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General Aviation Aircraft: A Comparative Analysis of Analog Instrument Display and Conceptual Primary Flight Display

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GENERAL AVIATION AIRCRAFT: A COMPARATIVE ANALYSIS OF ANALOG INSTRUMENT DISPLAY AND CONCEPTUAL PRIMARY FLIGHT DISPLAY

by

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A Graduate Thesis Submitted to the Human Factors and
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This graduate thesis was prepared under the direction of the candidate's thesis committee chair, Dr. J.W. Blanchard, Department of Human Factors and Systems, and has been approved by the members of the thesis committee. It was submitted to the Department of Human Factors and Systems and was accepted in partial fulfillment of the requirements for the degree of Master of Science in Human Factors and Systems Specializing in Systems Engineering

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ABSTRACT

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The primary purpose of this study was to evaluate the effects that analog instrument display versus primary flight display (PFD) had on pilot performance. Pilot performance was evaluated by: (a) time, and (b) number of errors. There were twenty subjects with a minimum of a private pilot license selected from the Aeronautical Science department at Embry-Riddle Aeronautical University. Three flight conditions (spoiler problem, engine problem, and flap failure) acting as a control group was given to the flight students while flying a traffic pattern. A Silicon Graphics® flight simulation software program and a video camera were used as the data gathering instruments. The results indicated that no significant difference existed between time under the primary flight display and under the analog instrument display ($p = 0.872$); however, the number of errors under the primary flight display was significantly less than the analog instrument display ($p = 0.008$).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADI	Attitude Display Indicator
AFDS	Autopilot Flight Director System
AGATE	Advanced General Aviation Transport Experiments
ANOVA	Analysis of Variance
AOA	Angle of Attack
ATC	Air Traffic Control
CADS	Computer Aided Debriefing System
CDM	Climb-Dive Marker
CDT	Curriculum Development Team
CDU	Control Display Unit
CPM	Critical Path Method
CRT	Cathode Ray Tube
DF	Degree of Freedoms
EFIS	Electronic Flight Instrument Systems
ERAU	Embry-Riddle Aeronautical University
FAA	Federal Aviation Administration
FMC	Flight Management Computer
FMS	Flight Management System
FPD	Flat-Panel Display
FPM	Flight Path Marker
GPS	Global Positioning System
HUD	Heads-Up Display
ICIS	Integrated Cockpit Information System
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IRS	Inertial Reference System
LCD	Liquid Crystal Display
MCP	Mode Control Panel
MEA	Minimum En Route Altitude
MFD	Multi-Function Display

MS	Mean Square
MSL	Mean Sea Level
MVFR	Marginal Visual Flight Rules
NASA	National Aeronautics and Space Administration
PCATD	Personal Computer-Based Aviation Training Devices
PELCC	Present Equivalent Life-Cycle Cost
PERT	Program Evaluation and Review Technique
PFC	Proposed Flight Conditions
PFD	Primary Flight Display
RVR	Runway Visual Range
SATS	Small Aircraft Transportation System
SEMP	Systems Engineering Management Plan
SID	Standard Instrument Departure
SMGCS	Surface Movement Guidance and Control System
SS	Sum of Squares
STAR	Standard Terminal Arrival
STT	System Training Testbed
TAS	True Airspeed
TDD	Type of Display Design
TFC	Total First Cost
UCF	University of Central Florida
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
W	Within Group (Error)

STATISTICS REPORT FORMAT

I. Method of Data Manipulation

A. Insertion into Allyn & Bacon Stat Demo for Shavelson (Factorial Analysis of Variance)

B. Calculation from Formulas (Factorial Analysis of Variance)

C. Data Manipulation

1. Time

a. Type of Display Design

1. Analog Instrument Display

2. Primary Flight Display

b. Proposed Flight Condition

1. Engine Problem

2. Spoiler Problem

3. Flap Failure

2. Number of Errors

a. Type of Display Design

1. Analog Instrument Display

2. Primary Flight Display

b. Proposed Flight Condition

1. Engine Problem

2. Spoiler Problem

3. Flap Failure

II. Statistical Analysis

A. Is There a Statistically Significant Difference of Time between Type of Display/Proposed Flight Conditions

1. Analyzed by Using Means of Data

2. Comparisons

a. Time, Analog Instrument Display

b. Time, Primary Flight Display

c. Time, Engine Problem

d. Time, Spoiler Problem

CHAPTER I

INTRODUCTION

Flight instruments have become more indicative of aircraft status and conditions of flight in the old-generation of general aviation aircraft. As the state-of-the-art developed, the pilots needed to know about the conditions of flight including the aircraft altitude, aircraft speed through the air, and the direction in which aircraft was pointed. These gages supplied information helpful to the pilot (IAP, 1985). The conventional displays have been utilized and used in aircraft from the very beginning of heavier-than-air aviation. The flight instruments found on different types of aircraft have considerable variety. They can be categorized according to types of work or information presented to the flight crew. Flight and navigation instruments give information such as altitude, airspeed, etc, or information required for navigating the aircraft. These types of flight instruments can be found in the standard "T" in a small airplane (see Figure 1)[1].

Figure 1. Conventional Instrument Display

[1] Picture from Jeppesen FS-200 Homepage:
http://www.jeppesen.com/STORE/CATALOG/Flitepro/demos.html

Standard "T" arrangement of primary instruments include an airspeed indicator, an attitude indicator, an altimeter, a turn and slip indicator, a heading indicator, and a vertical speed indicator.

Once flight technology came into existence such as high-powered jet aircraft with pressurized cabins and jet or turbo-propeller engines, flying an aircraft using feelings and intuition was no longer available to pilots. The progress in the number of new instruments and cockpit panels was provided in many types of aircraft produced. The requirement for the altimeter, airspeed indicator, RPM indicator, oil pressure gauge, aircraft's pitch and bank attitude, or rate of climb indicator become obvious (Pallett, 1981). Aircraft designers began creating electrically operated instruments in single-engine and multi-engine aircraft. However, since multi-engine aircraft could fly for longer periods of time, the problem of pilot fatigue occurred. The earliest flying machines were also extremely unstable and often hardly controllable. This was alleviated by an automatic pilot and cockpit automation. The automatic pilots or "autopilots" became available during the 1920s (Billings, 1997). With these devices in operation, pilots were able to devote more attention to instrument monitoring, as well as navigational and radio communication.

From the foregoing, flight deck automation was introduced in various commercial aircraft manufacturers. The implementation of advanced flight automation and navigation systems has been substantially beneficial to the tasks in which pilots have to perform. Aircraft automation was invented to complement and assist human operators in carrying out tasks that were difficult or even impossible without machine assistance. Until the late 1960s, automation was largely devoted to maintaining aircraft control, leaving navigation, communications, and management functions to the flight crew. The utility of digital computers that stimulated the development of miniaturized microprocessors with new solid-state circuitry based on the transistor was widely expanded in 1970s. During the 1980s, aircraft manufacturers such as Douglas, Boeing, and the new Airbus industry consortium gained confidence in the new automation technology. It was incorporated and its uses were extended in new designs (Billings, 1997).

Today's automated aircraft have a variety of features ranging from automations, automated tools and pilot support systems, numerous and complex subsystems, and highly integrated components. Use of cathode ray tube (CRT) screens has made for more information presentation and a better emulation of the outside world through map displays. These new cockpits have been christened "glass cockpits" to reflect this better representation of the outside world (the similarities between the instrument panel and the outside world) and the use of electronic display panels (Amalberti, 1999). The most advanced flight deck includes a sophisticated automated system and advanced flight management system (FMS). The cockpit panel generally includes a control display unit (CDU), flight management computer (FMC) as well as mode control panel (MCP), flight mode annunciation (FMA), and two electronic displays (e.g., PFD, MFD). The new technology has had profound effects on the ways aircraft are flown, on the ways the aviation system is managed, and on the human pilots who operate the system (Billings, 1997). This introduction of automation technologies has significantly impacted the general aviation transport flight decks; consequently this technology will increase flight operational capabilities.

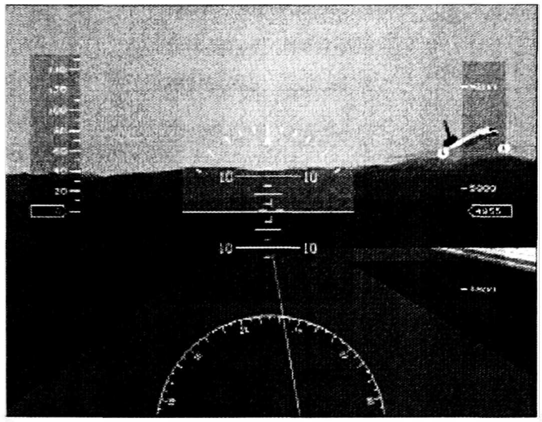

Figure 2. Primary Flight Display

In this research study, a PFD is considered to be one of the pictorial-based displays or electronic displays. The typical PFD is a multicolor CRT or liquid crystal display (LCD) that presents a display of aircraft altitude and flight control system steering. Electronic PFD (see Figure 2)[2] includes the same data from standard "T" arrangements, which are the most essential information that has been preserved in the electronic display. Conventional cockpit aircraft and electronic cockpit aircraft share the same purpose: transporting passengers and/or goods from one point to another. However, this does not mean that all the tasks that have to be achieved to fulfill this common mission or the performance of certain flight tasks are similar (Koning, 1992). To examine the effect the two displays have on time and accuracy of pilot performance, this study will compare the analog instrument display versus the PFD by using the Silicon Graphics (SGI)® flight simulation software program.

[2] Picture from Billings, C. (1997). *Aviation Automation. The Search for a Human-Centered Approach*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc. (Reproduced by Permission of the Boeing Company).

Statement of the Problem

The obsolete technology in an analog instrument display has enabled designers and engineers to design a new glass cockpit display in general aviation aircraft. There is evidence that old technology may reduce accuracy of pilot performance.

Review of the Literature

Effect of Display Design on Pilot Performance

Development of the display type has impacted the performance of pilot in flight situations. This can result in significant differences between the pilot performance in aircraft equipped with different types of displays. A number of studies here review the benefits or problems that may accrue from use of the different display designs.

A study by Shelnutt et al., (1982) found that several avionics manufacturers are developing electronic flight instrument systems (EFIS) for use in corporate and other general aviation aircraft. In light of the foregoing, the EFIS may provide numerous other benefits that are not directly related to their impact on pilot performance (e.g., reduced acquisition or maintenance costs). While such benefits are of obvious importance. The introduction of the EFIS into general aviation aircraft will constitute a major innovative change. For instance, the most significant new display format perhaps is the moving map display. Research has shown that such displays, in general, can dramatically reduce navigation errors, especially in situations where the pilot is operating in high workload conditions (McGrath, 1969; Ontiveros, 1968; Roscoe et al., 1950). Results of the study were shown that:

> These dısplays are effectıve ın enhancıng pılot performance because they (1) correspond to the ımage of the navıgatıon sıtuatıon that the pılot has ın hıs head and ın hıs hands, ın form of charts and plates, (2) reduce the need the pılots to ıntegrate ınformatıon from dıfferent flıght ınstruments, to calculate ınformatıon needed to determıne actual and desıred course, and to refer to prınted documents, and (3) clearly ıllustrate the nature of devıatıons of the actual flıght path from the desıred flıght profile, and the future consequences of such devıatıons. (Shelnutt et al , 1982, p 21)

In addition to the movıng map, there are several other differences between the EFIS and existing flıght ınstruments that have the potential to influence pilot performance. For example, many of the EFIS displays that are modeled directly after conventional displays have features that are not available in conventional displays (e.g., electronic attitude director indıcators that have supplementary information within their displays). Yet another difference is that pilots will have the capability to select subsets of information that they want displayed at a given location. Pilots will also able to "declutter" other displays by selecting subjects of information appropriate for the flight tasks being performed at a given point in time. Further, given failures in one or more of the CRTs, pilots will be able to select displays normally presented in a disabled location at other locations, or special combined displays on the CRT that are still functioning.

Furthermore, Shelnutt et al. discussed the pilot performance associated with the design of cockpit displays and controls.

> In general aırcraft, a number of factors ınfluence the performance of pılots Many of these factors affect the nature of task demands placed on the pılot. The pılot-aırcraft ınterface ınfluences the nature of ınformatıon processıng tasks as well as a wıde varıety of other demands placed on the pılot as he maneuvers the aırcraft The demands placed on the pılot at any poınt ın tıme, ıs determıned by the ınteractıon of a large set of factors When the pılot does not have the capabılıty to meet task demands that may arıse durıng a gıven flıght, he may lıkely make an error Such errors and other pılot performance problem can, therefore, be conceptualızed as arısıng from mısmatches between the level of demand ımposed by pılot tasks and the abılıty of the pılot to perform the tasks (Shelnutt et al , 1982, p 3).

Shelnutt et al. analyzed that extending this approach, it becomes clear that the way to reduce these problems is to identify and modify the factors that influence task demands that exceed pilot capabilities, and/or those factors that influence the capabılty of the pilot to perform the tasks in question. Therefore, the design of electronic flight instruments for general aviation aircraft is one of the major factors influencing task demands placed on the pilot.

