NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AN ANALYSIS OF REQUIREMENTS FOR A
P-3 WINDSHEAR TRAINING PROGRAM

by

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December 1989

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Postgraduate School 6b. OFFICE SYMBOL (If applicable) 54	7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000	7b. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
An Analysis of Requirements for P-3 Windshear Training Program

12. PERSONAL AUTHOR(S)
WHITE, KEVIN E.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Master's Thesis	FROM ______ TO ______	DECEMBER 1989	85

16. SUPPLEMENTARY NOTATION
The views expressed are those of the author and do not reflect the official policy or position of the Department of Defense of the U.S. Government

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	windshear, training, P-3

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

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An analysis was conducted to identify training objectives, equate them to learning outcomes, and recommend media to support the training. The resulting media combination is presently available at each Fleet Replacement Squadron. Additional recommendations were made concerning training materials, costs and benefits, and windshear technology.

Many of the procedures written in the P-3 NATOPS manual are the result of a major incident or the loss of lives. This thesis provides information necessary to implement a training program and procedures that could possibly save an aircraft and its crew.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL Alice Crawford	22b. TELEPHONE (Include Area Code) 408-646-2768	22c. OFFICE SYMBOL 54CR

DD Form 1473, JUN 86 Previous editions are obsolete SECURITY CLASSIFICATION OF THIS PAGE

S/N 0102-LF-014-6603 UNCLASSIFIED

An Analysis of Requirements for a P-3 Windshear Training Program

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Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1978

Submitted in partial fulfillment of the requirements for the degree of

MASTERS OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
December 1989

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ABSTRACT

The purpose of this thesis is to examine a deficiency in the Navy's P-3 flight crew training curriculum in the area of windshear and microburst survival and to analyze the requirements necessary for an effective training program.

An analysis was conducted to identify training objectives, equate them to learning outcomes, and recommend media to support the training. The resulting media combination is presently available at each Fleet Replacement Squadron. Additional recommendations were made concerning training materials, costs and benefits, and windshear technology.

Many of the procedures written in the P-3 NATOPS manual are the result of a major incident or the loss of lives. This thesis provides information necessary to implement a training program and procedures that could possibly save an aircraft and its crew.

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I. INTRODUCTION

A. GENERAL OVERVIEW

Windshear has been an atmospheric phenomenon since the beginning of time. The extent to which this spectacle presents a hazard to air carrier aircraft has been acknowledged only during the past 15 years. According to the Federal Aviation Administration (FAA) nearly 40% of all aircraft accidents in the takeoff and landing environment can be attributed specifically to windshear. "Since 1970, the Aviation Safety Board has identified a low altitude encounter with windshear as a cause or contributing factor in 18 accidents involving transport category aircraft. Seven of these mishaps were fatal and accounted for 575 deaths [Ref. 1:p. 1]."

From the standpoint of military aviation, the Naval Safety Center (NSC), while reviewing available data, found nine mishaps which were/may have been attributable to windshear/microburst activity resulting in the loss/damage of approximately 1.5 million dollars. The Air Force Inspection and Safety Center, NSC's counterpart, has statistics from 1977-1988 that indicate four aircraft mishaps were attributed to windshear and another seven may have been caused by windshear [Ref. 2].

Turbulence and severe weather conditions are occupational hazards of Naval aviation. Navy aircraft operate in a myriad of environments and are exposed to the full range of atmospheric situations. Navy pilots are taught from their first day in the training command to identify hazardous weather and avoid that danger to the fullest extent. However, there will always be the possibility that avoidance will not be sufficient. In these cases, preparation through proper training is the key to the aircrew's survival.

Currently, windshear survival training is not an official part of the flight crew training syllabus at the two P-3 Fleet Replacement Squadrons (FRS). There is not a requirement for this type of instruction for any aircraft type in Naval aviation. Pilots receive minimum exposure (four and a half paragraphs) to the windshear phenomenon during basic meteorology classes in undergraduate pilot training. However, in Patrol Squadron Thirty-One (VP-31), the West Coast FRS, there is an in-house windshear training program taught to new maritime pilots and during the annual instrument refresher training using an FAA developed program. Patrol Wing Two at NAS Barbers Point, Hawaii, is starting a similar in-house windshear training program for their flight crews to be administered during the annual instrument refresher training. Both training programs, unfortunately, use only the classroom media and do not incorporate windshear specific simulation.

This is due to technical shortcomings with simulation software and memory capacity of the current simulators.

The purpose of this thesis is to analyze the requirements of an effective windshear training program in the context of modern training theory and offer guidelines for its successful implementation. The study will accomplish this task in four steps: 1) identify the required behavioral objectives and equate them to media selection theory; 2) using available aids, identify possible training media to support the desired objectives; 3) recommend training media based on the preceding discussions; and 4) investigate the training need in cost/benefit terms.

The goal of this thesis is to generate an awareness of and an appreciation for the dangers inherent in a windshear microburst environment. Many procedures in flight manuals are born after fatal incidents. Hopefully this study can prevent needless loss of life.

B. WINDSHEAR BACKGROUND

Changing atmospheric conditions on the approach and terminal phases of a flight profile are the most difficult and challenging aspects of flying. Wind variations at low altitudes are a serious hazard, especially when associated with thunderstorms and rain showers. Uncertainties in wind direction and velocity can also come from topographical conditions, temperature inversions, sea breezes, frontal systems, and strong surface winds.

Windshear is any rapid change in wind direction or velocity. Severe windshear, which this study addresses, is a rapid change in wind direction or velocity causing changes greater than 15 knots or vertical speed changes greater than 500 feet per minute [Ref. 3:Sec. 2, p. 2]. Most severe windshear incidents occur in the vicinity of convective storms (thunderstorms, rain/snow showers). For this reasons most studies focus on windshears associated with convective weather conditions, the most hazardous form of windshear being the microburst. The microburst is the concentrated, powerful downdraft associated with convective windshears.

Approximately 5% of all observed thunderstorms produce a microburst. Downdrafts accompanying microbursts are typically only a few hundred to 3,000 feet (2.5 miles) across. When the downdraft reaches the ground, it spreads out horizontally and may form one or more horizontal vortex rings around the downdraft. The outflow region is typically 6,000 to 12,000 feet (1.1-2.3 miles) across. The horizontal vortices may extend to over 2,000 feet above ground level [Ref. 3:Sec. 2, p. 8]. Figure 1 is a depiction of a symmetrical microburst reproduced from Reference 3.

More than one microburst can occur in the same weather system. Creation of powerful updrafts from the vortices are

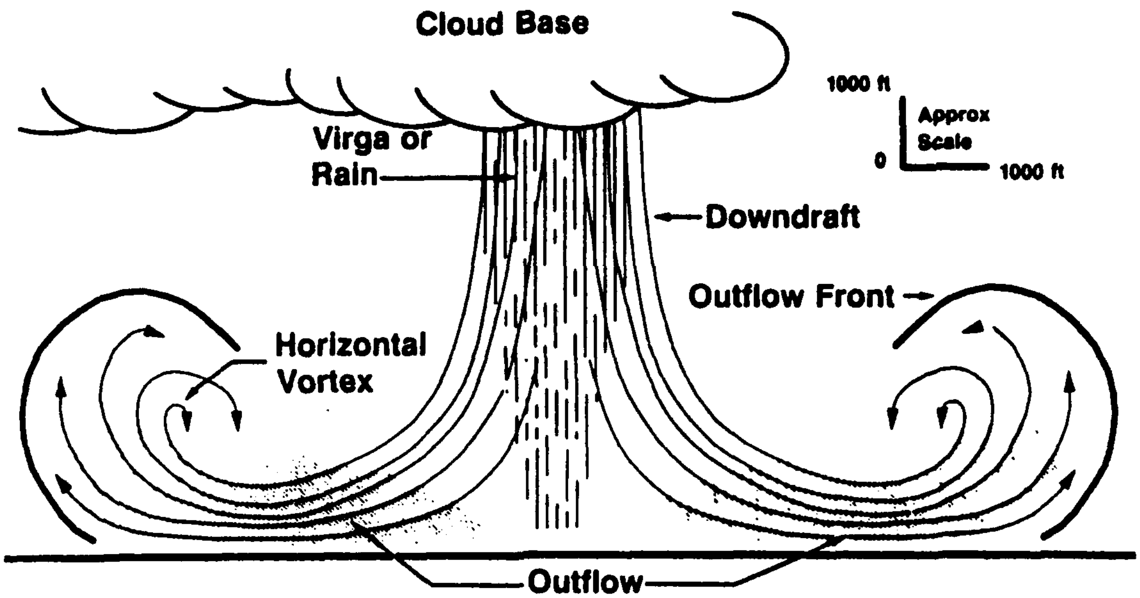

Figure 1. Symmetrical microburst

common and add to the aerodynamic difficulties. Recovery techniques used to escape the strong downdrafts can place the aircraft in an equally dangerous situation when encountering the updrafts of the outer vortices. Microbursts can also occur in relatively dry conditions of light rain or virga (precipitation that evaporates before it reaches the surface of the earth). The hazards in these environments are just as treacherous and possibly more deceiving due to the less obvious weather condition indicators.

The hazard to an aircraft and its flight crew from severe low altitude windshear lies in the inability of the flight station to recognize the situation and respond in sufficient time with the correct procedures. Only 5 to 15 seconds may be available to recognize and respond to a windshear encounter at an altitude from 0 to 300 feet above the ground. This extremely short response time is due to the narrow dimensions of the microburst, aircraft approach/takeoff speeds and drastic changes in wind velocity and direction. Windshear encounters occur during landing approaches *and* takeoffs. Standard instrument and aircraft performance recognition taught to all pilots in basic flight training is inadequate to survive the microburst phenomenon. If the flight crew encounters a windshear and correctly analyzes the situation, the recommended recovery techniques require the full use of the aircraft's abilities through higher than normal nose attitudes and full engine power. Many of the disastrous windshear incidents are a result of the flight crews' lack of skill training to use the full capabilities of the aircraft to recover.

