various situations from target, from which a successful outcome cannot always be achieved.

Application - Student flies ownship from initial conditions where target parameters are controlled by the instructor. Instructor modifies target parameters so that student must vary performance from the ideal to be successful. Instructor also outperforms student to expand student knowledge of what works and what does not work. Instructor critiques student performance using in-cockpit instant task segment replay in real time, slow time, stop action or freeze and uses graphic symbology to show student flight path, projected lead point and computer-perfect accomplishment of task.

Instructional Features - Instructor controlled target; instant in-cockpit task/segment replay; student ownship flight path; instructor controlled graphic symbology; computer-perfect flight path; instant replay in real time, slow time, stop action, freeze, and reinitialization; instructor manipulated student ownship; and student/instructor communication.

Reorganization Event Requirement

Rehearse Acceleration Maneuver using alternate weapons.

Instructional Techniques

Initialization - Student is initialized from freeze in varying situations from the target which may or may not permit a successful outcome.

Application - Student flies ownship on instructor controlled target to determine proper attack envelope for different weapons at his command. Instructor monitors and critiques student performance using in-cockpit instant task segment replay and graphic symbology of student ownship flight path, projected lead point, target aspect and range. Instructor may also compare student performance to computer-perfect performance of task or segment.

Instructional Features - In-cockpit instant task/segment replay graphic symbology of student ownship flight path and lead point; computer-perfect versus student performance comparison; instructor controlled target; instant replay in real time, slow time, stop action and freeze; instructor manipulated student ownship; and student/instructor communication.

Reorganization Event Requirement

Rehearse task until all doubt of angular concepts, procedures, and techniques have been replaced by smooth performance.

Instructional Techniques and Features - All instructional techniques and features for this training event are the same as those shown immediately above.

4. Advanced Skill Development Phase - Secondary Rehearsal Phase

Secondary Rehearsal Event Requirement

Rehearse complete task with target threats of varying flight characteristics from all aspects.

Instructional Techniques

Initialization - Student is initialized from freeze in various situations from identifiable targets of varying types and flight characteristics.

Application - Instructor selects type and position of target and whether flown by computer replay or instructor. Student is initialized and must detect and identify target (not all targets may be hostile). Hostile targets are engaged and the use of weapons is at the option of the student. Instructor critiques student performance using in-cockpit instant task/segment replay in real time, slow time, stop action or freeze and uses graphic symbology to show student flight path, lead point and computer-perfect accomplishment of task.

Instructional Features - Instructor selectable and controllable target. Computer replay programmed target; in-cockpit task/ segment; instructor controlled graphic symbology such as flight path or lead point; computer-perfect flight path; instant replay in real time, slow time, stop action, freeze and reinitialization; instructor manipulated student ownship; and student/instructor communication.

5. Inventive Phase

The Inventive Phase involves the use of task segments and combinations as alternatives to improvise performance in order to meet or counter problem situations. Thus, the proper utilization of this phase requires the competence of a repertoire of basic fighter maneuvers so that various combinations can be chosen. Because this research has dealt with only one air-to-air task, no alternatives are available to the student at this point.

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