October 1994, Parrish, Busquets, Williams, and Nold conducted research to compare the spatial awareness of commercial airline pilots on simulated landing approaches using conventional flight displays with their awareness using advanced pictorial displays. An extensive simulation study was conducted in which 16 commercial airline pilots repeatedly performed simulated complex microwave landing system (MLS) approaches to closely spaced parallel runways with an extremely short final segment. Parrish further examined that four separate display configurations were utilized in the simulated display with raw guidance data and the traffic collision and avoidance system (TCAS) II; the same conventional instruments with an active flight director; a 40° field-of-view (FOV), integrated, pictorial pathway format with TCAS II symbology; and a large-screen 70° FOV version of the pictorial display. Scenarios involving conflicting traffic situation assessments and recoveries from flight path offset conditions were used to assess spatial awareness (own ship position relative to the desired flight route, the runway, and other traffic) with the various display formats.

There were three scenarios acting as a control group: traffic conflicts, runway blunders, and offset scenarios. The performance metrics for the traffic conflict scenario were the detection time (from the beginning of the approaching traffic altitude maneuver to the pilot's announced detection of the resulting threatening situation) and maneuver time (from the beginning of the approaching traffic altitude maneuver to the initiation of an avoidance maneuver). For the runway blunder scenario, the detection time was measured from the beginning of the crossing maneuver by the neighboring traffic to the pilot's announced detection of the resulting threatening situation. The maneuver time was measured from the beginning of the crossing maneuver to the initiation of an avoidance maneuver. Lastly, the performance measure for the offset scenario was only recovery time (a return to path was defined as achievement of an error of less than half a dot in lateral and vertical tracking and a heading error of less than 5°). In conclusion, the study showed that the integrated pictorial displays (40° and 70° FOV) consistently provided substantially increased spatial awareness over the conventional display (EFIS formats) in all scenarios. The wider FOV pictorial display gave equivalent objective results as the narrow pictorial format and subjectively was preferred by 14 of the 16 pilots. The other two pilots had no preference between the two pictorial formats (Parrish et al., 1994).

The experimental study of flight attitude and steering display dynamics involving the principle of display frequency separation by Jacobs, Williges, and Roscoe, 1973; Johnson, 1971; Johnson, Wiliges, and Roscoe, 1971. Preliminary experiments employed a Link GAT-2 general aviation trainer with an experimental analog computing and display system that allowed systematic manipulation of motion relationships in the presentation of aircraft attitude and guidance information. This system, including its CRT unit and associated task generation and performance measurement equipment, was suitable for use in flight as well as in a flight simulator.

A research project by Harris and Parrish (1992), focused on pictorial displays, was conducted at NASA Langley Research Center. The purpose of this study was to investigate the parameters of pictorial displays and imaging sensors that affect pilot approach and landing performance. It had been hypothesized that pictorial display and/or imaging sensor presentations would provide the pilot with sufficient information to manually fly the airplane as well as (or better than) under normal visual flight rules (VFR) -- in essence, providing the pilot with electronic VFR.

Rationale of Development and Implementation of Electronic Display

The problems of existing conventional displays can be conceptualized in a number of ways. With regard to the analysis of "pilot-error" experiences in reading and interpreting aircraft instruments, Fitts and Jones (1947) conducted a study to determine methods of designing aircraft instruments so as to improve pilot efficiency and reduce the frequency of accidents. Accounts of 270 errors made by pilots in reading and interpreting instruments have been collected and analyzed. Hypotheses have been formulated regarding how each type of error can be prevented through redesign of instrument displays. It was found that the common errors were misreading the altimeter by 1,000 feet, difficulty in reading the instrument markings because of improper lighting, dirt, grease, worn markings, and vibration, mistaking of one instrument for another, and difficulty in interpolating between numbered graduations of scale (airspeed meter and gyro compass).

The study by Grether and William (1949) was found that most of the errors encountered in dial reading were of the comprehension of interpretation errors, in which an incorrect value is assigned to the graduation mark against which the pointer is being read. Grether speculated that it is quite possible the presence of a large number of graduation marks on a dial may greatly increase the probability of large comprehension errors and thereby nullify the precision, which a finely graduated scale makes possible.

Another study by Grether (1947) was the altimeter that presents an interpretation problem, which covers the altitude range in 20-foot steps. Grether examined that this is usually done with three pointers on a single scale. The first pointer indicates feet of altitude in hundreds, the second in thousands, and the third in ten thousands. The synthesis of these three pointer readings is very confusing to the novice. The altimeter includes another scale for setting in barometric pressure, which is expressed in inches of mercury rather than pressure altitude in feet.

Moreover, Grether further discussed the so called "flight instruments." There is an additional major variable in this direction-of-movement problem:

> It is the movement of the airplane, which the display indicates. This is important to accomplish the most natural combination of indicator movement and control movement in relation to response of the airplane. The pointer on the rate-of-climb indicator moves down when the plane is nosed downward by pushing the stick of control wheel forward, and vice versa The pointer on the turn-and-bank indicator moves to the left when the plane is turned to the left by application of pressure on the left rudder. In these examples the indicator and the airplane can be said to move in the direction in which the controls are displaced Other instruments, however, move in the opposite direction. On the artificial horizon, the horizon bar moves up when the plane is nosed down and rotates to the right when the plane banks to the left The pilot director indicator when displaced to the right, signals to the pilot that he is to turn to the right But as he turns to the right, the indicator moves to the left On the cross pointer, the pointers indicate the direction of the correct flight path from the airplane. Thus, as the pilot noses the plane downward the pointer moves upward, in a direction opposite to the control being made (Grether, 1947, p. 29).

Grether suggested that it would seem desirable, where possible, to eliminate these apparent inconsistencies in direction of indicator movements.

In discussing of pilot errors on a new cockpit design, Shelnutt et al. (1980) specifically examined that 80% of all general aviation accidents can be attributed to pilot error. Shelnutt et al. discussed six components, which contribute to that accident rate, including the aircraft, pilot certification and rating, and training and maintenance of proficiency assessments of pilots. Shelnutt et al. suggested that technology be employed to develop controls and cockpit instrument displays, which will be less conducive to error. However, Shelnutt et al. also recognized that completely new displays for cockpits could severely impair the performance of the existing population of current aircraft pilots by alienating their existing knowledge and experience (Hennessy III, 1995).

The related study of information display, O'Hare and Roscoe (1990) stated that pilots navigating with conventional general aviation equipment have to assimilate direction and distance information from a variety of separate radio and gyroscopic aids and combine this with the aircraft's altitude, airspeed, and heading obtained from another set of instruments. Wickens, Gordon, and Liu (1998) pointed out that the information displayed in the traditional flight instruments does not always correspond directly to the axis goals that need to be tracked. Although airspeed, pitch, and bank are directly displayed, there is no direct indication of how close the combination of these variables is to reaching a critical stall state, and the future lateral deviation from the flight path, on many aircraft there is no direct display of the latter variable. As a result, the pilot must collect this information from repeated fixations across the small instruments, often needing to acquire information with very high acuity demands.

Further, the information content of the conventional flight instruments was restricted by the limited capabilities of early aircraft sensors and navigation systems. The form in which this information was presented also was limited by the physical constraints imposed by electromechanical and mechanical display technology (e.g., dial and pointer display formats or gimbaled movement mechanisms). Few of these flight instruments were designed on the basis of a systematic analysis of their potential effect on pilot performance (Shelnutt et al., 1982).

Other problems of conventional display technology are related to the limitations in the type of accuracy of information that is presented to the pilots. Such limitations are associated with aircraft sensors and navigation systems employed with conventional flight instruments. Shelnutt et al., (1982) addressed that such related information is frequently segregated across several independent displays to current cockpits. Therefore, the pilot has to expend considerable effort to scan the separate instruments and integrate information from across the different sources. The existence of high demands would increase the probability of pilot errors that can threaten flight safety.

Venner, Daniels, and Hopper (1996) mentioned that in the 1950's cockpit of a T-28 aircraft, condensation, rain, and water vapor could form ice on mild days and then lead to blockage of restrictions that would result in errors. They further mentioned that harsh vibration experienced in aircraft would lead to elaborate designs that would prevent instruments from falling apart. Icing problems also lead to the addition of elements on the tubes. Even aspects such as lubricants can lead to variable drag on the linkages, which changes with varying temperature and contamination.

Furthermore, Chappell (1996) discussed the findings of some differences between advanced glass cockpits and the cockpits of traditional aircraft, in terms of the pilot's control inputs and the timelines and the type of feedback to the pilot. In the lowest technology aircraft, the pilot directly manipulates the aircraft control surfaces and throttles to achieve an immediate change in the attitude or the speed that is apparent on the gauge type instruments. The time between the pilot's action and the feedback of that action is less than a second. However, as autopilots are introduced to cockpits the changes are immediately and simultaneously seen on the indicators.

Due to several shortcomings of the conventional flight instruments, the advanced CRT or LCD and digital microprocessor technology employed in glass cockpits has provided avionics manufacturers with an opportunity to develop new display formats. Impetus for these new formats is derived from the desire to address certain shortcomings in the design of conventional displays. The benefits of glass cockpits are quite numerous.

Chroley (1981) explained that there are two main reasons for the move away from conventional instruments. First, the cost of procuring and maintaining electronic equipment is decreasing relative to the cost involved in the case of complex electro-mechanical devices, because of the high level of labor with specialized skills which these requires. Second, the use of electronic displays for navigational information makes it possible to provide the crew with moving map displays on which the weather radar information can be superimposed. This has operational advantages, as well as the possibility of obviating the need for a dedicated weather radar display.

Wickens, Gordon, and Liu (1998) recommended that with the development of more computer-based displays, aircraft designers have been moving toward incorporating human factors display principles of proximity compatibility, the moving part, and pictorial realism to design more “user-friendly” displays. The integrated electronic displays can allow the pilot to visualize a much broader view of the world surrounding the aircraft, than the more restricted conventional flight instruments can.

According to Huges (1988), in a three-year NASA study of 200 Boeing 757 pilots, it was found that the majority of pilots have reservations about safety issues related to so called “glass cockpits,” which rely on CRTs driven by computers. However, because of the glass cockpit, at least half the number of pilots has gained more experiences in the cockpit. Hughes felt that “the computerized cockpit is designed to reduce workload and it does in ideal conditions.” Clark (1995) stated that autopilots, flight directors, and alerting and warning systems are examples of automated systems. Using the glass cockpit with automated systems has had a beneficial effect on safety considerations and on the reduction of pilot workload. Charles (1996) also noted that the advanced aircraft automation has conveyed great benefits. Safety has improved dramatically. Some types of failures and errors have been eliminated by automation, which is now so capable that is has distanced pilots from some aspects of their operations.

In 1995, Rogers, Tenny, and Pew discussed that the pilots, who had been surveyed, presented an interesting portrait of the value of existing automation. These pilots are appreciative of the automation in current generation glass cockpits and claim to use it whenever it is appropriate. They want their automation to be simple and reliable and to produce predictable results. Thus, efficiency, reliability, and comfort have all benefited from the application of automation technology (Charles, 1996). According to a study conducted by Rudisill, NASA Langley Research Center, automation specially allows more "thinking and monitoring" time, less fatigue, and produces a less stressful work environment. Rudisill suggested that pilots believe automation allows them to concentrate on the real world outside and makes aircraft handling easier.

Additionally, Stokes, Wickens, and Kite (1990) stated that automatic systems perform tasks, which are too time-consuming, too costly, and too complex for human operators. Where tasks are appreciate for humans, automated systems may execute them more cost-effectively, reliably, and accurately. The glass cockpit of the most advanced aircraft introduces an entirely new design of flat displays and computer management to assist the pilot in the most efficient, effective, and optimum way (Clark, 1995). This type of display is smaller, costs less, uses less power, and performs more reliably and precisely than the traditional equipment. It also provides display flexibility and more precise flight maneuvers and navigation (Clark, 1995). Clark further examined the improved electronic equipment and found that it has experienced less down time than its analog counterparts. This significantly decreases the amount of maintenance required.

Barnhart and Wiener (as cited in Blanchard, Goehler, and Savard, 1996) mentioned that the advent of better LCD and CRT technologies, and the influx of military flat-panel display (FPD) technologies will eventually benefit general aviation. The new designs can better withstand extremes in temperature, air pressure, G-forces, and bright ambient lighting. The same study of cockpit display technology found, by Gibson, (as cited in Blanchard, Goehler, and Savard, 1996) that the CRT displays will become a generally accepted display media for use on both civil and military flight decks within the next few years. Advances in technology have produced CRT's that are brighter and sufficiently rugged enough to withstand the stresses imposed in the airborne environment providing what may be considered one of the most significant advances in display technology in recent years. A FPD was also studied by Venner, Daniels, and Hopper (1996). The results concluded that in FPDs, such as active matrix LCDs (AMLCD), the system weights significantly less than comparative electromechanical systems, requires less power, and considerably reduces life-cycle cost. Reliability is expected to be at least 10 times that of an equivalent electromechanical system. Moreover, as the display is in the same format as the primary instruments there is less chance of confusion or misinterpretation. The instrument gives accuracy, repeatability, and reliability far in excess of that achievable with electromechanical system.