C. AIRCRAFT VULNERABILITY

The vulnerability of any aircraft to severe windshear is a function of its ability to fly out of the encounter. All airplanes are vulnerable, but to different degrees. The thrust-to-weight ratio is one of two main factors in determining the degree of survivability. The second element is aircraft controllability in the complex wind flows associated with low-level windshear. FAA design regulations from Federal

Aviation Regulations Part 25 for large aircraft and Part 23 for small aircraft require than an airplane be able to maintain a positive rate of climb based on the number of engines available in the event of the loss of one engine [Ref. 4]. Thus, the remaining engines must be designed to compensate for that loss of available power. For small twin engine aircraft this means more extra power is available to fly out of a low level windshear encounter than for a large four engine aircraft. The smaller aircraft is thus "less vulnerable," all other factors being equal.

Dr. Roland Bowles from the NASA Langley Research Center in Hampton, Virginia, has developed a mathematical model to express the hazard the microburst exposes to aircraft. The greatest danger exists when the aircraft no longer has excess power to climb. Dr. Bowles' model relates the "excess thrust-to-weight ratio with the atmospheric terms" and produces the following relationship [Ref. 5:p. 3]:

$$\dot{h}_{pot} = ((T-D)/W - (\dot{w}_x/g - w_h/V)) * V$$

Where: $\dot{h}_{pot}$ = potential rate of climb of the aircraft

T = aircraft thrust

D = aircraft drag

W = aircraft weight

$\dot{w}_x$ = rate of change of the longitudinal windspeed

g = acceleration due to gravity

w_h = vertical windspeed

V = aircraft velocity

The term (T-D)/W represents the flight characteristics of the aircraft and the available excess thrust in any phase of flight. The term ($\dot{w}_x/g-w_h/V$) depicts the atmospheric conditions of the microburst and is known as the hazard index or "F-Factor." The index is defined "based on accepted fundamentals of flight mechanics and current state of knowledge of windshear phenomena" [Ref. 6:p. 3]. The relationship between the two factors will determine if the aircraft can survive the windshear based solely on available power of the plane. The equation does not consider pilot flight technique. Protection lies in the available power to climb with respect to the hazard presented by the environment.

As an example, consider a P-3 on an instrument approach to a field as it encounters a microburst. During the last phase of the approach, the aircraft would be descending at a constant rate in the approach configuration. With reference to the equation, there are three possible situations and windshear conditions:

1. The available excess thrust term is greater than the hazard index ($\dot{h}_{pot}$ is a positive value). In this case, the aircraft has sufficient power to recover from the downburst and could possibly continue the approach to a safe landing.

2. The available excess thrust term is nearly equal to the hazard index ($\dot{h}_{pot}$ is near zero). In this situation it is a standoff in terms of power. The addition of windshear survival flight technique could allow the aircraft to overcome the windshear

and fly out of the microburst. Continuation of the approach to the field would not be recommended.

3. The available excess thrust term is far less than the hazard index ($\dot{h}_{pot}$ is a negative value). Dr. Bowles considers this case "lethal;" the power of the microburst is beyond the capabilities of the aircraft and flight crew.

As the example shows, *every* aircraft is vulnerable to windshear to a degree. It is a matter of available thrust, piloting technique, and microburst severity that determines an aircraft's survivability.

D. THE P-3 ORION

The P-3 Orion is the Navy's primary anti-submarine aviation platform. Built by Lockheed Corporation, the four-engine, turboprop, straightwing aircraft has been in the inventory since the early 1960s. There have been three major airframe changes, mainly in the internal arrangement of flight stations, as well as numerous avionics updates to keep pace with technology. The land-based P-3 operates out of four home bases: Jacksonville, Florida; Brunswick, Maine; Sunnyvale, California; and Barbers Point, Hawaii, and deploys to sites in Europe and the Far East. The P-3 aircrews operate in all weather extremes from the snowy runways of Iceland to the monsoon seasons of the Philippines and Southeast Asia. In 1989 the last P-3s will roll off the production line at Lockheed to make room for the follow-on aircraft, the P-7.

E. FAA REGULATIONS FOR WINDSHEAR TRAINING

As of September 1988, the FAA amended Federal Aviation Regulations (FAR) Part 121 to require airborne low-altitude windshear warning and flight guidance equipment in airplanes, and Parts 121 and 135 to require windshear training for flight crew members [Ref. 7]. FAR Part 121 pertains to U.S. registered air carriers and Part 135 refers to U.S. registered air taxi commuters. However, the proposed simulation training requirements in section 121.358 for low-altitude windshear equipment apply to any turbine-powered airplane operated under Part 121 *except* turbopropeller-powered airplanes. This exception was a result of the different performance characteristics of turboprop powered aircraft that make them "less vulnerable," as well as the fact that there were no existing accident/incident data to support a requirement for windshear equipment. Thus older aircraft or commuter aircraft powered by turboprops are not required to formally train for the windshear environment using simulators. According to the FAA, all aircraft that are governed by Parts 121 and 135 will conduct FAA approved ground training for windshear. The FAA views the detection equipment/training requirements as part of a "systems concept." The concept includes an improved low-altitude windshear weather forecasting technique, ground based windshear detection equipment, airborne windshear warning and flight guidance, and improved flight crew training. [Ref. 7]

The Federal Aviation Act of 1958 excluded state aircraft, such as military aircraft, from the Federal Aviation Regulations. The act, reviewed on 1 March 1979, states "to continue this Civil Aeronautics Board as an agency of the United States, to create a Federal Aviation Agency, to provide for the regulation and promotion of civil aviation in such a manner as to best foster its development and safety and to provide for the safe and efficient use of the airspace by both civil and military aircraft, and for other purposes. [Ref. 4]" This statement means that FAR only regulate the military's use of airspace, not aircraft design or training requirements. In most instances though, military flight regulations are as rigid if not more restrictive than civilian directives. However, in the case of windshear training and windshear detection devices, P-3 aircraft do not carry windshear detection equipment and at present have no standardized windshear training program for the classroom or simulator.

II. LITERATURE REVIEW

Once a training need has been established based on skill and knowledge discrepancies, a systematic approach to the development of instruction may be conducted. While there is no one single systems approach model, such attempts may be characterized as a systematic process of carrying out the design, implementation, and evaluation of instruction based on research in human learning. A review of these models can be found in reference 8. The approach implies that all training decisions, from setting behavioral objectives to selection of delivery media, will be driven by existing learning theory.

"In the process of designing training systems, professionals have been inconsistent in integrating available knowledge and principles on how people learn. Frequently, the translation of psychological learning principles into practices useful for the classroom has not been accomplished." [Ref. 9: p.7]. Learning theory guides the technique used and, as with most topics in the behavioral sciences, there is an abundance of well-founded opinions on how an individual learns. The common thread to most theories is the "stimulus to response" concept.

According to Gagne in a 1984 article,

learning has been understood as a change of state of the human being that is remembered and makes possible a corresponding change in the individual's behavior in a given type of situation. This change of state must, of course, be distinguished from others that may be effected by innate forces, by maturation, or by other psychological influences. Instead, learning is brought about by one or more experiences that are either the same as or that somehow represent the situation in which the newly acquired behavior is exhibited. [Ref. 10:p. 377]

Psychologists have taken different approaches to identify the stimuli needed for this "change of state." Some limited their observations to humans while others included animal behavior to study learning phenomena. Other differences in fundamental approaches to the study of human learning arose such as empiricism versus rationalism, contiguity versus reinforcement, and gradual increments versus all-or-none learning spurts. These opposing views have yet to be resolved by a consensus of scientists [Ref. 10:p. 377]. The emergence of cognitive psychology, which shifted emphasis from behavioral outcomes to mental states and processes of learning, further confused the lack of agreement. This concept of situational learning moved many of the lab studies into the working classrooms, but created task specific learning theories. [Ref. 10:p.p. 377-378]. While this approach may eventually contribute to educational theory and practice, the extent to which these principles will be adapted is presently unclear [Ref. 11].

The method by which individuals learn will continue to be an ongoing research issue. A focus on what individuals learn versus how, provides a more productive input to a systematic approach to training development. One currently accepted theory is that individuals can learn capabilities of making responses, which accounts for the range and "generalizability" of human performances [Ref. 12]. This view suggests that each learned capability has a corresponding performance outcome and, as a result, each must be acquired under different instructional conditions.

Gagne has provided a classification of capabilities or outcomes of learning and the internal and external stimulus conditions under which they will be acquired [Ref. 10]. His ideas provide the needed basis for a systematic approach to training development, and will be described in more detail in a subsequent section. Gagne's theories are frequently used by instructional designers [Ref. 13].

Gagne's early contributions were made in the context of behavioral objectives for instruction. Identifying and specifying observable behaviors to be performed by the learner is now standard practice by advocates of any systems approach to training. A major contribution to this field was made in 1956 when the idea was put forth that objectives could be classified according to various types of learning outcomes [Ref. 14]. Subsequently, Gagne helped to identify the instructional implications of defining and classifying objectives [Ref. 11].

In 1965, Gagne theorized eight types of learning based on the outcomes of the learning process. The eight types of learning he proposed were: 1) Signal learning, 2) Stimulus response learning, 3) Chaining, 4) Verbal association, 5) Multiple discrimination, 6) Concepts, 7) Principles, and 8) Problem solving [Ref. 15]. By classifying types of learning, Gagne indicated that different forms of learning require different instructional approaches.

Gagne's ideas were the basis for an early attempt to develop a formal media selection technique in a manual published by the American Institute of Research. The five major steps in choosing media for instruction presented in the book were: 1) to state the behavioral objectives for the course; 2) for each objective, to identify the type of learning involved; 3) using the conditions of learning as a guide, to design a media program for each objective; 4) to prepare a summary of the media selected for the group of objectives; and 5) to determine the most appropriate media for the whole program [Ref. 16]. These same five steps were the basis for a follow-on manual also published by the American Institute for Research [Ref. 17]. The second book provided a structured approach to designing instruction by teaching how to develop course objectives, construct tests, select media, and prepare first-draft materials.