Billings (1997) suggested that there has been considerable concern among operators about transitioning back and forth between the older displays and the advanced, more integrated, primary flight displays, which could increase training requirements and perhaps compromise safety. Electronic primary flight displays represent additional information, in particular trend information. The intent is to provide integrated information concerning attitude and flight path, similar to the integrated navigation displays that have been so successful in glass cockpits.

The study by Way (1989) was a 3-D pictorial format of aircraft cockpits. Way examined a HUD as the primary flight instrument, and suggested the intent of pictorial formats is to present information to the aircrew in a native, intuitive, way which can be understood quickly and directly, with a minimum interpretation.

According to the control and feedback loops in the cockpits perspective, Chappell (1996) suggested that a look at the control and feedback loops for the glass cockpit and traditional aircraft reveals how technology has changed the pilot's task. As autopilots are introduced to the new designs of glass cockpits, the pilot may command a heading, an altitude or a speed, in addition to a throttle setting, roll and pitch angle. The commanded values are observed in the respective windows on the autopilot panel, or as "bugs" on the primary flight displays. The pilot can select a new altitude by turning a knob while observing the number in the altitude window and pushing a button to activate the climb. The change in pitch is felt immediately and simultaneously seen on the attitude indicator. In the advanced glass cockpit aircraft, the pilot usually controls the aircraft by keystrokes, which the flight management computer translates into autopilot movement of the aircraft's control surfaces. Depending on the type of pilot input, the immediate feedback available may only be a change in a number on the control display unit (Chappell, 1996).

O'Hare and Roscoe (1990) also discussed that the integrated pictorial displays combine information from several sources in a common framework. Such displays eliminate many of the difficulties associated with the presentation of a variety of information in quite different frameworks. They also summarized that the introduction of CRTs provides an opportunity for rethinking display formats and offers new degrees of freedom in their execution. With the same results, Chroley (1981) also suggested that the information in which the pilot is not currently interested could be suppressed from the displays. Whereas in the past, the pilot has been confronted with all the information all the time, and has had to mentally filter out the items in which he is interested. It is now possible to affect at least some of this filtering by suitable organization of the programming of the display symbol generators, which has the effect of reducing the pilot workload.

Applications of Electronic Display Technologies

Commercial and Military Aircraft

Electronic displays will form an essential part of the equipment installation of future transport aircraft, both commercial and military. Electronically generated, primary flight displays, (particularly formats generated with CRT) have shown great potential in reducing the pilot's visual workload (Abbott, Nataupsky, and Steinmertz, 1987). For instance, the increasing use in commercial aircraft is characterized by installation in the Boeing 747, Boeing 777, and the Airbus 310-320 families. In military aircraft, flight information may require a head-up as well as a head-down display. The head-up display (HUD) has been extensively utilized in the combat fighter cockpit. With this display type coupled with an integrated flight control computer, the fighter pilot might be able to plot a flight path to enable a combat firing solution or other maneuver (Hennessy III, 1995).

Chroley stated that British Aerospace (BAe) has developed the advanced flight deck for its BAe 1-11 aircraft with two monochrome PFDs, two navigation displays, and two system displays. A number of features on the PFD include a full range, single scale, single pointer airspeed indicator, and specific indication. It was concluded that application of the flexibility of electronic displays provides the possibility of configuring the flight deck for two-man operation, and thus the flight engineer's station can be eliminated. From the economic point of view, this may be of value in equipping a transport aircraft with CRT displays.

The investigation of HUDs was carried out at NASA by examining the pilots' abilities to detect unexpected obstacles on the runway (Weintraub, Haines, and Randle, 1984, 1985; Fischer, Haines, and Price, 1980). The obstacle used was a large aircraft positioned at a 45° angle partially on the runway. During the tests, some of the pilots failed to notice the plane on the runway. When detected, reaction time to detect the plane was actually longer when flying with the HUD than with the conventional flight instrument.

Reising, Liggett, and Munns (1999) examined the research studies of the new cockpit technologies such as HUD (head-up primary flight display), head-down MFDs and both 2-D and 3-D. They mentioned that these technologies will have the potential of significantly helping pilots efficiently maintain adequate attitude and situational awareness. The display technologies, coupled with innovative control technology will allow pilots to continue to utilize these displays for traditional purposes.

In a similar study, Reising, Liggett, and Munns (1999) discussed that the primary reason for including a HUD (primary flight instrument) is to enable takeoffs and landings in low visibility conditions. Alaska Airlines has led the way with the incorporation of HUDs into their 727s. Because of the advantage of operating under adverse weather conditions, other airlines are also considering incorporating HUDs into their fleets.

Reising et al. also mentioned the cockpit display design applications in the military aircraft such as the F-18. The advent of the F-18 is generally regarded as a "watershed." The cockpit displays are composed of largely of CRTs presenting data that had been digitally processed by the aircraft's on-board systems. The real impact of this digital processing was the design flexibility of the displays, and the ability to vary the display according to the information required by the pilot.

Hawkins, Reising, and Gilmoure (1984) reported formal subjective evaluations and certain objective assessments of three pictorial display formats tested with both Air Force and Navy pilots. Pictorial formats were presented on the HUD, and on two head-down CRTs – a horizontal situation display (HSD) and a vertical situation display (VSD). The HUD display showed a pictorial "path-in-the-sky" superimposed upon the external scene. The VSD displayed an "outside-in" representation of the aircraft as though from above and behind. Hawkins et al. reported that pilots' performances were superior when using the color pictorial displays. Flight path error from the displayed flight path is reported to have been over 25% better with the color formats. This was confirmed in a study conducted by Stollings (1984). This study also compared traditional alphanumeric formats with pictorial formats.

The successful evolution of pictorial displays (enhanced vision) will be accompanied by the promise of highly accurate global satellite based navigation systems; the increase in compact computer processing power; the growth in portable mass storage media; and the potential of object oriented, graphical databases (Blanchard, Goehler, and Savard, 1996). Blanchard et al. addressed that research now underway includes the definition of technical requirements for the next generation of advanced military aircraft and commercial supersonic transports, such as the high-speed civil transport (HSCT). Preliminary designs of the HSCT include elimination of the forward windshield to save weight, increase fuel efficiency, and improve the aerodynamic profile for supersonic flight.

General Aviation Aircraft

The likelihood of increasing the electronic displays, for instance, PFD, multi-function display (MFD), or navigation display in the general aviation, has led to aircraft designer's concerns. One such effort is exploring the PFD used in the advanced general aviation transport experiments (AGATE) aircraft and the training devices led by the NASA Langley Research Center. Research and development (R&D) efforts address these PFD concerns. The PFD information displayed on the future general aviation aircraft includes electronic instrument displays (airspeed indicator, altitude indicator, heading/track indicator, vertical speed indicator, etc.) and possibly a new technology found in commercial aircraft such as FMS, MCP, or CDU. The AGATE PFD employs a concept of the synthetic or enhanced vision systems. The presentation on the PFD allows pilots to electronically "see through" darkness, terrain and obstacles, precipitation and other forms of obscuration and to safely taxi, take off, and land in low visibility weather conditions. The perspective image of displays represents a three-dimensional view out of the cockpit window or an overhead view for flight planning purposes. The artificial images of the outside world is extended by virtual elements. For example, a spatial flight path predictor and the predetermined flight path are made visible on the display and permit the pilot to intuitively understand his actual situation and react with foresight.

With regard to the synthetic or enhanced vision systems, Billings (1997) recommended that such technology could permit pilots to land, without assistance from the ground, on any appropriate surface if they were guided to the proximity of that surface by appropriate on-board navigation equipment. Therefore, one major benefit of such devices could be a decrease in the number of ground navigation aids, as well as cost. Additionally, designed digital instruments are generally used to display primary flight condition information such as airspeed, altitude, altitude rate, attitude heading, etc. Other flight conditions displayed include angle-of-attack (AOA), or load factor (Helmetag, Kaufhold, and Purpus, 1997). Another qualification on a PFD is the concept of the highway in the sky. This concept represents a graphical view of position on three axes. ERAU (1996) mentioned that the highway in the sky's representation over the customary "follow me" boxes in the sky is used to increase the transference rate for pilots who fly the AGATE airplane. Moreover, it also stated that the highway in the sky is also used to represent approaches in airports. The road shows the standard instrument arrival procedure and the final approach have a 3° descent and narrow as the aircraft approaches the runway.

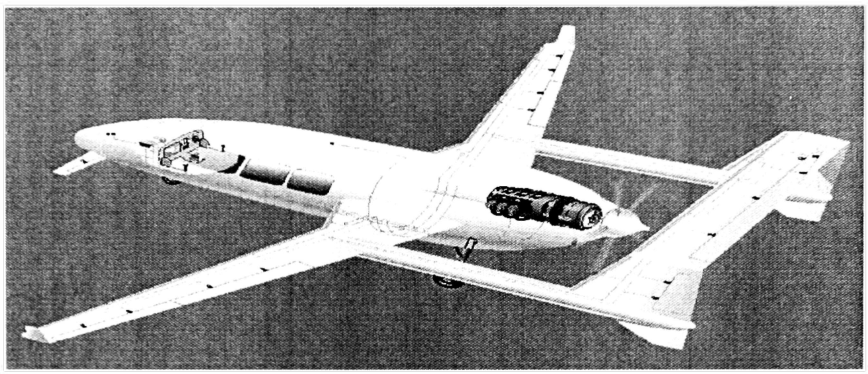

Figure 3. AGATE Aircraft

The interests in automation technology as a new breed of display design are intended for the AGATE project, which focuses on the revitalization of the general aviation aircraft industry. The AGATE project is a program derived from a small aircraft transportation system (SATS) concept, which develops training technologies and operating infrastructure capabilities and systems (see Figure 3)[3] The overall project is composed of eight program analysis work packages that include: flight systems, propulsion sensors and controls, integrated design and manufacturing, ice protection systems, AGATE integration platforms, training systems technologies, airspace systems infrastructure, and finally ground system infrastructure. The role of cockpit display design is described in the flight systems and the training systems technologies work package. The cockpit panel of the actual AGATE aircraft presents a PFD, an integrated cockpit information system (ICIS) acting as a MFD, and a navigation display essential to the pilots throughout the flight.

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[3] Picture from NASA AGATE Homepage: http://agate.larc.nasa.gov/images/Seethru.jpeg

STT Integrated Mockup

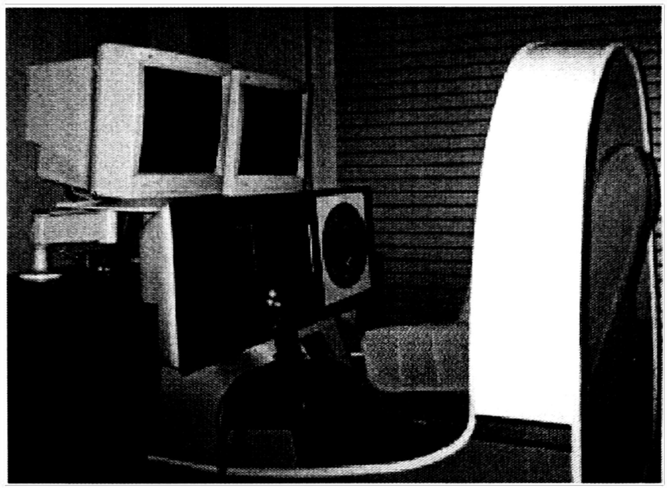

Figure 4. STT Integrated Mockup

The system training testbed (STT) represents the design of the flight-training device or computer-based training (CBT) for the AGATE project, which served as a training medium for flight students (see Figure 4). The function of a STT is to run a generic emulation for control and display set-ups. It also provides data collection algorithms built into log subject performance, training time, error, etc (ERAU, 1997). The infrastructure of the STT system is assembled from three Pentium based personal computers, which are composed of one experimenter workstation and two simulation computer workstations. The experimenter's station is a personal computer used to monitor the test and control timing and events during a test run by using a textual interface with commands being transmitted to the simulation via an interface such as RS-232 (Stokes and Associates, 1998). These transmitted commands are input to the station by using a mouse or keyboard. The other two simulation computer workstations perform all required simulation modeling and the generation of required flight displays, such as the ICIS and PFD (see Figure 5)[4].

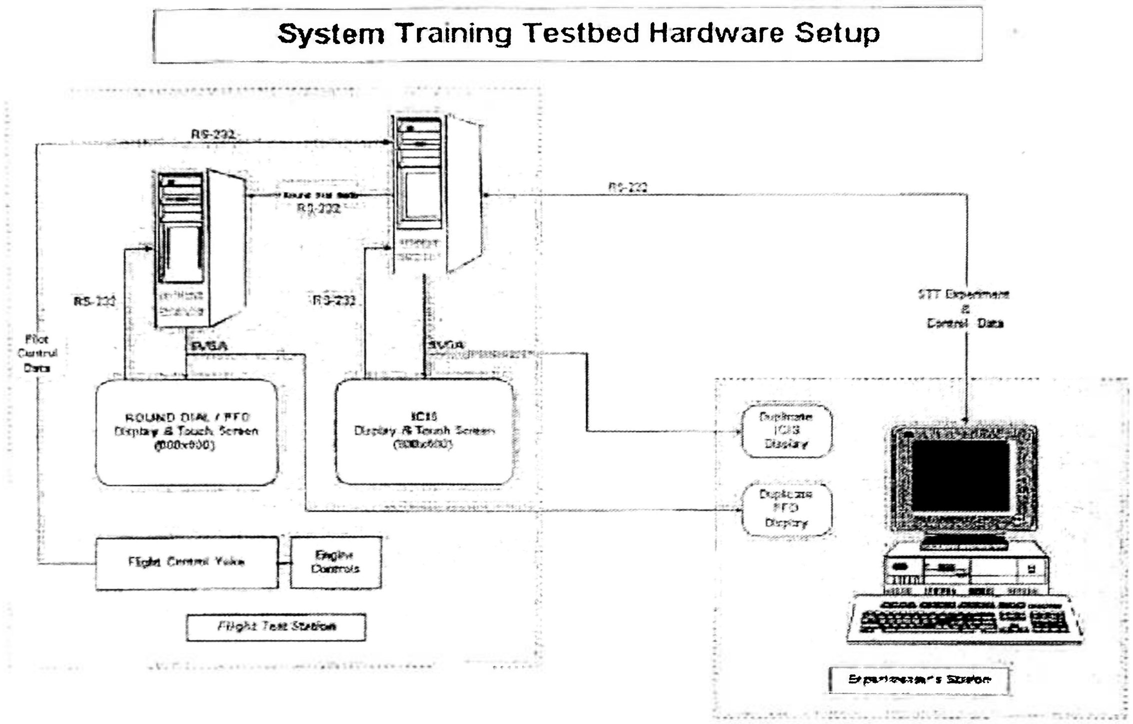

Figure 5. STT Hardware Setup

Development and testing of a PFD module on the STT were established after the CBT experiment had been conducted and defined. Meanwhile, the training curriculum was also established in order to train the functions of the PFD module. The training module and PFD experimentation module would then be developed and integrated into the STT and the system tested. After that, the PFD experiment was performed and analyzed.

[4] Picture from Stokes & Associates (1998, May). AGATE CDT: Systems Training Testbed (STT) "Strawman" Systems Analysis (pp. 4) Technical Report. AGATE-CDT-TR-98-4.

Personal Computer-Based Aviation Training (PCATD) Defined

CBT has become an extensive training device in aviation industry. Owing to the advanced capabilities of personal computers, an increase in the number of flight simulation programs has made available personal computer-based aviation training devices (PCATD). Williams and Blanchard suggested that these devices are relatively inexpensive, compared with flight training devices and simulators that more closely approximate the physical characteristics of an actual aircraft. A concept of PCATD (see Figure 6)[5] is a system for individual training using sophisticated multimedia technologies based on PC computers. PCATD is an integrated, ground-based training device that would be used solely for aviation training purposes.

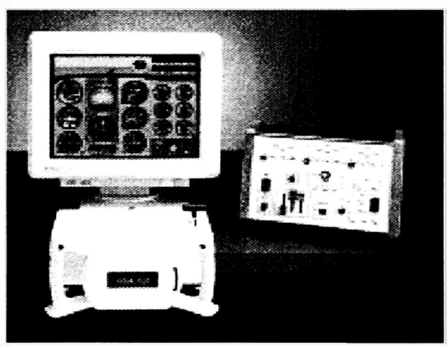

Figure 6. Personal Computer-Based Aviation Training Devices

A qualified PCATD is designed to prepare a pilot to fly in instrument conditions. The PCATD makes it easier for pilot students to comprehend the concept of navigation, flight, and instrumentation. In general, PCATD consists of specific software and hardware, which must meet all of the requirements qualified and approved by the FAA.

[5] Picture from PCATC of Jeppesen FS-200 Homepage: http://www.mcs.nl/pilotshop/fs200e.html

Chamberlain (1998) also suggested that the specific type of make and model of hardware, and specific version of software contained in the manufacturer's PCATD application, should meet all the conditions outlined in AC 61-126; then it can become "qualified." In addition to advisory circular (AC) 61-126 written by the US Department of Transportation, FAA reported that PCATD qualifications may be used only for instrument training tasks. They may not be used for testing and checking. Furthermore, the design requirements of PCATD must provide control devices, a display unit, flight dynamics system, and instructional management. The control requirements shall provide some physical controls and some virtual controls (FAA, 1997). The basic instruments and indicators such as altimeter, heading, vertical speed, airspeed, turn and bank indicator shall be included in the display requirements. The PCATD can be also included in the communication and navigation radio and some miscellaneous indicators. All of the above displays must be visible during all flight operations. Also, the flight dynamic, aircraft performance parameters, aircraft vertical lift components, flap setting, slat setting, gear position and the presence and intensity of wind and turbulence must be comparable to the way the training aircraft represented performs and handles (FAA, 1997). Finally, the system must be designed to provide the instructor to pause at any point during events, and manipulate the aircraft and flight parameters.

Benefits of PCATD

The potential benefits of computer based training in aviation have been widely utilized by flight schools, and industrial organizations. The use of PCATD would enhance flight safety and training effectiveness. Williams and Blanchard (1995) mentioned that it should enhance safety because students can gain at least minimum proficiency before attempting most flying maneuvers, and therefore reduce training time. As a result, the use of PCATD should then reduce costs of training for both students and flight schools. The ability of students to gain self-guided practice on some tasks and maneuvers should improve skill maintenance and pilot proficiency. Also, they suggest that PCATD systems provide the opportunity to deliver training to a student in a reasonably organized fashion, free from the biases and limitations of human instructors. Additionally, instrument-rating students can learn basic instrument skills in much less time, compared to the flight training devices or flight simulator. Computer-trained students have shown to have less difficulty in transferring their flight instrument skills to the aircraft. IAAS (1997) discussed that under the guidance of a flight instructor, PCATD is extraordinarily efficient at teaching basic instrument skills, procedures, and situational awareness. Apparently, various number of flight schools have adopted the use of personal computer training devices for both IFR and VFR training through a syllabus integrating PCATD into instrument flight instruction. Sicinski (1998) identified that PCATD will increase training level and effectiveness, increase the speed of modification to the training materials, increase possibility of an individual training in the time convenient for the student, reduce the cost of supervising the students, reduce the training cost, increase flexibility of the training center or training section and provide an easy way of protecting training materials against undesired users. Computer developers and customers for whom the PCATD is useful and effective have recognized these potential benefits.

Predictable Performance of PCATD Experience

According to pilots who use flight simulators designed for the personal computer, suggestions from ER Labs (1999) were that the usage of computerized flight simulators may aid or hinder the performance of a pilot in the simulator field. The benefit or detriment of personal computer flight simulator usage will increase the proficiency scores. These proficiency scores for pilots with personal computer flight simulator experience are significantly different than the proficiency scores for pilots without personal computer flight simulator experience. This is a statistically significant difference in the distribution of the pilots with or without personal computer flight simulator experience.

Problems with PCATD

The PCATD has become famous and widely used as a training medium in instrument rating training and has been officially approved by the FAA as shown in AC 61-126. Significant suggestions from many situation experts, experienced instrument flight instructors, flight school managers, university aviation professors, aviation researchers, and others in flight training opposed this idea. The main concern is basically a safety issue. Frasca (1997) explained that the PCATD provides a part task training, in lieu of full task training. While there is acknowledgement that the devices do have potential use as supplemental training devices, this position statement urges caution in their use. It sets forth the belief that acceptance of PCATD time instead of actual aircraft flight training would be an unwarranted and substantial move away from the long standing, guiding principle of using high fidelity simulation in exchange for the actual aircraft flight training time. Furthermore, Frasca (1997) suggested that PCATD does not adequately serve any of the three primary reasons for using flight simulation: training efficiency, economy, and safety. In training efficiency, a number of users using PCATD presently have negative training value. The transfer of training knowledge for a part task trainer from PCATD to the actual aircraft or flight simulator is not completely transferable. The IFR requires a pilot to posses a very specific set of skills, which includes the ability to divide attention, manage a multiple workload, maintain situational awareness, and prioritize tasks, substituting PCATD for "full task learning" is yet unproven in the development of these special skills (Peterson, 1997). This may also contribute to a negative transfer. However, some specific tasks such as learning to operate navigation equipment, pitch and power capabilities, systems operation, and procedural sequences have been proven to be effective. Referring to the economic concern, training in PCATD is definitely less expensive than training in the actual aircraft, because the operating cost per hour in the actual aircraft is far more inexpensive. However, when computing the real cost of training, the result has turned out differently. From the summary of the University of Illinois, Urbana-Champaign research study, Frasca (1997) states that:

> The PCATD group had a savings of about 4 hours of aircraft time but it took 26.5 hours of PCATD time to do it, meaning it required 22 5 more hours of training time to eliminate 4 hours in the airplane. With hourly rates for the aircraft of $69.00, the PCATD $5 00, and the instructor $25.00, the numbers do not support the PCATD. The students who learned exclusively in the aircraft paid an additional $276 00 for the extra 4 hours they required plus an additional $100 for the instructor's time for a total of $376 00 The students who received training in both the PCATD and aircraft spent $132 50 for the additional 26.5 hours of PCATD time required at $5 00 per hour plus $662.50 for the additional 26.5 hours of instructor time required at $25 00 per hour for a total of $795.00. The PCATD group actually spent $419 00 more than the aircraft-only group to save 4 additional hours of flight time While the study suggested that the savings could be achieved in approximately 11.25 hours, there is no objective proof offered to support that statement. (Frasca, 1997, p. 1).

Apparently, this research study asserted that it would cost the flight student more to train in PCATD than the real aircraft.

The last reason for considering PCATD is a safety issue. Discussion of several studies has shown that PCATD is a part task-training device, not a full task-training device. It means that a pilot could spend less time on PCATD than the actual aircraft. Nevertheless, the question asked by Frasca (1997) was, "Will the result produce a safer pilot?" Owing to the use of a part task-training device creates a negative transfer of training, which is also known as "learning bad habits." These bad habits take longer to correct than if learned correctly the first time. The procedures shown in AC 61-126 show that a certified instrument flight instructor must sign off all training, after using a part task-training device. As can be seen, once those instructors have already perceived the connotation of a negative transfer, the instructor would not assure a sign off due to the flight safety issue involved.

Summary

In the field of commercial aviation and military aerospace applications, the conventional displays have proved too costly to maintain and too unreliable to depend on (Venner, Daniels, and Hopper, 1996). The designs of early flight instruments were limited by engineering constraints associated with the technology that was available during their development. Several studies have shown that there are several shortcomings in the design of conventional flight instruments such as instrument infrastructure, the information presented, etc. As such, these existing instruments may contribute to a variety of pilot performance problems. The need for new flight displays has been created, in part, by shortcomings in the design of existing flight instruments (Shelnutt et al., 1982). There is a need for high performance electronic displays to replace and upgrade the traditional flight indicators used in the cockpits of many older aircraft. Shelnutt drew the conclusion that the electronic displays will differ in a number of ways from the conventional flight instruments that they will replace. The new displays will represent a significant new subset of resources for the general aviation pilot. Use of these new resources will influence the performance of not only the psychomotor tasks involved in control of the aircraft, but also the procedural tasks. The replacement of these older generation instruments may lead to increase safety margins, reduce pilot workload, improve pilot performance, or even reduce time between the pilot's action and the feedback of that action. A need of electronic displays, in the future aircraft and the ground based training systems, will be demanding as the visual displays. This glass cockpit based technology will dominate the installed high performance displays, and may continue to be used for many years in the future.

Statement of the Hypothesis

It is hypothesized that a pilot using primary flight display simulation will perform significantly better (e.g., time and number of errors) than a pilot using flight simulation with an analog instrument display.

CHAPTER II

METHOD

Participants

Participants were recruited from the volunteer Embry-Riddle Aeronautical University (ERAU) students who held at least a private pilot's license. 20 participants (19 male and 1 female) volunteered to participate in this study. A sample size of 20 participants was the goal, but the number of participants was contingent on the volunteer pilots who were told that participation was voluntary and that there would not be compensatory. Participants were of differing ages. The range of the participants' ages was 18 to 26, with the mean age was 23.3 years. The participants possessed a mean of 27.03, a mode of 50, a median of 16.45, and a range of 0 to 110 actual instrument hours. The participants also possessed a mean of 269.96, a mode of 0, a median of 245, and a range of 45 to 720 total flight hours.