Gagne's categories of learning outcomes were proposed in 1972 [Ref. 18] as the next step in identifying learning skills of individuals. These groupings were the refinement of the concept that,instead of focusing on the internal learning processes of individuals, the focal point in instruction should be on the desired results or behavioral objectives. Each category was created under well-defined characteristics. The guidelines were: 1) each category of learning outcomes should be distinguishable in terms of a formal definition of the class of human performance made possible by the learning; 2) each category should include a broad variety of human activities that are independent of intelligence, age, race, economic situations, and so on; 3) each category should be seen to differ in the nature of information-processing demands for its learning; and 4) it should be possible to generalize the principles concerning factors affecting the learning of each category to a variety of specific tasks within the category but not to learning tasks in other categories. The categories of learning outcomes (learned capabilities) are [Ref. 18]:

1. Intellectual skills. These skills include the use of concepts, rules, and procedures. Sometimes this category is referred to as procedural knowledge. The rules for mathematical computations are a good example of intellectual skills. [Ref. 19]

2. Verbal information. This category is also known as declarative information and it refers to the ability of the individual to declare or state something. An example of this is stating the main

kinds of fire extinguishers and their uses. [Ref. 19]

3. Cognitive strategies. This refers to the idea that learners bring to a new task not only intellectual skills and verbal information, but also a knowledge of how to use this information. Cognitive strategies form a type of strategic knowledge that enables the learner to know when and how to choose the intellectual skills and verbal information they will use. [Ref. 19] This learning outcome is an internally organized skill that governs the learner's own intellectual processing [Ref. 20].

4. Motor skills. This skill refers to one of the more obvious examples of human performance. Examples of motor skills include writing, swimming, using tools, or riding a bike. [Ref. 19]

5. Attitudes. This is the least tangible of the learning outcomes due to the complexity of identifying attitudes. The learning outcome would be concerned with a *willingness* to perform according to a standard as opposed to a skill performed to that standard. It also involves integrating or organizing a value or attitude into a pattern or behavior. An example of attitude learning would be complying with known safety standards while performing a maintenance procedure on a high voltage supply in a radar set. [Ref. 21]

These concepts of learning outcomes were addressed in a training context by the Navy in two reports published during 1975 to 1976 by the Training Analysis and Evaluation Group in Orlando, Florida. The first report presented a technique for choosing a cost effective instructional delivery system for proposed training programs [Ref. 22]. In the study, the authors categorized learning algorithms into twelve groups. For each algorithm, the report identified behavioral attributes, action verbs, and examples of objectives to help the developer categorize the desired training outcomes. Worksheets for each group were available to assist in choosing the "most training and cost effective" [Ref. 22] delivery system. There was also a brief section on descriptions of media. The second report presented "training strategies for 11 common classes of training objectives" [Ref. 9] in the form of flow charts. The classes discussed are: 1) recalling bodies of knowledge, 2) using verbal information, 3) rule learning and using, 4) decision making, 5) detecting, 6) classifying, 7) identifying symbols, 8) voice communicating, 9) recalling procedures and positioning movements, 10) steering and guiding, continuous movement, and 11) performing gross motor skills. Attitudes was the one class left out in the second report. These seemingly specific classes are very much like the learning outcomes proposed by Gagne. These two studies are the basis for NAVEDTRA 108, A *Technique for Choosing Cost Effective Instructional Delivery Systems* which is the current manual the Navy has in the area of media selection.

In 1982, the U.S. Office of Naval Education and Training in Pensacola, Florida, published NAVEDTRA 110A *Procedures for Instructional Systems Development*. As the title suggests, it "provides guidance for the analysis, design, development, implementation, and control of instructional programs under the cognizance of CNET" (Chief of Naval Education and Training) [Ref. 21]. The manual categorizes a majority of the learning objectives of NAVEDTRA courses into two groups: Knowledge (remember) objectives and Performance (use) objectives. The remaining objectives fall into the categories of problem solving, physical or motor skills and attitude. Once again, these groupings of learning objectives are equivalent to Gagne's five learning outcomes. These learning objectives were identified to more effectively develop a viable training program and to assist in the proper media selection. Using the learning algorithms of NAVEDTRA 108 and 110A, a novice in training program design will be equipped with a set of guidelines.

Similarly, the U.S. Army Research Institute for the Behavioral and Social Sciences published a study in 1981 which proposed a learning based model for media selection [Ref. 23]. The study presented a simplified method of media selection using previously identified behavioral objectives and resource availability. Each step of the flowchart asks questions concerning various aspects and desired characteristics of the objectives. Examples of some questions are: "Are the consequences of task error serious?"; "Is the training designed to serve students dispersed over a wide geographic area?"; "Which type of learning outcome is desired?"; "Will self-instruction be required?"; "What is the availability of instructors?"; and "Are the students readers or non-readers?" The chart then presents "candidate media," from which the media selector can choose, with guidelines and a worksheet to record choices. One major assumption that the process is centered on is the classification of the objectives into the learning outcomes of Gagne. An important and very valuable aspect of the study is the list of selection factors to be considered after the preliminary "candidate media" are chosen. These factors address availability, production costs, maintainability, and compatibility, to name a few.

As with learning theory, there has been considerable research and development in media selection aids such as those described above. A study conducted by the Navy Personnel Research and Development Center (NPRDC) in San Diego, California, in 1988, reviewed 23 of the most current and viable military training decision aids [Ref. 24]. The study used a list of "Training Situation/Level Criteria" to evaluate each training aid. These critique factors provide a useful set of considerations in training program development. The NPRDC report states that to be optimally effective, such aids must be appropriately designed and oriented to the needs of specific users, which is one function that will be served by this thesis. The study also noted that decision aids that are to be used by military personnel who may not be highly experienced in instructional systems development should provide strong user guidance. Many of the current training aids decision methods rely on a strong foundation in the area of instructional development, which can hinder development of a functional program.

Gagne [Ref. 25.] discusses media selection factors in two categories: 1) physical attributes of media, and 2) learner, setting, and task characteristics. In his review of 10 media selection models, he uses these two groupings to discuss the strengths and weaknesses of the different models. Gagne seems to stress three points: 1) one must identify the audience and environment; 2) there is no one medium that will address all factors; and 3) *both* categories of factors need to be considered in media selection.

In investigating the physical attributes of media, Gagne feels the following must be considered:

1. Visuals: Are visual displays necessary and to what degree? For some tasks, words alone are not sufficient to help the learner acquire and retain visual images. Visual requirements include graphics, alphanumeric symbols, pictorials and possibly 3-D images.

2. Printed Words: A determination of the learner's reading strength drives the level, or even use, of printed media. Poor readers could become more frustrated and less receptive if this media factor is misinterpreted. A possible alternative is an audio narrator.

3. Sound: "Sound media are considered necessary to present the appropriate stimulus response information if the goal of instruction is the recall or recognition of the sounds themselves" [Ref. 25:p. 503]. There are also instances when spoken words are a more effective medium for poor readers.

4. Motion: Motion is a viable factor if the objective involves a recognition or copying of particular

movements being shown. Consideration needs to be given to the familiarity of the movement, the learner's concepts of the involved motion, and the desired speed at which the instruction and repetition must be performed.

5. Color: This media factor should be considered "if the color of the object is relevant to the performance of some cognitive or psychomotor objective" [Ref. 25:p. 504].

6. Real Objects: This factor addresses the issue of fidelity or, in other words, the degree of realism of the training equipment in relation to the operational equipment. The key to successfully addressing this factor is to analyze the learner's abilities with respect to the skills to be taught. Realistic objects should be used to teach motor skills because it can teach task error more effectively than traditional classroom instruction.

Learner characteristics have a strong bearing on the type of media selected. The three most common items are reading ability, age, and experience. The reading level of the learners will not only determine the difficulty of the printed material, but also the learning motivation in terms of self-instruction and instructor flexibility. The age of the learner plays a role in that "older, more experienced learners may have developed learning strategies that enable them to manage some aspects of instruction for themselves" [Ref. 25:p. 505]. This age factor can also act as a detriment to acceptance of updated methods of instruction or new concepts. The experience factor is much like the age factor in that there is potential for less concrete and more abstract media usage. An indepth analysis of these two factors previous to training development will allow for this expansion of concepts, but can backfire if the factors are misinterpreted.

Gagne addresses the issue of instructional setting in light of three questions [Ref. 25:p. 505]:

1. In what location is the instruction to be delivered?

2. Is the instruction to be presented to individuals or to a group?

3. If a group is to receive the instruction, what is the size of the group?

The concern about individuals versus group instruction will guide the media of teaching, as well as feedback. According to Gagne, "it is sometimes maintained that individual instruction should be delivered via media capable of providing corrective feedback,so as to provide learners with information about the inadequacy of their response [Ref. 25:p. 505]".

The application of theoretical learning to practical universal requirements has proven to be the major stumbling block in systematic training development. A viable windshear training program falls into this category. The current FAA syllabus available was not created using learning theory. Rather, it is based on the presumption that windshear survival is another skill a flight crew must master. As a result there appears to be no formal literature addressing the methods to properly train for this threat.

The next sections will integrate some of the theoretical training concepts discussed in the literature review and apply them to this specific type of training. Parameters will be established using available training literature to substantiate some basic assumptions such as the skills required by the flight crew to fly through a severe windshear. From this process, recommendations for media and methods to conduct the training will be made.

III. TRAINING ANALYSIS

Following needs analysis, there are four basic steps in systematically developing a well-structured training program: 1) identify desired behavioral objectives; 2) categorize the learning outcomes; 3) discuss the appropriate media to enhance internal and external stimuli; and 4) using specific media selection factors, address lesson guidelines to convey the training based on the previous three steps. Each level of progression has a specific purpose and is integral to the end product. In this chapter the first three steps will be discussed in general and then related to the specific training of P-3 flight crews. The fourth phase will be developed in the next chapter. Additionally, this section will investigate media selection factors that are specific to aviation and windshear training.

A. BEHAVIORAL OBJECTIVES

Identifying behavioral objectives enables the developer to characterize the critical correspondence between the stimuli of the job and the stimuli presented in the instruction [Ref. 21:p. 3-107]. This characterization is necessary for three reasons. First, it helps to determine the most effective learning strategy for the objectives. Each different category of objectives/outcomes are taught in unique ways. Secondly, categorization assists in a review of existing instructional materials. This can result in cost savings where it reveals enough substance in existing materials to modify those resources as opposed to building an entirely new program. The third reason to categorize objectives is to determine the most effective delivery system to use in the course. [Ref. 21] This step evaluates the audience's knowledge, skills, and abilities.

The behavioral objectives for windshear survival training are comprised of two branches, avoidance and recovery from inadvertent entry. Avoidance of the windshear environment is the primary objective. It involves recognizing the potential hazard by looking at weather charts previous to flight, as well as identifying developing atmospheric conditions during the flight. The second behavioral objective requires "aircraft awareness" to recognize the change in aircraft performance through the available gauges and to implement the proper recovery technique if it is a windshear condition.

B. LEARNING OUTCOMES

"The importance of the perceptual-motor skills to pilot performance has long been considered crucial, as is evident both in the extent to which pilot training has focused on perceptual-motor processes and in the predominance of perceptual-motor tests used to select candidates for pilot training." [Ref. 26:p. 10] According to discussions with subject matter experts on the subject of teaching windshear microburst survival, the consensus is that the outcomes required are the same as those needed to fly an instrument approach in poor weather conditions.[1] The only differences seem to be the extremely short (5 to 15 seconds) recognition/response time and a change in mind set. Therefore, in identifying the learning outcomes windshear training should achieve, advanced pilot skills will be used as the base case. The additional training will be focused on taking advantage of the short time available to recognize and react, as well as develop an understanding of the potential danger associated with a microburst and its close proximity to the ground.

Gagne's five learning outcomes (verbal information, intellectual skills, cognitive strategies, motor skills, and attitude) are an integral part of successful aviation training. Each phase of training builds upon the previous skill acquired. As the instruction becomes more cognitive and the mechanical movements increasingly automatic, the mixture of the five learning outcomes becomes complex. The following

[1] Two Navy P-3 pilots (one currently a P-3 flight instructor), a former P-3 pilot flight instructor, and three commercial airline pilots, were asked what critical skills were required to be trained to survive an inadvertent windshear microburst. All six pilots have flown a windshear microburst simulation and successfully flew to safety.

discussion will present each learning outcome and describe how it not only relates to general Naval aviation training, but also to windshear survival training.

Verbal Information: This outcome is the cornerstone and primary building block to every other learning outcome. Basic aviation nomenclature, system descriptions, and large bodies of information must be absorbed before further training is productive. For windshear training, meteorological identification of parts of the windshear environment, recalling basic aerodynamic facts, and memorization of emergency recovery procedures are the outcome of this phase.

Intellectual Skills: These performance objectives are the next level of complexity in learning. A solid foundation established with the mastery of the verbal information skills is a prerequisite to achieving this outcome. For the aviation student, these learning outcomes involve problem solving with predetermined procedures, classifying meteorological conditions, and troubleshooting/analyzing aircraft malfunctions. The emphasis is more on "doing" instead of just "recognizing" or "recalling" [Ref. 21:pp. 3-4]. In terms of the windshear training, an example of an intellectual skill would be the recognition of possible atmospheric conditions leading to windshear and avoiding that route with an alternate flight plan. In this outcome, concepts are applied, not just memorized.

Cognitive Strategies: This outcome involves the highest level of complexity, requiring highly realistic problem solving techniques. It incorporates all of the lower levels of knowledge and skill objectives. The outcome of this phase is the acquisition, through training, of how to think and solve problems. The skill enables one to strategically adapt in a less structured environment. In aviation, this skill is the one that separates the mechanical from the thinking pilot -- the ability to survive non-structured problems using structured skills. This outcome is vital in windshear survival because the microburst is not an isolated incident. The weather conditions, aircraft configuration, and a host of distractions can lead to disaster if a cognitive strategy is not developed.

Motor Skills: This learning outcome is obvious for the success of the aviator. Once again, verbal information and intellectual skills are a prerequisite to proper training of motor skills. This competence enables a pilot to think and move aircraft controls at the same time. After a time, the body will acquire this skill without any conscious effort as it develops a "physical motion memory." This training outcome is crucial to the survival of a microburst. The control inputs the pilot uses to recover need to be natural and comfortable. Practice of the movements is the best method to train for this outcome.

Attitude: How a person feels about a topic is attitude. In aviation, from the very beginning of training, pilots are taught a safety attitude. They also are trained an attitude for procedure knowledge, as well as respect for the flight environment. The attitude outcomes that should come from windshear training are, first, a healthy respect for the power of a microburst and, second, avoidance is the safest measure. There are many aviators who do not understand the windshear environment and challenge it.

C. MEDIA SELECTION

Media selection involves the choice of the "best" method of stimulating the trainee's learning abilities. The medium has to be designed to activate both the internal and external stimuli. There is no single medium that can address both stimuli or train all the desired learning objectives. The most effective learning is usually the result of a combination of media. There are numerous factors to consider when selecting the media package. Selection of the training media needs to be cost effective and accomplish the following goals: 1) maximize training effectiveness; 2) minimize training time; 3) maximize retention of training over time; and 4) maximize trainee motivation [Ref. 21:pp. 3-19].

Internal stimuli are those learning incentives originating from within the trainee. There are many theories that categorize internal learning. For the purposes of this thesis, Gagne's five learning outcomes will be used. As noted earlier, Gagne's theory has been widely used by instructional designers [Ref. 13]. Table 1 equates these skill results with the 12 learning algorithms described in NAVEDTRA 108. This Navy publication, though dated, is the official method available for practical media selection.

TABLE 1. COMPARISON OF SKILLS AND LEARNING ALGORITHMS

Gagne's Learning Outcome	NAVEDTRA 108 Learning Algorithm
1. Verbal Information	Recalling Bodies of Knowledge Identifying Symbols
2. Intellectual Skills	Using Verbal Information Rule Learning and Using Detecting Classifying Voice Communications
3. Cognitive Strategies	Making Decisions
4. Motor Skills	Recalling Procedures Positioning Movement Steering and Guiding-Continuous Movement Performing Gross Motor Skills
5. Attitude	Attitude Learning

To properly train a flight crew in windshear survival, eight of the twelve learning algorithms will be used. They are: 1) Recalling bodies of knowledge, 2) Using verbal information, 3) Rule learning and using, 4) Detecting, 5) Classifying, 6) Making decisions, 7) Steering and guiding-continuous movement, and 8) Attitude learning. Each of these outcomes can be mapped onto an "instructional delivery system" designed to achieve the desired skill. The Appendix, taken from NAVEDTRA 108, presents the media selection matrices for each of the learning algorithms. It is most notable that there are many factors the training developer must consider before selection of the "best" media. These factors will be discussed in more detail later.

Gagne's five learning outcomes address stimuli that are internal to the trainee and his own personal learning abilities. In selecting the most effective method of instruction, the developer must also investigate the external factors required to stimulate learning. In the training domain these factors have been called events of instruction by Gagne [Ref. 15]. Each event focuses on a different aspect of the training environment and can require individualized media to be most effective. According to Gagne these events are "designed to support the internal processes of learning." [Ref. 20:p. 155]. The nine events and a short description of each event's goals are presented.

1. Gaining attention: This event involves establishing a productive learning environment by removing distractions and using an initial medium that focuses attention on the instructor.

2. Informing the learner of the objectives: The media used for this event should provide the student with a clear indication of the skills and knowledge that will be expected upon course completion, assist in keeping the focus of the course, and present examples of the skills to be acquired.

3. Stimulating recall of prerequisite learning: Most group training is designed at the same level of skills or knowledge of the students. The media chosen for this event should provide a means of retrieving prior learning to working memory to establish a common level of schemata among all students.

4. Presenting the stimulus information: This is the event that is the traditional focus of media selection. The stimuli chosen for this event should be the same as those involved in the learning.

5. Providing learning guidance: Not only should the skills be presented, they must also be retained. This event focuses on the need to have a medium that teaches the students in placing information and skills learned into long term memory. The media chosen should provide a meaningful organization of the information to prevent the student from viewing the instruction as a series of disjointed bits of information. The organization will also facilitate the "chunking" of information which can enhance long term memory and recall. This "guidance" does not provide answers to specific questions, but does give the student a line of thought to apply to learned concepts.

6. Eliciting the performance: This event is known as the "show me" state. Up to this point the student has been exposed to the desired skills and knowledge and, now, it is time to practice. Ideally the practice will be in the same context as the actual application. However, in the case that it isn't, the media chosen should be similar in order to provide meaningful reinforcement techniques.

7. Providing corrective feedback: Feedback to the student is an essential element of external

stimuli. The return of information provides the student with an opportunity to judge his performance against the predetermined objectives. The media selected should be chosen to give a timely assessment of the student's actions.

8. Assessing the performance: This event establishes the criteria by which the student's performance is measured. It is a checkpoint to determine if the learning objectives stated in the beginning were realized. As with the previous event, the media chosen will be guided by the required timeliness to the student. A key element to this event is the student's understanding of how he will be judged based on the established criteria.

9. Enhancing retention and transfer: The media chosen for this event provides the learner with a source of cues to retrieve skills and information from long term memory. The ability to draw the needed knowledge is the enduring measure of success in training programs. Media can also be chosen that provide a systematic review for critical skills. An important part of the cues used is that they resemble the situation the student will face when the application is required.

A well developed program must address three sets of factors in order to enhance training effectiveness and efficiency. The previous two sections discussed two of these elements that are specific to the learner: internal and external stimuli. This next segment will analyze some of the more realistic and prohibitive factors facing windshear training program development.

D. WINDSHEAR TRAINING FACTORS

Chapter II addressed some of the general factors that training program developers need to consider, particularly those suggested by Gagne. He pointed out that each set of training objectives, learners, and environment creates a unique requirement. This section will address factors relevant to a windshear training program.

The learners in this training program will be of two types. The first group is first-tour pilots and flight crew members. The pilots have just recently become designated Naval Aviators and upon completion of the P-3 FRS syllabus will join an operational squadron. The second category of learners are fleet pilots returning for annual instrument refresher training or refresher training for a second or third operational tour. Their ages will range from the 22-year-old "nugget" to a 40-year-old squadron commander. Due to selection factors in flight training, reading abilities of the two types will be similar and will allow for moderately in-depth discussions of aerodynamic and meteorological concepts. The greatest differentiating factor is experience and, as with age, there will be a wide range. Therefore, the designed program needs to accommodate this variation by being flexible enough to challenge the lowest and highest levels of experience.