Certificates held included: 20 private, 15 private/instrument, 10 commercial, 9 commercial/instrument, 5 certified flight instructor (CFI)-I, and 3 CFI-II (1 indicated "certified held" and 0 indicated "non-certified held"). Additionally, 19 out of 20 participants indicated that they had experience using PC-based flight simulators. 7 participants had flown a PFD type display with PC-based flight simulators. The total time ranged from 3 to 20 hours in using the PFD type display, with a mean of 8.5 hours. In regard to level of flight experience, a private pilot's license was represented by the number of flight hours more than 40 and a commercial pilot's license was represented by the number of flight hours over 200 hours. The descriptive demographics data for 20 participants are shown in appendix G.

Apparatus

A flight-training simulator that represents a cockpit display experiment's workstation was located in the interactive technologies laboratory at ERAU, Daytona Beach, FL. This simulator was a SGI interactive flight simulator, version 3.4.1 with a copyright by Silicon Graphics Inc. There were two interchangeable cockpit displays in this flight simulator provided to the participants. The first display was an old 2D-style instrument panel, which was the IFR training system. The display screen illustrated a basic analog instrument display described as: airspeed indicator, approach horizon, altimeter, course indicator, and vertical speed indicator. One large viewport showed the world and several smaller viewports simulated instruments.

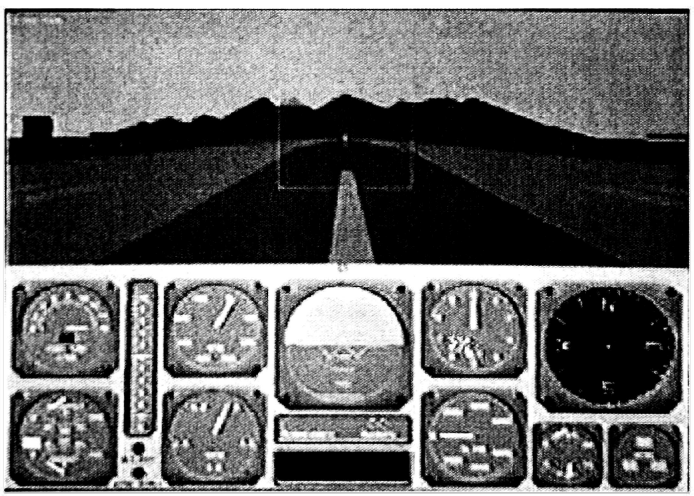

Figure 7. Analog Instrument Display of the SGI Flight Simulator

The second display was a head-up display (HUD) or a PFD as shown in commercial or military aircraft. One large viewport showed the world and digital displays demonstrated the information of each indicator.

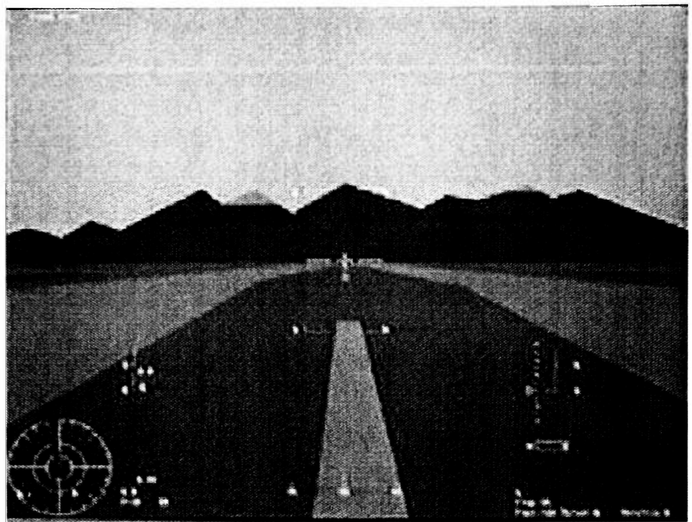

Figure 8. Heads-Up Display of the SGI Flight Simulator

This flight-training simulator was the simulator that replicated the dynamics of flying, and allowed the pilots to control the aircraft and its environment by a mouse and a keyboard. The system was run on a Silicon Graphics computer using a R5000 processor-based workstation, 32-bit architecture, 32 KB cache, 200 MHz CPU, and color graphic display and additional apparatus included in this experiment was a video recorder. Additionally, the statistical analysis for this study was performed by using a factorial analysis of variance (ANOVA) of the Allyn & Bacon Statistic Demo for Shavelson by David W. Abbot, Ph.D, copyright 1989, University of Central Florida (UCF). The factorial analysis of variance of both statistical software program and mathematical formulas was used to analyze and compute the mean of data (average).

Design

The traffic pattern appended below was chosen to improve the pilot's effectiveness of his flying skills, aircraft control during particular conditions that occurred during flight, and instrument crosscheck. In the beginning, the pilot took off and proceeded by climbing ahead on the upwind leg until beyond the departure end of the runway and within 300 feet of traffic pattern attitude. At this point, the pilot started a turn onto the crosswind leg. Then the pilot continued the climb to pattern altitude, which was 2,800 feet height above airport (HAA). At pattern altitude, a turn was made onto the downwind leg and the aircraft was flown parallel to the runway. At the end of downwind leg, a turn was made onto the base leg and the descent continued. Finally, a baseleg turn onto the final approach was made and finished at 400 feet above airport elevation. The aircraft was then leveled off.

Upwind Leg – an extension of the runway in the direction of taking off and landing
Crosswind Leg – a flight path at right angles to the runway in use and beyond its departure end
Downwind Leg – a flight path parallel to the runway in the opposite direction to takeoffs and landings
Base Leg – a flight path at right angles to the landing runway, and off its approach end, extending from downwind leg to the intersection of the extended runway centerline. (Thom, 1990).

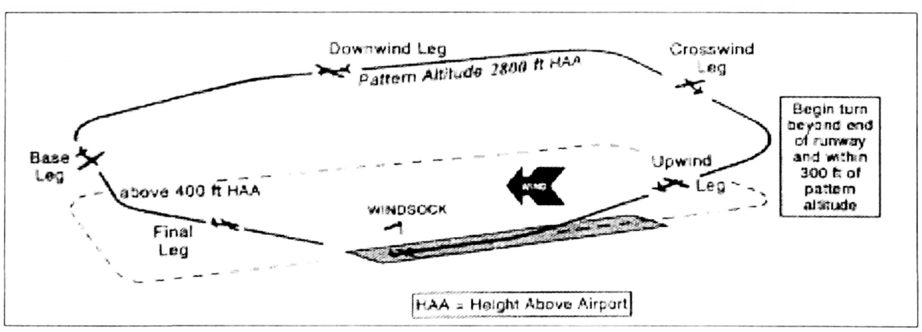

Figure 9. Traffic Pattern

There were three proposed flight conditions acting as a control group given during flying. These three conditions were an engine problem at 2,000 feet during climbing, a spoiler problem at 2,800 feet before a turn onto the downwind leg of the traffic pattern, and a flap failure at 1,300 feet after the base leg of the traffic pattern. The criteria for estimating time was obtained by assuming that after each flight condition takes place, the aircraft would reduce in altitude to a certain level. Then pilots attempted to recover his flight by pitching the nose up. By this time, the dial of the altitude indicator moved up whereas the dial of the climb rate indicator also moved up. The time was measured from these three phases. The first phase was the time from taking off to the time of a pilot recovers his flight (after the engine problem occurred). By observing the altitude indicator's dial started to move up, the ending time was counted. The second phase was the time after recovery from the first condition to the time of recovery after the spoiler problem occurred. The last phase was the time after recovery from the second condition to the time of recovery after the flap failure occurred. On the final leg pattern, the results of all three conditions caused tremendous power loss in the aircraft. Some pilots crashed their aircraft and failed to pitch the nose up. As a result, the experimenter had only one alternative to determine the ending time of the third condition by finding the last second before crashing.

Furthermore, measurement of the number of errors was made with assistance and guidance from the assigned certified flight instructor. This reading was assumed from a deviation of altitude, a deviation of climb rate, a deviation of navigation display in the analog instrument display and heading/track indicator in the HUD, and the retracting and extracting of the landing gear. The overview of both outcome data is demonstrated on page 72 and 73.

Procedures

The procedures of the experiment can be described as follows: introducing the participants who volunteered to take part in the experiment for a general outline of this research. Then, participants filled out a pilot demographic profile paper and signed an informed consent. After that, the experimenter gave specific instructions for and introduced participants to the flight-training simulator. Participants were allowed to practice with a simulator to become accustomed to a given traffic pattern. Meanwhile, the experimenter began to run the experiment. There was a break of five minutes between each cockpit display. During this time, the experimenter explained the instructions of the next display to the participants. Eventually, the experimenter gave a debriefing sheet containing questions to the participants. In addition, the experimenter set up and reset the simulator for the next participants.

CHAPTER III

RESULTS

Overview of Results

The dependent variable was a measurement of pilot performance (e.g., time and number of errors) for an analog instrument display versus a primary flight display. The independent variables were proposed flight conditions (e.g., engine problem, spoiler problem, and flap failure). Pilot performance data was derived from a video recorder by measuring the time of each flight condition for each participant's performance. The total time was calculated by combining the measured engine problem, spoiler problem, and flap failure conditions' data to get a total score. Simultaneously, the assigned flight instructor (CFI-II) determined how many errors occurred in each phase of flight condition. After that, by taking the mean pilot performance (time and number of errors) under each flight condition, a single pilot performance score for each participant was determined. This information was inserted into the Allyn & Bacon Statistic demo for Shavelson. Then it was used to conduct a factorial analysis of variance or two-way ANOVA, using display type as the grouping variable and proposed flight conditions as the independent variable. The results of this analysis supported the research hypothesis. The results indicated that the measurement of pilot performance (number of errors) by using a primary flight display during three proposed flight conditions was superior to a measurement of pilot performance by using an analog instrument display.

Processing of Raw Data

Raw data of 20 participants was coded into the statistical software program.

Data was input by using a factorial analysis of variance method to test hypotheses about differences between means in the factorial design. Omega-square was used to measure the strength of association for fixed-effects ANOVA between each independent variable and the dependent variable. To find out a F observed, the corresponding sum of squares (SS), degree of freedoms (df), mean squares (MS) omega square (ω^2), and P value would be determined and presented by the software program and mathematical computation. The value of F critical was calculated by formulas compared to the F observed. The purpose was to examine a statistically significant difference between mean scores. These results of the raw data were interpreted into the spreadsheet and text file so that a comparative analysis could be conducted to evaluate a display design type.

Analysis of Data

A two-way ANOVA or factorial analysis of variance was conducted with a fixed-effects model using a display type as the grouping variable and proposed flight conditions as the independent variable. The factorial ANOVA was used to examine data from a 2×3 factorial design with two levels of display design (analog instrument display, primary flight display) and three levels of proposed flight conditions (engine problem, spoiler problem, and flap failure). The purpose was to compare the mean scores in order to decide if the differences between means may be due to the effect of the first factor (main effect for type of display design), the second factor (main effect for proposed flight conditions), or a combination of certain levels of the first factor with certain levels of the second factor (type of display design and proposed flight conditions interaction).

The results of the ANOVA are described below:

Hypothesis (Time)

Type of display design with 2 levels: analog instrument display, primary flight display

H0 = The null hypothesis stated that there is not a statistically significant difference in the mean time for the pilots using analog instrument display versus pilots using primary flight display

$H0 = \mu_{\text{analog instrument display}} = \mu_{\text{primary flight display}}$

H1 = The alternative hypothesis stated that the mean time for the pilots using analog instrument display are greater than the means time for pilots using primary flight display

$H1 = \mu_{\text{analog instrument display}} > \mu_{\text{primary flight display}}$

Proposed flight conditions with 3 levels: engine problem, spoiler problem, flap failure

H0 = The null hypothesis stated that there is not a statistically significant difference in the mean time among the three proposed flight conditions

$H0 = \mu_{\text{engine problem}} = \mu_{\text{spoiler problem}} = \mu_{\text{flap failure}}$

H1 = The alternative hypothesis stated that at least two of the mean time among the three proposed flight conditions are different

$H1 = \mu_{\text{engine problem}} \neq \mu_{\text{spoiler problem}} \neq \mu_{\text{flap failure}}$

Type of display design × proposed flight conditions interaction

H0 = The null hypothesis stated that there is not a statistically significant interaction between type of display design and proposed flight conditions

H0 = interaction effect = 0

H1 = The alternative hypothesis stated that there is a statistically significant interaction between type of display design and proposed flight conditions

H1 = interaction effect ≠ 0

Interpretation of the Results of the Two-Way ANOVA

Main Effect for Type of Display Design

The means time for analog instrument display and primary flight display were 2.4087 and 2.3897, respectively. The means do not differ using the main effect of a factorial ANOVA F (1,114) = 0.014, p = 0.872. The F critical value obtained by $\alpha = 0.05$, df (TDD) = 1, and df (W) = 114 is equal to 3.93. This critical value applies to the test of main effect for type of display design. Since F observed is less than F critical, the null hypothesis cannot be rejected. Therefore, two types of display design differ insignificantly in the mean time. However, from looking at the graph means, it appears that the flight students exposed to a primary flight display fly slightly less time than the flight students exposed to an analog instrument display.