The instruction of windshear survival goes beyond the traditional classroom discussion of theory. The physical attributes of the media must span both the printed text explaining the concepts, and visual cues to enhance recognition. Printed text establishes the theoretical portion of the training and provides a reference source for the future. Visual media implant valuable images in the learner's long term memory that can be called upon in avoidance methods and possibly recovery techniques. The most controversial attribute is the desired fidelity of instruction, particularly with the flight simulation. A more "realistic" flight environment can enhance the learner's transfer of skills to the actual task. However, the marginal cost of the additional fidelity, measured with respect to productive learning, needs to be weighed by the developer. More fidelity usually produces more costs in terms of simulator software and hardware. For windshear training the fidelity characteristics need not capture 100% of the aircraft actions. Rather, it should provide realistic cockpit indications, variable windshear parameters that are measurable, and the range of motion that exists in the current P-3 simulators.

The typical instructional setting of P-3 FRS training is individualized study with programmed texts, group training in the classroom, and paired training in the simulators. The training environment, in terms of an established setting,is a favorable factor at the bases containing the FRS's. However, the facilities at NAS Brunswick, Maine, and NAS Barber's Point, Hawaii, are not as conducive to refresher training in the classroom and simulator phases. This factor needs to be addressed in the implementation of a windshear training program.

The attitude and perceptions of the Navy and P-3 community toward the windshear hazard and danger potential need to be addressed as a selection factor. At this time there is not a requirement within Naval aviation to train in this area. Even within the P-3 community there is a difference of opinions as to the need for this type of training. As mentioned earlier, the two West Coast patrol airwings are using an in-house program that teaches the ground school phase. The media selected to teach windshear will most likely be successful if they have two attributes. First, the need must be established and secondly, the costs must be attractive. A program that can easily be assimilated into current training pipelines without a lot of turbulence or developmental costs is very attractive and will be well received.

The cost of operating and maintaining a training program is normally the make or break point. Operations costs include instructors, classrooms, texts, simulators, audio-visual aids, and many miscellaneous items. Simulator repair and upkeep, textbook revisions, and building upkeep comprise maintenance costs. If a training program can be incorporated into an existing system, the operation and maintenance costs will most likely be reduced and be a more positive selection factor. The institution of a new program is best served if the media selected are readily available. Purchase of a new method of instruction or the development of tailor-made media can be an unacceptable cost and impose an implementation delay. Off-the-shelf technology seems to best suit a new training program. For the Navy this usually means the use of media in the Navy supply system.

The final selection faction is qualified instructor availability. Qualified instructors or the lack of them can severely hamper a training program. The credibility of a training system rests with the quality of students produced. Instructors play a key role in this effort. Each P-3 squadron has a cadre of flight instructors to train incoming pilots. They are qualified to instruct in both the classroom and simulator environment. The core of P-3 instructors are attached to the two Fleet Replacement Squadrons and are tasked with training first tour and experienced flight crews. The factors that need to be addressed are: 1) how will an additional training program impact on the current instructors' time; 2) will it detract from the quality of instruction presently provided; and 3) will more instructors need to be added to implement the new program?

E. SUMMARY

This chapter has provided a transition from the theory of learning to the practical application of a windshear training program. It discussed the relationship between Gagne's five learning outcomes and the Navy's 12 learning algorithms. From these algorithms, an initial combination of media can be selected. Additionally, the events of instruction and other selection factors were addressed to provide a framework for the recommendations that will be made.

The next chapter will present recommendations for training media and methods for each behavioral objective. A training program will be suggested along with additional recommendations to support the training effort.

IV. PROPOSED WINDSHEAR TRAINING PROGRAM

As discussed in an earlier section, the behavioral objectives of a windshear training program are twofold: 1) avoidance, and 2) recovery in case of inadvertent entry. The media selected to internally and externally stimulate the learner are overlapping. The objectives can be met using one combination of media to instruct instead of developing separate training programs.

For this study, NAVEDTRA 108 will be used as the training media selection aid since it is currently the Navy's media selection guide. As can be seen in the Appendix, each learning algorithm has a matrix to assist the developer. On the selected algorithm page, the alternative instructional delivery systems are divided between those that permit the application of *all* learning guidelines and algorithms and those that do not. The matrix has three sections depicting the major aspects of selection: stimulus criteria, training setting criteria, and administrative criteria. Within each category are algorithm specific criteria. A recommended medium is indicated by the X in the box. It is readily evident that there are numerous combinations of criteria that can suggest many instructional delivery systems.

A new training program will most likely succeed, assuming the need is realized, if the operating costs are acceptable and implementation does not create serious turbulence in the organization. Simplicity is the key. For the purposes of this study of training a new skill, a set of selection parameters will be established. In the Appendix, stimulus criteria will be selected for the lowest acceptable level of fidelity. The criteria for the training setting will be for a small group, large group, or individual trainee at a fixed location. This is consistent with the current FRS method of instruction. The administrative criteria will have the site of the courseware and special hardware development at a central location. Also, the magnitude of acquisition costs will be selected to be low.

Using the preset parameters to select the instructional delivery systems, the following is a list of the eight relevant learning algorithms and their candidate media: (* indicates application of all learning guidelines and algorithms)

1. Recalling bodies of knowledge:
   a) microfiche with self-scoring tests *
   b) programmed texts, branching with self-scoring tests *
   c) traditional classroom
   d) programmed text -- linear with instructor scored criterion

2. Using verbal information

   a) programmed texts -- branching *

   b) microfiche with self-scoring tests *

   c) tutor with diagnostic tests *

3. Rule learning and using:

   a) procedure trainer with instructor and instructor handbook *

   b) teaching machine, branching *

   c) programmed text, branching *

   d) microfiche with self-scoring tests *

   e) programmed instruction -- linear

4. Making decisions:

   a) manual simulation game *

   b) microfiche with self-scoring tests *

   c) programmed text -- branching with self-scoring test *

   d) case study materials

5. Detecting:

   a) Informal on-the-job training

6. Classifying:

   a) study card sets *

   b) microfiche *

   c) slide sets with instructor

   d) traditional classroom with AV materials

   e) sound slide/film strip program

7. Steering and guiding -- continuous movement:

   a) operational system, real environment with instructor *

   b) simulator with motion platform and full visual field *

   c) simulator without motion platform and full vision field *

   d) procedure trainer, instructor and instructor handbook *

   e) operational system, real environment without instructor

8. Attitude learning:

   a) case studies

   b) lectures, seminars

With the parameters previously assumed, the combination of media that most effectively teaches windshear survival will include:

1. Microfiche with self-scoring tests or programmed text with branching capabilities

2. Flight simulator with motion

3. Windshear case studies

This recommendation can be supported by the media presently available at the FRS. It is designed with the individual learner in mind and does not easily accommodate group instruction.

The majority of the cost lies in simulator software and hardware development. Proper flight simulation is an important factor in training for the windshear environment. Recall that the flight crew has as little as 5 to 15 seconds to recognize the situation and take corrective action. This is due to the aircraft speed through the microburst, the powerful wind velocity and directional changes, and, most importantly, the proximity to the ground. Simulation allows for development of anticipatory decision strategies. According to a study published by the Air Force Office of Scientific Research [Ref. 27], anticipatory decisions are those in which the situational factors are anticipated and the threshold criteria for executing the process are preselected. The other type of decisions, ongoing decisions, require more time to reach the criteria threshold and in the windshear environment could be fatal. The study categorizes emergencies into three groups based on predictability and labels them situations 1, 2, or 3, with situation 3 being unpredictable and situation 2 being partially predictable. An inadvertent entry into a microburst would be somewhere between a situation 2 and 3. The study implies that simulated situations are the most effective method of preparing a pilot for these emergencies.

The major hurdle in initiating a training program once the theoretically best media are chosen is the development of those media and incorporating them into the specific training pipeline. Sometimes, rather than requiring the optimal instructional delivery system, the command may choose a previously developed program that has proven to be successful. With such a selection, the developers may realize great cost savings. In the case of windshear training there is such an opportunity.

A windshear training aid, published by the FAA in 1987, is the result of 15 months of effort by a group of aircraft builders, meteorologists, and the FAA. The goal of the training program is to instruct flight crews in the hazards of windshear, avoidance measures and recovery techniques in case of entry. United Airlines was tasked with developing the actual training program. The instructional package is the only windshear training program available and is strongly recommended by the civilian aviation industry. A measure of its success is that for the past 48 months, there have been no aircraft incidents involving windshear alone whereas, in the past,windshear was one of the largest single causes of aircraft accidents [Ref. 28].

The two binder training program, entitled *Windshear Training Aid* [Ref. 3], consists of ground school lecture material, slides, tests, answer bank and simulator programming information necessary to program seven actual windshear encounters. The simulations include both departures and arrivals and use aircraft flight information from the "black boxes" to set parameters. These valuable data provide grading criteria for the program. The training aid is published by the FAA with no copyright attached. The only item not provided by the training aid is software for the simulators.

The FAA training package is used by virtually all civilian aviation facilities to satisfy the regulation in FAR Parts 121 and 135. Most employ it during initial air transport training, as well as during the annual instrument refresher training. Some Navy pilots, like Lt. Ken Underwood, the Naval Safety Center's multi-engine/heavy aircraft analyst, have been trained by civilian experts using the program. The following is a quote expressing Lt. Underwood's view:

> As a P-3 pilot, I received no formal windshear training, i.e., recognition, avoidance, recovery procedures simulations, etc. As a C-12 pilot, however, I was exposed to windshear training during a 2 week syllabus at SimuFlite in Dallas, Texas. The training included simulated approaches flown into microburst activity at various stages of development. I feel the experience was invaluable. Reading about what microburst conditions are like and actually flying through one are two different things. Yes, the instruments react just as advertised, but SEEING it happen and utilizing recovery techniques make a lasting impression. [Ref. 29]

The program is designed for one hour of classroom time and 30 minutes of flight simulation time. Conversations with civilian aviators validate the time requirements and its success.

A. ALTERNATIVES

The FAA windshear training package is designed for a traditional classroom learning environment. Development of individualized program texts or some type of computer assisted instruction could enhance the learning experience and provide greater transferability to the avoidance objective. Presently, an instructor at the P-3 FRS at NAS Moffet Field, California, has videotaped a windshear training lecture using the FAA program to send to Hawaii P-3 squadrons.

Simulator fidelity could be increased as an alternative. International Simulation, a company that develops simulator software and hardware, has a three dimensional microburst model that provides greater variation to each windshear simulation. Instead of the two dimensional parameters provided by the FAA program, the microburst model incorporates known weather and turbulence models. This added degree of authenticity gives the learner a more "realistic" feel for the environment. One drawback to this method is the lack of solid criteria needed for grading the learner.

On the other end of the fidelity spectrum is the current informal method used to introduce students to windshear. The instructors at the West Cost FRS who are familiar with the windshear hazard teach it by instantaneously changing the wind direction, wind velocity, and vertical speed of the aircraft in the simulator. This method is less than realistic and provides no grading criteria except pass/fail.

The Canadian Air Force flies a version of the P-3 called the Aurora. Similar to the U.S. Navy's program, their undergraduate flight students receive extensive windshear training in the classroom during ground school. Primary flight training is conducted at the Second Canadian Forces Training School located at Moosejaw, Saskatchewan. However, the instruction is all theoretical without any simulation. Aurora pilots report to 404 Squadron at CFB Greenwood, Nova Scotia, in preparation for their operational tours. As with the P-3 FRS, there is no formal windshear training program. There are, however, two windshear scenarios available to instructors who choose to use them. The microburst is simulated by resetting the airspeed for a 20 knot change which will occur instantaneously. The Aurora pilots, on a yearly basis, attend instrument refresher training during which meteorological theory is reviewed. Windshear theory is discussed as a part of this review. [Ref. 30]

B. ADDITIONAL RECOMMENDATIONS

As a result of a recommendation made by VP-31, the P-3 model manager, at the most recent NATOPS conference, the following note was added to the P-3 NATOPS manual:

> Windshears at low altitudes have long been recognized as a potential hazard to aircraft during takeoff and

landing. Most windshears are relatively weak and, if anticipated, do not exceed the performance capability of the aircraft to fly through them. The principal causes of such low altitude windshears are convective activity, frontal systems, lake and sea breezes, and temperature inversions. Windshear is defined as a rapid change in direction and/or speed of the wind that results in an airspeed change of 10 knots or more and/or vertical speed changes greater than 500FPM.

If low altitude windshear is predicted on approach, consideration should be given to maintaining airspeed 5 to 10 knots higher than normal approach speeds. If executing a non-precision approach descending rapidly to your missed approach point altitude should be avoided in favor of a 3 degree glideslope. A stabilized approach airspeed and attitude provides for enhanced windshear detection. Selection of land flaps is not recommended. If low altitude windshear is forecast for takeoff, precautions include: Using the longest available runway, using maximum rated power, and using increased rotation speed. However, in all cases, avoidance is the best precaution. [Ref. 31]

This note has been incorporated in the foul weather section of chapter six of the NATOPS manual. It is recommended that this note be upgraded to a warning, written in stronger terms, expressed in terms more compatible with FAA policies of avoidance, and placed in section five (emergency procedures) of the NATOPS manual. This move will facilitate discussion of the situation and provide the flight crews with an opportunity to develop their personal criteria for the anticipatory decisions.

The vulnerability of an aircraft, as stated in the first chapter, is a function of its excess thrust-to-weight ratio, as well as aircraft controllability. Depending on the strength of the downdraft and the location of the aircraft in the microburst, the windshear may or may not be survivable. Vulnerability tests on Navy landbased aircraft such as the P-3, C-130, and C-9 could possibly give a greater range of data on how that particular aircraft may react in a microburst. From this aerodynamic information, flight procedures and recovery techniques can be developed to take advantage of the aircraft's characteristics. Vulnerability tests should be a part of the design and test phase of new aircraft. Design features of the aircraft could actually make it more vulnerable to a microburst environment.

The FAA views windshear survival from a systems approach. Avoidance and inflight recovery training is just a part of the plan. The larger, more expensive segment is the development of Low Level Windshear Alert Systems (LLWAS). A simple LLWAS consists of six wind sensors located around the periphery of the airfield. The sensors measure the velocity and direction of the wind at that location. The sensors are connected to the field's control tower and, by comparing the sensor's information, the controller can monitor potential windshear conditions. In a 1988 letter to OP-554 (Airspace, Airfields and Air Traffic Control branch of the Assistant Chief of Naval Operations, Air Warfare), the commander of the Naval Safety Center proposed the "feasibility of obtaining a modern LLWAS" [Ref. 2]. His major point was that it is true that most of the Navy's aircraft inventory is made up of tactical aircraft with plenty of excess thrust to fly out of a microburst. However, the advance warning from a LLWAS would be valuable to a pilot in that it would allow him to anticipate the windshear potential. The danger does not only lie with the strength of the microburst, but also in the proximity to the ground when the burst hits. The letter states that at this time the procurement cost of a LLWAS is prohibitive and recommends that the Navy "initiate long-lead funding initiatives/actions to procure LLWAS when it becomes cost effective for our major airfields with specific attention to those that operate large transport/logistics type aircraft, including P-3s, C-9s, C-141s, and C-5s, and in locales where there is a high probability of convective weather associated with thunderstorms." [Ref. 2]

C. SUMMARY

This chapter identified the media, with established parameters, that would most effectively train flight crews in windshear survival. The FAA's windshear training aid was introduced as a viable alternative to developing a Navy P-3 specific training program. The FAA package trains the stated objectives, sacrificing only the aspect of individualized instruction, which could be modified at a later time. Recommendations to improve the awareness and flight crew preparation were made. In the area of windshear, the civilian aviation industry is far ahead with many lessons that can be learned by military aviation.

V. BENEFITS AND COSTS OF TRAINING IMPLEMENTATION

As with the addition of any proposed change to an existing program, the costs and benefits of implementation must be addressed. This chapter will discuss the major benefits to the P-3 community and Naval aviation if the proposed training is included in the current instruction. This section will also examine the costs of executing the new training program. It must be kept in mind that at the present time the training of newly designated pilots at the Fleet Replacement Squadrons (FRS) is a well-developed program that has particular requirements and restrictions in the areas of flight crew proficiency, available training time, and instructional resources.

A. BENEFITS OF IMPLEMENTATION

The most obvious benefit to implementing a windshear training program is the increase in flight crew and passenger safety. It is very difficult to place a price on their lives and what is saved if the aircraft survives a microburst. Up until 1987 windshear had one of the highest single cause death rate percentages among civilian air transport carriers [Ref. 28]. According to the FAA, since 1987 when the civilian aviation industry started formal windshear training, there have been no documented cases of physical damage, injuries, or deaths due to windshear [Ref. 28.] In fact, in a soon-to-be released case study, Mr. Herbert Schlickenmaier of the FAA's Flight Crew Systems Research Branch documents five aircraft approaches, on July 11, 1988, to Stapleton Airport in Denver, Colorado, that survived unexpected microburst encounters. Each flight crew credits the training program for their success in maneuvering their aircraft through the microburst. [Ref. 32]

A windshear training program can enhance pilot proficiency in that the skills involved are transferable to other situations the flight crew might encounter. As mentioned earlier, P-3s operate in many different weather environments that task the flight crews to their limits. One aspect of windshear training is a greater appreciation of the aircraft's capabilities in severe weather and how to use all the available power and aerodynamics to fly out of the microburst. Making an approach to an airfield in the monsoon rains of the Far East or snow storms of the North Atlantic can be nearly as treacherous as making an approach through a microburst. The additional skill from windshear training could make the difference between a successful approach and the loss of a flight crew.

In most cases the Navy is more rigid than civilian aviation in terms of fight regulations. A formal training program will interject more compatibility with FAA regulations and training guidelines in the area of windshear. The program appears to be working for the civilian flight crews who implemented the training in 1987. In fact, it was the civilian aviation industry along with the FAA who called for the development of a program to meet the windshear threat. Advances in windshear detection, both in the aircraft and on the ground, are a major project of the industry, NASA, and the FAA.

The Navy prides itself on its superb aviation safety record. In light of the environment in which the crews are tasked to operate, the minimal number of incidents is remarkable. Unfortunately, since the Navy is "public property," aircraft incidents and associated deaths are widely publicized. Steps to prevent an aircraft accident and possible loss of life can be made by implementing a windshear training program. The training can be viewed as preventative, as are most emergency training evolutions. None of the sister services or Canadians is using a formal windshear training program as part of its aircrew training pipelines.

If the need for a training program is realized, there is one further benefit. For the P-3 flight crew training there will be no curriculum development costs if the *FAA Windshear Training Aid* is used. As mentioned earlier, this package contains all the items needed to start a training program. The FAA package is free and has no copyright attached. The FAA strongly encourages its use among aviators. Before the package was developed there was no standard method of training windshear, if it were taught, except through informal discussions. Now, in compliance with Federal Aviation Regulations, the training must be FAA certified and the only available program is the FAA package.

B. COSTS OF IMPLEMENTATION

One item not available with the FAA windshear training aid is the application software needed to program the simulators so that they will accept the windshear models. The simulators (2F87F) currently in use at the FRS were built by Digital Corporation with the original system software written by Singer. If developed,application software needed to input the windfield parameters provided by the FAA package would be limited due to hardware constraints of the 2F87F.The 2F87F uses a DEC PDP 11/45 processor that employs older technology such as core memory and paper tape readers, which reduce the capabilities of the simulator, such as the ability to add computer memory [Ref. 33]. Presently, the operators find themselves limited in loading the current simulator parameters. Additionally, because of its outdated components, the PDP 11/45 is no longer supported with new parts by its manufacturer. Used and spare parts make up the repair parts inventory. [Ref. 33]

Relatively inexpensive technology exists to update the capabilities of the 2F87F simulator. According to International Simulation [Ref. 33], there are two possible alternatives available that could be considered. The first option would be to purchase the updated version of the PDP 11/45, the PDP 11/44. For approximately $5,000, a used 11/44 could be purchased commercially to replace the PDP 11/45. Software from the current simulator would be compatible with the PDP 11/44. To "rehost" the simulator with a PDP 11/44, write software for the windshear models, and make minimal adjustments would cost just under $150,000. The upgraded system would have an increased capability and be logistically supportable for 5-10 years.

Another possible alternative would be the addition of a satellite processor to the PDP 11/45. The processor would supplement the simulator and feed information into the simulator using an interface with the PDP 11/45. A microprocessor would expand the capabilities of the simulator to provide a windshear scenario, as well as many other modes. Adding a satellite processor to the current system would cost approximately $300,000. This option offers more than the first, in that the processor would allow greater expansion of the simulators' capabilities in the future. [Ref. 33]

Most of the software used by the civilian aviation industry to program the simulators for windshear is written in FORTRAN.