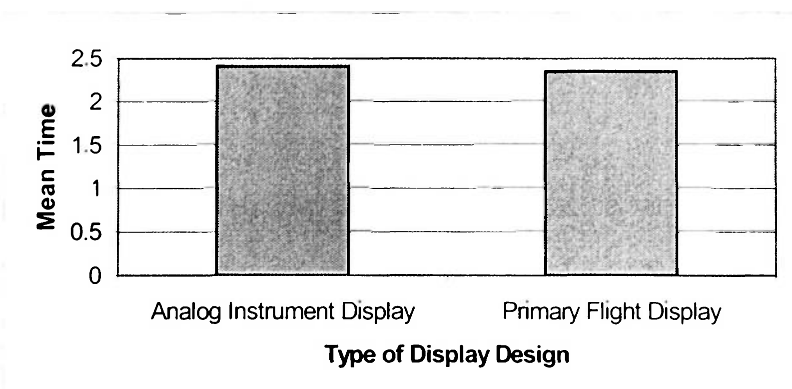

Figure 10. Graphs between Type of Display Design and Time

Main Effect for Proposed Flight Conditions

The means time for engine problem, spoiler problem, and flap failure were 1.5595, 1.7003, and 3.9378, respectively. The means do differ significantly using the main effect of a factorial ANOVA $\underline{F}$ (2,114) = 93.092, $\underline{p}$ = 0.000. The F critical value obtained by α = 0.05, df (PFC) = 2, and df (W) = 114 is equal to 3.08. This critical value applies to the test of main effect for proposed flight conditions. Since F observed is greater than F critical, the null hypothesis can be rejected. An omega-square of 0.611 indicates that 61.1 % of the variability in time is due to the proposed flight conditions. Therefore, the flight students exposed to an engine problem fly less time than the flight students exposed to a spoiler problem and a flap failure.

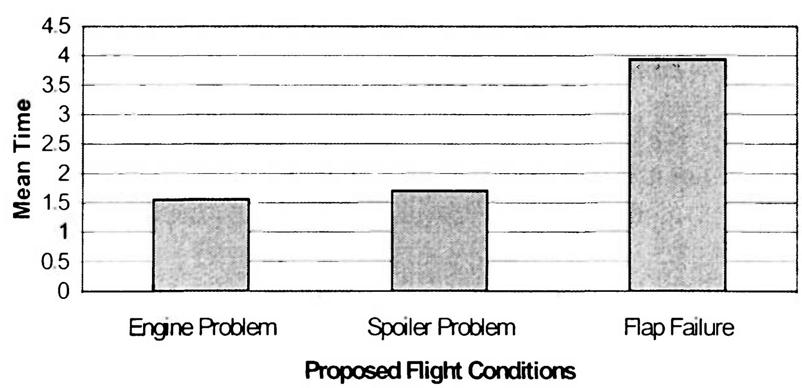

Figure 11. Graphs between Proposed Flight Conditions and Time

Type of Display Design and Proposed Flight Conditions Interaction

For the analog instrument display with the different proposed flight conditions: an engine problem, a spoiler problem, and a flap failure, the means of the time were 1.615, 1.742, and 3.869, respectively. Additionally, for the primary flight display with the different proposed flight conditions: an engine problem, a spoiler problem, and a flap failure, the means of the time were 1.504, 1.6585, and 4.0065, respectively. These means do show an insignificant pattern of interaction with a factorial ANOVA, F (2,114) = 0.24, p = 0.787. Therefore, the flight students exposed to a primary flight display or an analog instrument display do not benefit from any flight conditions.

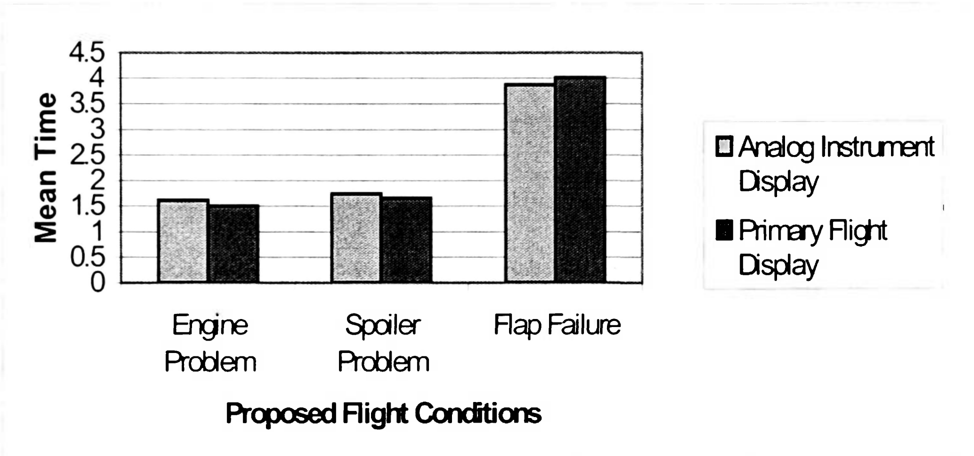

Figure 12. Graphs of Interaction between Proposed Flight Conditions and Type of Display Design and Time

Hypothesis (Number of Errors)

Type of display design with 2 levels: analog instrument display, primary flight display

H_0 = The null hypothesis stated that there is not a statistically significant difference in the mean number of errors for the pilots using analog instrument display versus pilots using primary flight display

$H0 = \mu_{\text{analog instrument display}} = \mu_{\text{primary flight display}}$

H_1 = The alternative hypothesis stated that the mean number of errors for the pilots using analog instrument display are greater than the mean number of errors for pilots using primary flight display

$H1 = \mu_{\text{analog instrument display}} > \mu_{\text{primary flight display}}$

Proposed flight conditions with 3 levels: engine problem, spoiler problem, flap failure

H_0 = The null hypothesis stated that there is not a statistically significant difference in the mean number of errors among the three proposed flight conditions

$H0 = \mu_{\text{engine problem}} = \mu_{\text{spoiler problem}} = \mu_{\text{flap failure}}$

H_1 = The alternative hypothesis stated that at least two of the mean number of errors among the three proposed flight conditions are different

$H1 = \mu_{\text{engine problem}} \neq \mu_{\text{spoiler problem}} \neq \mu_{\text{flap failure}}$

Type of display design × proposed flight conditions interaction

H_0 = The null hypothesis stated that there is not a statistically significant interaction between type of display design and proposed flight conditions

H_0 = interaction effect = 0

H1 = The alternative hypothesis stated that there is a statistically significant interaction between type of display design and proposed flight conditions

H1 = interaction effect ≠ 0

Interpretation of the Results of the Two-Way ANOVA

Main Effect for Type of Display Design

The means number of errors for analog instrument display and primary flight display were 2.0667 and 1.7167, respectively. The means do differ using the main effect of a factorial ANOVA $F(1,114) = 7.1677$, $p = 0.008$. The F critical value obtained by $\alpha = 0.05$, df (TDD) = 1, and df (W) = 114 is equal to 3.93. This critical value applies to the test of main effect for type of display design. Since F observed is greater than F critical, the null hypothesis can be rejected. An omega-square of 0.0263 indicates that 2.63 % of the variability in number of errors is due to the type of display design. Thus, the flight students exposed to primary flight display make fewer errors than the flight students exposed to analog instrument display.

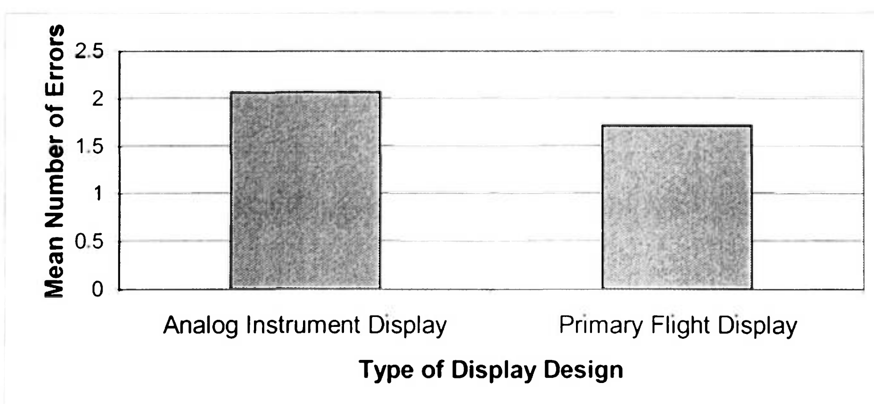

Figure 13. Graphs between Type of Display Design and Number of Errors

Main Effect for Proposed Flight Conditions

The means number of errors for an engine problem, a spoiler problem, and a flap failure were 0.9249, 2.475, and 2.275, respectively. The means do differ using the main effect of a factorial ANOVA $\underline{F}$ (2,114) = 55.4579, $\underline{p}$ = 0.000. The F critical value obtained by $\alpha = 0.05$, df (PFC) = 2, and df (W) = 114 is equal to 3.08. This critical value applies to the test of main effect for proposed flight conditions. Since F observed is greater than F critical, the null hypothesis can be rejected. An omega-square of 0.4649 indicates that 46.49 % of the variability in number of errors is due to the proposed flight conditions. Thus, the flight students exposed to an engine problem make fewer errors than the flight students exposed to a flap failure and a spoiler problem conditions.

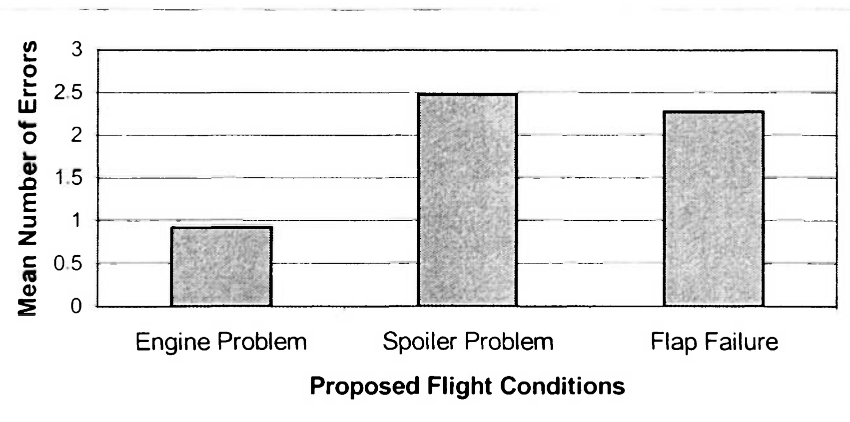

Figure 14. Graphs between Proposed Flight Conditions and Number of Errors

Type of Display Design and Proposed Flight Conditions Interaction

For the analog instrument display with the different proposed flight conditions: an engine problem, a spoiler problem, and a flap failure, the means of the number of errors were 1.05, 2.6, and 2.55, respectively. For the primary flight display with the different proposed flight conditions: an engine problem, a spoiler problem, and a flap failure, the means of the number of errors were 0.8, 2.35, and 2, respectively. These means do show an insignificant pattern of interaction with a factorial ANOVA, F (2,114) = 0.5851, p = 0.564. Thus, the flight students exposed to a primary flight display or an analog instrument display do not benefit from any flight conditions. The means for both displays show a similar pattern at all flight conditions.

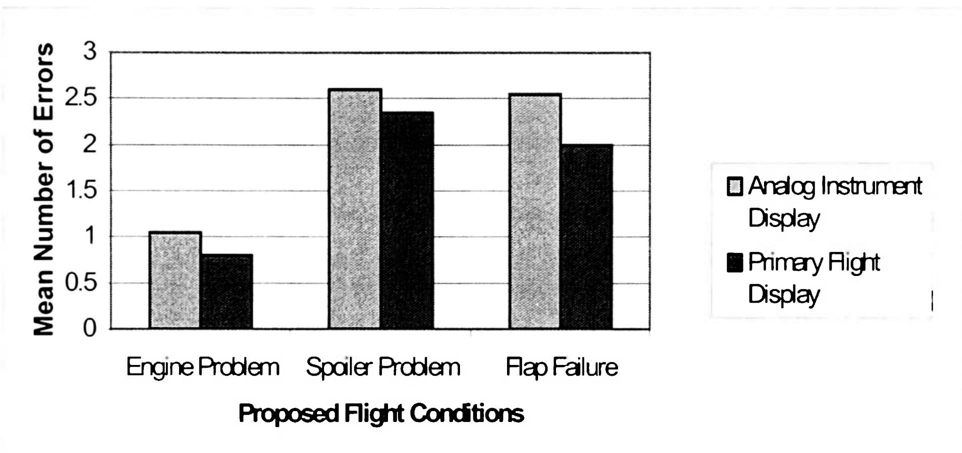

Figure 15. Graphs of Interaction between Proposed Flight Conditions and Type of Display Design, and Number of Errors

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The statement of hypothesis, for those pilots who were exposed to primary flight display perform with fewer numbers of errors than pilots who were exposed to analog instrument display, is evidently acceptable. Based on the results of this study, it is possible to conclude that the accuracy of pilot performance with a PFD type significantly decreases the number of errors ($F = 7.1677$, $p = 0.008$, $\omega^2 = 0.0263$). The study also indicated that during the engine problem condition, the pilots appear to fly less time and make fewer errors than the pilots under the spoiler problem and flap failure conditions, $F = 93.092$, $p = 0.000$, $\omega^2 = 0.611$, and $F = 55.4579$, $p = 0.000$, $\omega^2 = 0.4649$, respectively. This concludes that there are statistically significant differences in both the mean time and the mean number of errors among the three proposed flight conditions.