Some work was done between United Airlines and instructors at VP-31 in developing software for the P-3 simulator at NAS Moffet Field. Unfortunately, copyright negotiations and contracts between the Navy and the 2F87F developers precluded the use of the designed software. [Ref. 34]

The second potential cost will be the opportunity costs of the instructors and students as they train in the classroom and simulator. If the FAA package is used, it requires one hour of classroom time and 30 minutes of simulator time. For a first-tour pilot (Category 1) it costs the government $25,185 for the training in the FRS. This encompasses 42 hours in the simulator and 34 actual flight hours in a P-3. From start to finish it costs approximately $165,000 to prepare a pilot for his first squadron tour [Ref. 35]. The scheduling of instructors and students with minimal slack time is the result of years of experience. The addition of further time requirements for classroom and simulator time may not be acceptable.

For the flight crew members who will receive windshear training at their annual instrument refresher training, this additional training time is converted into time away from the operational squadron. Additionally, the extra simulation time could strain an already extended simulator schedule. As one further cost, flight crew instructors will have to be trained to properly instruct the windshear information and simulation.

This additional training can be incorporated into the current Instructor Under Training (IUT) syllabus.

C. SUMMARY

In reviewing the benefits and costs of implementation it appears that the benefits equal or exceed the costs. However, in order to introduce this training program a conscious decision must be made to accept the costs. Software development and the needed hardware support for the current P-3 simulators are the set of expenses that can prevent implementation. Fortunately, due to the insight of the P-3 Aircraft Simulation Branch of the Naval Training Systems Center in Orlando, Florida, the follow-on aircraft to the P-3, the P-7, has the requirement for windshear simulation in its Request For Proposal (RFP) and will bypass this major expense [Ref. 36]. This foresight, however, does not solve the shortcomings of the P-3 simulator. The issue of time spent for training versus operational requirements will always be a controversial topic of discussion.

VI. SUMMARY

This thesis addressed a segment of Naval aviation training that is deficient at this time. The danger of the windshear environment has been recognized by the civilian aviation industry. Every day new data are collected in order to analyze it and develop systems to detect and survive microbursts. Civilian industry has chosen to make the investment in training flight crews to operate in the windshear environment.

This study used the systematic approach to training program development to analyze the requirements of a proposed windshear training program. This technique is the most straight forward and efficient method available and is easily adapted to the skills and objectives of aviation training. The analysis identified the desired learning objectives, equated them to learning outcomes, and recommended media combinations to achieve the outcomes. Factors affecting training such as resources, time, student characteristics, and training environment were addressed in each phase. This approach does not require in-depth expertise in the area of training development to use it effectively.

The results of the training analysis produced recommendations for a formal windshear program requiring media and resources that are presently available within the training syllabus. However, development costs of a viable training package can overcome the positive training provided. In light of this dilemma, it is recommended that the *FAA Windshear Training Aid* be incorporated into the formal P-3 flight crew training curriculum.

The FAA windshear training package is the simplest, quickest and most cost effective method to get the P-3 community up to date with civilian aviation. The program has a proven success record and has the full support of the industry. The FAA package has all the necessary elements to start a productive training program.

The P-3 will be in the Navy's inventory for many more years with its replacement, the P-7, not expected to get to the operational fleet until the mid-1990s. There are many hours to be flown and the operating environment will not improve. The implementation of a windshear training program, both in a ground school phase and in flight simulation, will give the flight crews the advantage they need against the windshear environment.

Implementing the formal training is only the first step in awakening the P-3 community to the windshear hazard. Recommendations were also made for windshear alert systems for the aircraft and ground stations. Attitudes toward windshear and other severe weather conditions need to improve, as well. Misconceptions about the aircraft's capabilities in hazardous weather must be dispelled. Many of the procedures and training evolutions pilots face are the result of an accident not trained for. With a formal windshear training program, procedures can be implemented without a costly incident or possible loss of life.

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM

5

RECALLING BODIES OF KNOWLEDGE

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems	√	Alternative Instructional Delivery Systems: Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm					Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm			
		CAI	Teaching Machine - Branching	Microfiche with Self-Scoring Tests	Programmed Text - Branching with Self-Scoring Tests	Audio Visual Control with Program Tests, AV Modules and Self-Scoring Tests	Traditional Classroom with Instructor, Overhead Projector, Texts, and Paper and Pencil Tests	Independent Study Using Textbooks, Handbooks, Tests and Workbooks	Instructional Television Broadcast or CCTV Without Feedback, Tests	Programmed Text - Linear with Instructor Scored Criterion Test
Stimulus Criteria										
● Visual Movement										
Limited		X	X			X			X	
Full		X				X			X	
● Visual Spectrum										
Full Color		X	X	X		X	X	X	X	
● Audio										
Voice Sound Range		X	X			X	X		X	
Full Sound Range						X				
Training Setting Criteria										
● Individual Trainees at Fixed Location		X	X	X	X	X	X		X	X
● Individual Trainees with Simultaneous Instruction at Many Locations									X	
● Individual Trainees with Independent Instruction at Any Location				X	X			X		X
● Small Group							X		X	
● Large Group at a Single Location							X		X	
● Team Setting										
Administrative Criteria										
● Site of Courseware and Special Hardware Development										
Local				X	X	X	X	X		X
Central		X	X	X	X	X		X	X	X
● Magnitude of Acquisition Cost										
Low				X	X		X	X		X
High		X	X			X			X	

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 2)

USING VERBAL INFORMATION

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems		Alternative Instructional Delivery Systems: Delivery Approaches Permitting the Application of ALL Learning Guidelines and Algorithm						Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm		
		Computer Assisted Instruction with Adjunct Equipment and Materials	Programmed Text - Branching	Programmed Text - Branching with Paper Simulation	Teaching Machine - Branching Still Visual	Microfiche with Self-Scoring Tests	Tutor with Diagnostic Tests and Instructor's Guide with Student Exercises	Traditional Classroom	On-the-Job Training	
Stimulus Criteria										
● Visual Movement										
Limited		X			X			X	X	
Full		X						X	X	
● Visual Spectrum										
Full Color		X		X	X	X		X	X	
● Audio										
Voice Sound Range		X			X		X	X	X	
Full Sound Range									X	
Training Setting Criteria										
● Individual Trainees at Fixed Location		X	X	X	X	X	X		X	
● Individual Trainees with Independent Instruction at Any Location			X	X		X				
● Small Group								X		
● Large group at a single location								X		
● Team Setting									X	
Administrative Criteria										
● Site of Courseware and Special Hardware Development										
Local			X	X		X	X	X	X	
Central		X	X	X	X	X	X			
● Magnitude of Acquisition Cost										
Low			X	X		X	X	X	X	
High		X			X					

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 3)

RULE LEARNING AND USING

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Alternative Instructional Delivery Systems

- Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm: columns 1–7
- Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm: columns 8–9

Criteria for Selecting Instructional Delivery Systems	√	Operational Equipment with Instructor and Instructor Handbook	Simulator with Instructor and Instructor Handbook	Procedure Trainer with Instructor and Instructor Handbook	Computer Assisted Instruction	Teaching Machine, Branching	Programmed Text, Branching	Microfiche with Self-Scoring Tests	Traditional Classroom	Programmed Instruction - Linear
Stimulus Criteria										
● Visual Form										
Pictorial, Plane					X	X	X	X	X	X
Line Construction, Plane					X	X	X	X	X	X
Object, Solid		X	X	X					X	
Environment		X	X	X						
● Visual Movement										
Limited			X	X	X	X			X	
Full		X	X	X	X					
● Visual Spectrum										
Gray Scale					X	X	X	X	X	X
Color		X	X	X	X	X		X	X	
● Audio										
Voice Sound Range		X	X	X	X	X			X	
Full Sound Range		X	X	X						
Ambient Sounds		X	X							
● Other										
Tactile Cues		X	X	X						
Internal Stimulus Motion Cues		X	X	X						
External Stimulus Motion Cues		X	X							
Instructional Setting Criteria										
● Individual Trainee at Fixed Location		X	X	X	X	X	X	X	X	X
● Individual Trainee with Independent Instruction at Any Location							X	X		X
● Small Group									X	
● Large Group at a Single Location									X	
Administrative Criteria										
● Site of Courseware and Special Hardware Development										
Local							X	X	X	X
Central		X	X	X	X	X	X	X		X
● Magnitude of Acquisition Cost										
Low				X		X	X	X	X	X
High		X	X	X	X	X				

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 4)

MAKING DECISIONS

Directions:

To choose a delivery system:

1. Place a "✓" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "✓". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems		Alternative Instructional Delivery Systems									
		Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm						Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm			
		Simulator Diagnostic Tests with Instructor	Manual Simulation Game with Diagnostic Tests and Instructor	CAI with Adjunct Equipment and Materials	Teaching Machine - Branching	Microfiche with Self- Scoring Tests	Programmed Text - Branching with Self-Scoring Tests	Operational System with Tutor	Case Study Materials w/wo Instructor	Role Playing Materials with Instructor	
Stimulus Criteria											
● Visual Form											
Alphanumerics			X	X	X	X	X		X	X	
Pictorial, Plain			X	X	X	X	X		X	X	
Object, Solid		X						X		X	
● Visual Movement											
Still			X	X	X	X	X		X		
Full Movement		X		X				X			
● Audio											
Voice Sound Range		X	X	X	X			X		X	
Full Sound Range		X						X			
● Other											
Tactile Cues		X						X			
External Stimuli Motion Cues		X						X			
Training Setting Criteria											
● Individual Trainee at Fixed Location		X	X	X	X	X	X	X	X		
● Independent Trainee with Independent Instruction at Any Location						X	X				
● Small Group								X	X	X	
● Team Setting		X	X					X		X	
Administrative Criteria											
● Site of Courseware and Special Hardware Development											
Local			X			X	X		X	X	
Central		X	X	X	X	X	X	X	X	X	
● Magnitude of Acquisition Cost											
Low			X			X	X		X	X	
High		X		X	X			X			

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 5)