Although research implied that a decrease in pilot's errors and a slightly decrease in time (from looking at the graph means) are dependent on the display type, it is uncertain why there is not significant difference in the mean time of both displays. The results found may result from inadequate training of the PFD type. In fact, participants are presented with a future electronic display, but most of participants do not have experience with this display type. Obviously, there are only seven out of twenty test participants who had flown with PC-Based Flight Simulators. However, the feedback from participants (after completing the experiment) showed that they considerably prefer to fly the PFD type rather than the old-traditional style. Furthermore, the interaction pattern for both time and number of errors shows that there is no effect due to the interaction of display type and flight conditions. Hence, the flight students exposed to either a PFD or an analog instrument display do not benefit from any flight conditions.

Recommendations

The outcome associated with the pilots' errors and time could indicate the need to develop a new cockpit panel that integrates aspects from both traditional and advanced display designs. A new breed of the new glass cockpit is obtained from a previous concept along with advanced technologies in the electronic/electrical system. In addition, a glass cockpit can be found to significantly increase human performance by reducing time and number of errors. In the real flight environment, pilots will be able to simply control the aircraft with autopilot engaged. It is likely that the number of errors would be small compared to the numbers experienced in the study. The PC-Based Flight Simulator in this study is controlled by the uncomplicated control devices, not highly advanced flight deck automation. Moreover, the time of flying from one point to another point would be likely to decrease. In the actual AGATE aircraft, pilots simply program routes and flight destinations into the FMS, which is similar to one in a commercial airplane. These changes will reduce the possibilities of fatigue and boredom. Therefore, safety will greatly increase.

A past study found that a similar pictorial display presenting the follow-me-box was very easy to use and intuitive in nature and considered for the future computer-augmented instrument approach displays. It is easier to use than the conventional course deviation indicator needles (Adams and Lallman cited in Hennessy, p. 8). According to Bruning, cited in Hennessy (p. 8), the pathway in the sky display (PTIS) allows pilots to quickly and easily take control of the aircraft in the event of an autopilot failure during a critical phase of flight (e.g., climbout, approach, landing, etc.).

In future studies of glass cockpit displays, there would be a substantial benefit for designers to conduct a comparative analysis of general aviation versus commercial airplane or the military's glass cockpit displays. It is possibly hypothesized that the general aviation glass cockpit display is far better in improving human performance than the commercial airplane or military aircraft's glass cockpit displays regard to the advanced technology of highway-in-the-sky as well as out-of-the-window concepts. Indeed, the represented attitude indicator or horizontal awareness indicator is still being utilized in the military and commercial airplane industries in forms of a flight deck automation. In the next century, a general aviation glass cockpit will present the sophisticated automated system and state-of-the-art aircraft technologies for the new era of air transportation.

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APPENDIX A

PILOT DEMOGRAPHICS

PILOT DEMOGRAPHICS

PARTICIPANT NUMBER	______________
STUDENT COLLEGE ID	______________
NAME	______________
AGE	______________
GENDER	______________
DEGREE OF STUDY	______________
PILOT RATING	______________
TOTAL INSTRUMENT HOURS	______________
TOTAL FLIGHT HOURS	______________
FAMILIARITY WITH PC-BASED FLIGHT SIMULATORS	______________
TOTAL TIME OF USING A PFD TYPE DISPLAY	______________
SIGNATURE	______________
DATE	______________

APPENDIX B

CONSENT FORM

CONSENT FORM

The purpose of this experiment is to determine how accurately you as a test pilot fly a flight-training simulator using an analog instrument display versus a primary flight display. In this experiment, participants will fly both an analog instrument display and a PFD under the same control group that is an engine problem, a spoiler problem, and a flap failure condition. You will be given a traffic pattern to complete the flight mission. A five-minute break will be given between each display. The entire experiment should take no longer than 30 minutes. There are no predictable risks to you in participating. If you have any questions or need any additional information about this experiment, please contact:

Name: *Ungul Laptaned*
Email Address: *Laptaneu@db.erau.edu*

I have read and fully understand the above information.

Name (printed): ______________________________

Signature: ______________________________

Date: ______________________________

APPENDIX C

INSTRUCTIONS FOR EXPERIMENT

INSTRUCTIONS FOR EXPERIMENT

1. Have participants read and sign informed consent.

2. Read the instructions (below) to the participant, explaining how the study will proceed.

3. Give the specific instructions to the participants:

A. Analog Instrument Display. Participants are allowed to practice with a simulator of an analog instrument display to become accustomed to the given traffic pattern. The experimenter will then begin to run the experiment and record the video. There is a break of five minutes after completing this type of cockpit display. During this time, the experimenter explains instructions of the next display to the participants.

B. Primary Flight Display. Participants are allowed to practice with a simulator of a primary flight display to become accustomed to the given traffic pattern.

4. The experimenter will then give a debriefing sheet containing questions to the participants.

Participants' Instructions for the Cockpit Display Experiment

"In this experiment you will fly a Silicon Graphics Inc. flight training simulator of both analog instrument display and primary flight display. I will record this testing by a video recorder, observe, and assist you while you are flying this simulator."

"There will be a five minute break between each display. The entire experiment should take no longer than 30 minutes to complete."

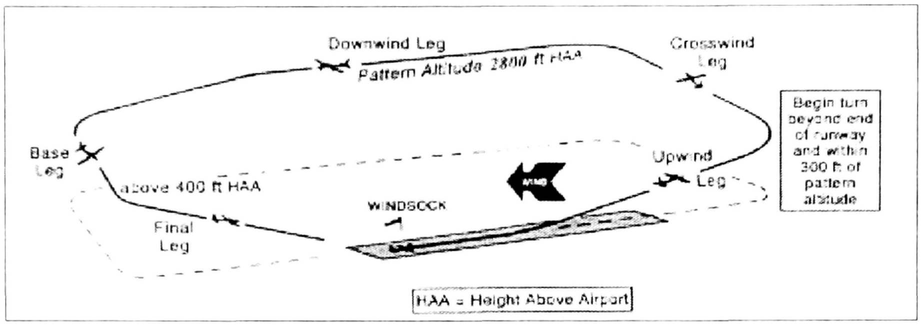
"Do you understand the instructions?" "Do you have any questions?"

"Let's start."

APPENDIX D

TRAFFIC PATTERN

TRAFFIC PATTERN



1. In the beginning, the pilot should take off and proceed by climbing ahead on the upwind leg until beyond the departure end of the runway and within 300 feet of traffic pattern attitude.

2. At this point, the pilot should start a turn onto the crosswind leg. Then the pilot should continue the climb to pattern altitude, which is 2,800 feet height above airport (HAA).

3. At pattern altitude, a turn is made onto the downwind leg and the aircraft is flown parallel to the runway. At the end of downwind leg, a turn onto is made onto the base leg and the descent continues.

4. Finally, a baseleg turn onto final approach is made and should be finished at 400 feet above airport elevation. The aircraft should be leveled off.

Terms and Abbreviations

Upwind Leg – an extension of the runway in the direction of taking off and landing.

Crosswind Leg – a flight path at right angles to the runway in use and beyond its departure end.

Downwind Leg – a flight path parallel to the runway in the opposite direction to takeoffs and landings.

Base Leg – a flight path at right angles to the landing runway, and off its approach end, extending from downwind leg to the intersection of the extended runway centerline.

APPENDIX E

PROPOSED FLIGHT CHECKLIST

PROPOSED FLIGHT CHECKLIST

1. TAKE OFF WITH 100 THRUST LBS.

2. FLAP TO 40 DEGREES

3. NOSE UP

4. LANDING GEAR UP

5. (65 THRUST LBS. AT 2,000 FEET)

6. CLIMB UP TO 2,800 FEET

7. TURN TO WEST (MAINTAIN ALTITUDE AT 2,800 FEET)

8. (SPOILER TO 40 DEGREES)

9. TURN TO SOUTH (MAINTAIN ALTITUDE AT 2,800 FEET)

10. END OF DOWNWIND LEG, DESCEND TO 1,700 FEET

11. TURN TO EAST AND DESCEND TO 1,300 FEET

12. (FLAP TO 0 DEGREE AT 1,300 FEET)

10. LANDING GEAR DOWN

APPENDIX F

DEBRIEFING SHEET

DEBRIEFING SHEET

Explanation of the Cockpit Design Experiment

This experiment is testing the accuracy of pilot performance (e.g., time and number of errors) by flying a flight simulator with an analog instrument display versus a primary flight display along with the control group (e.g., engine problem, spoiler problem, and flap failure). If you would like a copy of the results when they are completed, please contact:

Name: *Ungul Laptaned*
Email Address: *Laptaneu@db.erau.edu*

APPENDIX G

DESCRIPTIVE DEMOGRAPHICS DATA

DESCRIPTIVE DEMOGRAPHICS DATA

Participant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Gender	M	M	M	M	F	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Age	21	24	22	23	24	23	25	24	25	18	24	26	23	23	20	26	26	25	23	21
Private Pilot License	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Private Pilot License/Instrument Rating	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0
Commercial Airplane License	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0
Commercial Airplane License/Instrument Rating	1	1	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0
CFI - I	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
CFI - II	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Instrument Hours	55	50	6	15	6	17.9	20	5	0	7	3 7	110	70	10	35	50	25	50	3	2
Flight Hours	350	274	260	380	150	157.4	280	170	45	53	185.1	575	480	230	720	320	90	450	160	69.7
Familiarity with PC-Based Flight Simulators	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Total Time of Using a PFD Type Display	3	3	6	0	3	0	0	0	0	20	0	0	0	0	0	20	0	20	0	0

APPENDIX H

OUTCOME DATA

OUTCOME DATA

Time (Minutes)

Type of Display Design \ Proposed Flight Conditions	Engine Problem	Spoiler Problem	Flap Failure	Total
Analog Instrument Display	1.36 1.41 2.16 1.50 1.38 1.43 1.43 2.11 1.57 1.46 1.59 2.07 1.38 1.52 2.11 1.38 1.47 1.44 2.05 1.48	1.76 2.68 1.20 1.82 1.13 1.57 3.02 2.20 1.67 1.00 2.40 1.44 1.89 1.55 1.29 1.62 1.76 1.66 1.47 1.71	2.17 2.48 4.20 6.13 2.73 2.29 4.78 7.27 3.69 2.65 4.17 3.98 2.19 3.35 6.00 3.37 3.88 3.17 5.61 3.27	5.29 6.57 7.57 9.45 5.24 5.30 9.23 11.58 7.20 5.11 8.56 7.49 5.46 6.42 9.40 6.37 7.11 6.27 9.13 6.46
Primary Flight Display	1.27 1.30 1.50 1.54 1.32 1.38 1.56 1.47 1.36 1.55 1.51 2.02 1.31 1.48 1.38 1.56 1.43 1.56 2.01 1.57	1.94 1.73 1.68 1.83 1.10 1.73 2.70 1.60 1.68 1.66 1.87 1.23 1.21 1.60 1.70 1.66 1.81 1.47 1.26 1.71	2.17 2.45 4.24 5.97 2.07 3.32 6.75 6.28 3.16 2.84 3.85 6.25 2.90 4.29 5.15 4.10 2.97 3.18 4.02 4.17	5.38 5.48 7.42 9.34 4.49 6.43 11.01 9.35 6.20 6.05 7.23 9.50 5.42 7.37 8.24 7.32 6.21 6.21 7.29 7.45

Number of Errors (#)

Proposed Flight Conditions / Type of Display Design	Engine Problem				Spoiler Problem				Flap Failure				Total			
Analog Instrument Display	0	1	1	1	3	3	2	2	3	3	2	2	6	7	5	5
	0	0	1	0	3	3	3	2	2	3	3	3	6	6	7	5
	2	1	2	2	3	3	2	3	3	2	2	3	8	6	6	8
	1	1	0	1	3	3	2	2	3	3	2	3	7	7	4	6
	2	1	3	1	2	3	3	2	2	2	2	3	6	6	8	6
Primary Flight Display	2	0	0	0	2	2	1	2	4	2	1	1	8	4	2	3
	1	0	1	0	3	3	1	3	2	2	2	3	6	5	4	6
	2	0	1	2	3	3	2	2	2	3	2	1	7	6	5	5
	1	1	1	0	3	2	3	2	2	2	2	4	6	5	6	6
	0	2	1	1	3	2	2	3	1	2	1	1	4	6	4	5

APPENDIX I

COMPUTATION OF THE TWO-WAY ANOVA

COMPUTATION OF THE TWO-WAY ANOVA

Time (Minutes)