DETECTING

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems	√	Alternative Instructional Delivery Systems: Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithms					Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithms		
		Operational System with Stimulated Signals, and an Instructor with Instructor Handbook	Simulator with Instructor and Instructor Handbook	Simulator with Adjunct Displays and Logic	Procedure Trainer, with Instructor and Instructor Handbook	Procedure Trainer with Adjunct Displays and Logic	Operational System with Instructor	Informal On-the-Job Training on Operational System	
Stimulus Criteria									
● Full Visual Environment		X					X	X	
● Full Ambient Sounds		X	X	X			X	X	
● External Stimulus Motion Cues		X	X	X			X	X	
Training Setting Criteria									
● Individual Trainee at Fixed Location (School)		X	X	X	X	X	X		
● Individual Trainee On-the-Job		X					X	X	
Administrative Criteria									
● Site of Courseware and Special Hardware Development									
Local							X	X	
Central		X	X	X	X	X			
● Magnitude of Acquisition Cost									
Low								X	
High		X	X	X	X	X	X		

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 6)

CLASSIFYING

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems	√	Alternative Instructional Delivery Systems — Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithms: CAI w/Adjunct Equipment and Materials	Study Card Sets	Microfiche	Teaching Machine - Branching	Simulator with Adjunct Displays or Instructor	Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithms: Slide Sets with Instructor	Traditional Classroom with AV Materials	Audio Recorders - Disc or Tape	Specimen Set	Sound Slide/Film Strip Program	
Stimulus Criteria												
● Visual Form												
Alphanumeric		X	X	X	X	X	X	X			X	
Pictorial, Plane		X	X	X	X		X	X			X	
Line Construction, Plane		X	X	X	X		X	X			X	
Object, Solid						X				X		
Environment						X						
● Visual Movement												
Still		X	X	X	X		X	X		X	X	
Limited		X			X			X			X	
Full						X		X				
● Scale												
Exact Scale						X				X		
● Audio												
Voice Sound Range		X			X	X	X	X	X		X	
Full Sound Range						X			X			
Ambient Sounds						X						
Other Tactile Cues						X				X		
Internal Stimulus Motion Cues						X						
External Stimulus Motion Cues						X						
Training Setting Criteria												
● Individual Trainee at a Fixed Location		X	X	X	X	X	X		X	X	X	
● Individual Trainee with Independent Instruction at Any Location			X	X					X		X	
● Small Group							X	X	X		X	
● Large Group at Single Location							X	X	X		X	
Administrative Criteria												
● Site of Courseware and Special Hardware Development												
Local			X	X	X		X	X	X	X	X	
Central		X	X	X	X	X	X	X	X	X	X	
● Magnitude of Acquisition Cost												
Low			X	X			X	X	X	X	X	
High		X			X	X						

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 7)

IDENTIFYING GRAPHIC SYMBOLS

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems	√	Alternative Instructional Delivery Systems: Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm					Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm				
		CAI (with visual display)	Teaching Machine - Branching	Programmed Text - Branching	Microfiche with Self-Scoring Tests	Study-Card Sets with Self-Scoring Tests	Traditional Classroom	Textbook	Chart	Automatic Rater	
Training Setting Criteria											
● Individual Trainee at a Fixed Location		X	X	X	X	X		X	X	X	
● Individual Trainee with Independent Instruction at Any Location				X	X	X		X	X		
Administrative Criteria											
● Site of Courseware and Special Hardware Development											
Local				X	X	X	X	X	X	X	
Central		X	X	X	X	X		X	X	X	
● Magnitude of Acquisition Cost											
Low				X	X	X	X	X	X	X	
High		X	X								

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 8)

VOICE COMMUNICATING

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Alternative Instructional Delivery Systems

Criteria for Selecting Instructional Delivery Systems	√	Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm: Simulator with Instructor, Instructor Handbook, and Diagnostic Tests	Procedure Trainer with Instructor, Instructor Handbook and Diagnostic Tests	Language Laboratory, Audio, Active-Compare Mode, with Manual Simulation Game and Instructor	Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm: Language Laboratory, Audio, Active-Compare Mode, with Printed Materials	Performance Aid	Traditional Classroom	Operational Equipment in Real Environment with Instructor	
Stimulus Criteria									
● Visual Form									
Pictorial, Plane				X	X	X	X		
Solid Object		X	X					X	
● Visual Movement									
Still				X	X	X	X		
Full Movement		X	X					X	
● Audio									
Voice Sound Range		X	X	X	X		X	X	
Ambient Sounds		X	X	X	X			X	
Training Setting Criteria									
● Individual Trainee at a Fixed Location		X	X	X	X		X	X	
● Individual Trainee with Independent Instruction at Any Location						X			
● Team Setting		X	X	X		X		X	
Administrative Criteria									
● Site of Courseware and Special Hardware Development									
Local						X	X	X	
Central		X	X	X	X	X			
● Magnitude of Acquisition Cost									
Low				X	X	X	X		
High		X	X					X	

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 9)

RECALLING PROCEDURES AND POSITIONING MOVEMENT

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Alternative Instructional Delivery Systems: Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm (first 8 columns); Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm (last 3 columns and a blank column)

Criteria for Selecting Instructional Delivery Systems	√	Operational System in Laboratory with Tutor	Simulator with Tutor and Tests	Procedures Trainer with Tutor and Tests	Logic Trainer with Tutor	CAI with Photo or Operable Mockup	Teaching Machine with Photo or Operable Mockup	Microfiche w/wo Photo or Operable Mockup	Programmed Text - Branching	Laboratory Carrel with Equipment and Linear Instructional Materials	Operational System in Real Environment with Tutor	Texts, Lectures and Demonstrations	
Complexity Criteria													
● Difficult Motor Acts		X	X	X	X					X	X		
● Smooth Motor Performance at End of Training		X	X	X						X	X		
Stimulus Criteria													
● Visual Form													
Alpha-Numeric		X	X	X	X	X	X	X	X	X		X	
Pictorial, Plane					X	X	X	X	X	X		X	
Object, Solid		X	X	X	X			X		X	X	X	
● Visual Movement													
Still					X	X	X	X	X	X		X	
Full Movement		X	X	X	X	X				X	X		
● Audio													
Voice Sound Range		X	X	X		X				X	X	X	
Full Sound Range		X	X	X						X	X		
Ambient Sounds		X	X	X							X		
● Other													
Tactile Cues		X	X	X						X	X		
Internal Stimulus Motion Cues		X	X	X						X	X		
Training Setting Criteria													
● Individual Trainee at Fixed Location		X	X	X	X	X	X	X	X	X	X	X	
● Individual Trainee with Independent Instruction at Any Location								X	X				
● Small Group					X							X	
● Large Group at Single Location												X	
● Team Setting		X	X	X	X						X		
Administrative Criteria													
● Site of Courseware and Special Hardware Development													
Local								X	X	X	X	X	
Central		X	X	X	X	X	X	X	X	X	X		
● Magnitude of Acquisition Cost													
Low		X						X	X	X		X	
High		X	X	X	X	X	X			X	X		

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 10)

STEERING & GUIDING — CONTINUOUS MOVEMENT

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems	√	Alternative Instructional Delivery Systems — Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm: Operational System, Real Environment with Instructor and Instructor Handbook	Simulator with Motion Platform and Full Visual Field, Instructor and Instructor Handbook	Simulator (Without Motion Platform and Full Visual Field) Instructor and Instructor Handbook	Procedure Trainer, Instructor and Instructor Handbook	Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm: Operational System, Real Environment Without Instructor	
Stimulus Criteria							
Full Visual Environment		X	X			X	
External Stimulus Motion Cues		X	X			X	
Fine Movement Manipulative Acts		X	X	X		X	
Broad Movement Manipulative Acts		X	X	X	X	X	
Training Setting Criteria							
Individual or Team Training at a Fixed Location		X	X	X	X	X	
Individual or Team Training with Independent Instruction at Many Locations		X				X	
Administrative Criteria							
Site of Courseware and Special Hardware Development — Local		X				X	
Central		X	X	X	X	X	

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 11)

PERFORMING GROSS MOTOR SKILLS

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (columns) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems		Alternative Instructional Delivery Systems — Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm: Tutor in a Job-Like Setting with Equipment, if required, an Instructor Handbook and Student Diagnostic Tests	Alternative Instructional Delivery Systems — Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm: Tutor in a Job-Like Setting with equipment, if required, an Instructor Handbook, Student Diagnostic Tests, and Portable TV with a Record/Playback Capability and a Series of Taped Demonstrations	Alternative Instructional Delivery Systems — Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm: Programmed Text - Branching and a Series of Film Loops with Equipment, if required, and a Part-Time Instructor with Criterion Tests	Alternative Instructional Delivery Systems — Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm: Supervisor Managed Informal On-The-Job Training	
Training Setting Criteria						
● Individual Trainee at a Fixed Location		X	X	X		
● Individual Trainee with Independent Instruction at Many Locations				X	X	
● Small Group					X	
● Team Setting		X	X		X	
Administrative Criteria						
● Site of Courseware Development						
Local		X	X	X	X	
Central		X	X	X		

APPENDIX: INSTRUCTIONAL DELIVERY SYSTEM CHART FOR THE ALGORITHM (page 12)

ATTITUDE LEARNING

Directions:

To choose a delivery system:

1. Place a "√" (light pencil) in boxes representing criteria (rows) that must be met.

2. Select the delivery systems (column) that have an "X" in each row designated by a "√". These are the candidate delivery systems.

Criteria for Selecting Instructional Delivery Systems	√	Alternative Instructional Delivery Systems: Delivery Approaches Permitting the Application of All Learning Guidelines and Algorithm		Delivery Approaches NOT Permitting Complete Application of Learning Guidelines and Algorithm				
		Operational Job Setting with Instructor and Instructor Handbook with Diagnostic Attitude Tests	Simulated Job Setting with Instructor and Instructor Handbook with Diagnostic Attitude Tests	Role Playing	Case Studies	On-The-Job Training by Supervisors	Lectures, Seminars, etc.	
Training Setting Criteria								
● Individual Trainee at Fixed Location		X	X		X			
● Individual Trainee with Independent Instruction at Many Locations						X	X	
● Small Group		X	X	X	X	X	X	
● Team Setting		X	X	X	X	X	X	
Administrative Criteria								
● Site of Courseware Development								
Local		X		X	X	X	X	
Central		X	X	X	X			
● Magnitude of Acquisition Cost								
Low				X	X	X	X	
High		X	X					

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