	Engine Problem	Spoiler Problem	Flap Failure	Total Sums for Rows
Analog Instrument Display	32 3	34 84	77 38	144 52
Primary Flight Display	30 08	33 17	80 13	143 38
Total Sums for Columns	62 38	68 01	157.51	287 9

$$\frac{(32.3)^2}{20} = 52.1645 \quad \frac{(34.84)^2}{20} = 60.6913 \quad \frac{(77.38)^2}{20} = 299.3832 \quad \frac{(30.08)^2}{20} = 45.2403$$

$$\frac{(33.17)^2}{20} = 55.0124 \quad \frac{(80.13)^2}{20} = 321.0408$$

$$\frac{(144.52)^2}{3(20)} = 348.1005 \quad \frac{(143.38)^2}{3(20)} = 342.6304 \quad \frac{(62.38)^2}{2(20)} = 97.2816$$

$$\frac{(68.01)^2}{2(20)} = 115.634 \quad \frac{(157.51)^2}{2(20)} = 620.235$$

$$\sum_{p=1}^{N} Xp = 32.3 + 34.84 + 77.38 + 30.08 + 33.17 + 80.13 = 287.9$$

$$\frac{(\sum_{p=1}^{N} Xp)^2}{nqr} = \frac{(287.9)^2}{20(2)(3)} = 690.7201$$

$$\frac{\sum_{i=1}^{q}(\sum_{j=1}^{r}\sum_{p=1}^{n} Xpij)^2}{nr} = 348.1005 + 342.6304 = 690.7309$$

$$\frac{\sum_{j=1}^{r}(\sum_{i=1}^{q}\sum_{p=1}^{n} Xpij)^2}{nq} = 97.2816 + 115.634 + 620.235 = 833.150$$

$$\frac{\sum_{i=1}^{q}\sum_{j=1}^{r}(\sum_{p=1}^{n} Xpij)^2}{n} = 52.1645 + 60.6913 + 299.3832 + 45.2403 + 55.0124 + 321.0408$$

$$= 1,331.15$$

$$(\sum_{p=1}^{N} Xp)^2 = (1.36)^2 + (1.38)^2 + (1.57)^2 + (1.38)^2 + (1.47)^2 + (1.41)^2 + (1.43)^2 + (1.46)^2 + (1.52)^2 + (1.44)^2 + (2.16)^2 + (1.43)^2 + (1.59)^2 + (2.11)^2 + (2.05)^2 + (1.50)^2 + (2.11)^2 + (2.07)^2 + (1.38)^2 + (1.48)^2 + (1.76)^2 + (1.13)^2 + (1.67)^2 + (1.89)^2 + (1.76)^2 + (2.68)^2 + (1.57)^2 + (1.00)^2 + (1.55)^2 + (1.66)^2 + (1.20)^2 + (3.02)^2 + (2.40)^2 + (1.29)^2 + (1.47)^2 + (1.82)^2 + (2.20)^2 + (1.44)^2 + (1.62)^2 + (1.71)^2 + (2.17)^2 + (2.73)^2 + (3.69)^2 + (2.19)^2 + (3.88)^2 + (2.48)^2 + (2.29)^2 + (2.65)^2 + (3.35)^2 + (3.17)^2 + (4.20)^2 + (4.78)^2 + (4.17)^2 + (6.00)^2 + (5.61)^2 + (6.13)^2 + (7.27)^2 + (3.98)^2 + (3.37)^2 + (3.27)^2 + (1.27)^2 + (1.32)^2 + (1.36)^2 + (1.31)^2 + (1.43)^2 + (1.30)^2 + (1.38)^2 + (1.55)^2 + (1.48)^2 + (1.56)^2 + (1.50)^2 + (1.56)^2 + (1.51)^2 + (1.38)^2 + (2.01)^2 + (1.54)^2 + (1.47)^2 + (2.02)^2 + (1.56)^2 + (1.57)^2 + (1.94)^2 + (1.10)^2 + (1.68)^2 + (1.21)^2 + (1.81)^2 + (1.73)^2 + (1.73)^2 + (1.66)^2 + (1.60)^2 + (1.47)^2 + (1.68)^2 + (2.70)^2 + (1.87)^2 + (1.70)^2 + (1.26)^2 + (1.83)^2 + (1.60)^2 + (1.23)^2 + (1.66)^2 + (1.71)^2 + (2.17)^2 + (2.07)^2 + (3.16)^2 + (2.90)^2 + (2.97)^2 + (2.45)^2 + (3.32)^2 + (2.84)^2 + (4.29)^2 + (3.18)^2 + (4.24)^2 + (6.75)^2 + (3.85)^2 + (5.15)^2 + (4.02)^2 + (5.97)^2 + (6.28)^2 + (6.25)^2 + (4.10)^2 + (4.17)^2$$

$$= 920.7491$$

$$SS\ (TDD) = \frac{\sum_{i=1}^{q}(\sum_{j=1}^{r}\sum_{p=1}^{n} Xpij)^2}{nr} - \frac{(\sum_{p=1}^{N} Xp)^2}{nqr}$$

$$= 690.7309 - 690.72$$

$$= 0.0108$$

SS (PFC)

$$= \frac{\sum_{j=1}^{r}(\sum_{i=1}^{q}\sum_{p=1}^{n} Xpij)^{2}}{nq} - \frac{(\sum_{p=1}^{N} Xp)^{2}}{nqr}$$

= 833.1506 – 690.72

= 142.4306

SS (TDD×PFC)

$$= \frac{\sum_{i=1}^{q}\sum_{j=1}^{r}(\sum_{p=1}^{n} Xpij)^{2}}{n} - \frac{\sum_{i=1}^{q}(\sum_{j=1}^{r}\sum_{p=1}^{n} Xpij)^{2}}{nr} \quad \frac{\sum_{j=1}^{r}(\sum_{i=1}^{q}\sum_{p=1}^{n} Xpij)^{2}}{nq} + \frac{(\sum_{p=1}^{N} Xp)^{2}}{nqr}$$

= 833.5325 – 690.7309 – 833.1506 + 690.72

= 0.3712

S(W)

$$= (\sum_{p=1}^{N} Xp)^{2} - \frac{\sum_{i=1}^{q}\sum_{j=1}^{r}(\sum_{p=1}^{n} Xpij)^{2}}{n}$$

= 920.7491 – 833.5325

= 87.2166

SS (Total) = SS (TDD) + SS (PFC) + SS (TDD × PFC) + SS (W)

= 1.083 + 142.4306 + 0.3712 + 87.2166

= 231.1014

df (TDD) = q 1

= 2 - 1

= 1

df (PFC) = r - 1

= 3 1

= 2

df (TDD × PFC) $= (q - 1) \times (r - 1)$

$= (2 \quad 1) \times (3 \quad 1)$

$= 2$

df (W) $= q \times r \times (n \quad 1)$

$= 2 \times 3 \times (20 - 1)$

$= 114$

df (Total) $= (q \times r \times n) \quad 1$

$= (2 \times 3 \times 20) - 1$

$= 119$

MS (TDD) $= \dfrac{\text{SS (TDD)}}{\text{df (TDD)}}$

$= \dfrac{0.0108}{1}$

$= 0.0108$

MS (PFC) $= \dfrac{\text{SS (PFC)}}{\text{df (PFC)}}$

$= \dfrac{142.4306}{2}$

$= 71.2153$

MS (TDD × PFC) $= \text{SS (TDD} \times \text{PFC)}$

$\text{df (TDD} \times \text{PFC)}$

$= \dfrac{0.3712}{2}$

$= 0.1856$

MS (W) $= \dfrac{SS\ (W)}{df\ (W)}$

$= \dfrac{87.2166}{114}$

$= 0.765$

F (TDD) $= \dfrac{MS\ (TDD)}{MS\ (W)}$

$= \dfrac{0.01083}{0.765}$

$= 0.014$

F (PFC) $= \dfrac{MS\ (PFC)}{MS\ (W)}$

$= \dfrac{71.2153}{0.765}$

$= 93.092$

F (TDD × PFC) $= \dfrac{MS\ (TDD \times PFC)}{MS\ (W)}$

$= \dfrac{0.1856}{0.765}$

$= 0.2464$

$$\omega^2\ (PFC) = \frac{SS\ (PFC) - [(df_{(PFC)}) \times MS(W)]}{SS\ (Total) + MS\ (W)}$$

$$= \frac{142.4306 - [(1)(0.765)]}{231.1014 + 0.765}$$

$$= \frac{141.6656}{231.8664}$$

$$= 0.611$$

Results of the Fixed-Effect ANOVA for Time

Source of Variation	Sum of Squares (SS)	degree of freedoms (df)	Mean Square (MS)	F observed
Type of Display Design	SS(TDD) = 0.01083	df(TDD) = 1	MS(TDD) = 0.01083	F(TDD) = 0.014
Proposed Flight Conditions	SS(PFC) = 142.4306	df(PFC) = 2	MS(PFC) = 71.2153	F(PFC) = 93.092
Interaction (Type of Display Design ×Proposed Flight Conditions)	SS(TDD × PFC) = 0.3712	df(TDD × PFC) = 2	MS(TDD × PFC) = 0.1856	F(TDD × PFC) = 0.2426
Within Group (Error)	SS(W) = 87.2166	df(W) = 114	MS(W) = 0.765	
Total	SS(Total) = 231.1014	df(Total) = 119		

Number of Errors

	Engine Problem	Spoiler Problem	Flap Failure	Total Sums for Rows
Analog Instrument Display	21	52	51	124
Primary Flight Display	16	47	40	103
Total Sums for Columns	37	99	91	227

$\frac{(21)^2}{20} = 22.05$ $\frac{(52)^2}{20} = 135.2$ $\frac{(51)^2}{20} = 130.05$ $\frac{(16)^2}{20} = 12.8$

$\frac{(47)^2}{20} = 110.45$ $\frac{(40)^2}{20} = 80$

$\frac{(124)^2}{3(20)} = 256.2666$ $\frac{(103)^2}{3(20)} = 176.8166$ $\frac{(37)^2}{2(20)} = 34.225$ $\frac{(99)^2}{2(20)} = 245.025$

$\frac{(91)^2}{2(20)} = 207.025$

$$\sum_{p=1}^{N} Xp = 21 + 52 + 51 + 16 + 47 + 40 = 227$$

$$\frac{(\sum_{p=1}^{N} Xp)^2}{nqr} = \frac{(227)^2}{20(2)(3)} = 429.4083$$

$$\frac{\sum_{i=1}^{q}(\sum_{j=1}^{r}\sum_{p=1}^{n} Xpij)^2}{nr} = 256.2666 + 176.8166 = 433.0832$$

$$\frac{\sum_{j=1}^{r}(\sum_{i=1}^{q}\sum_{p=1}^{n} Xpij)^2}{nq} = 34.225 + 245.025 + 207.025 = 486.275$$

$$\frac{\sum_{i=1}^{q}\sum_{j=1}^{r}(\sum_{p=1}^{n} Xpij)^2}{n} = 22.05 + 135.2 + 130.05 + 12.8 + 110.45 + 80 = 490.55$$

$$(\sum_{p=1}^{N} Xp)^2 = (0)^2 + (0)^2 + (2)^2 + (1)^2 + (2)^2 + (1)^2 + (0)^2 + (1)^2 + (1)^2 +$$
$$(1)^2 + (1)^2 + (1)^2 + (2)^2 + (0)^2 + (3)^2 + (1)^2 + (0)^2 + (2)^2 +$$
$$(1)^2 + (1)^2 + (3)^2 + (3)^2 + (3)^2 + (3)^2 + (2)^2 + (3)^2 + (3)^2 +$$
$$(3)^2 + (3)^2 + (3)^2 + (2)^2 + (3)^2 + (2)^2 + (2)^2 + (3)^2 + (2)^2 +$$
$$(2)^2 + (3)^2 + (2)^2 + (2)^2 + (3)^2 + (2)^2 + (3)^2 + (3)^2 + (2)^2 +$$
$$(3)^2 + (3)^2 + (2)^2 + (3)^2 + (2)^2 + (2)^2 + (3)^2 + (2)^2 + (2)^2 +$$
$$(2)^2 + (2)^2 + (3)^2 + (3)^2 + (3)^2 + (3)^2 + (2)^2 + (1)^2 + (2)^2 +$$
$$(1)^2 + (0)^2 + (0)^2 + (0)^2 + (0)^2 + (1)^2 + (2)^2 + (0)^2 + (1)^2 +$$
$$(1)^2 + (1)^2 + (1)^2 + (0)^2 + (0)^2 + (2)^2 + (0)^2 + (1)^2 + (2)^2 +$$
$$(3)^2 + (3)^2 + (3)^2 + (3)^2 + (2)^2 + (3)^2 + (3)^2 + (2)^2 + (2)^2 +$$
$$(1)^2 + (1)^2 + (2)^2 + (3)^2 + (2)^2 + (2)^2 + (3)^2 + (2)^2 + (2)^2 +$$
$$(3)^2 + (4)^2 + (2)^2 + (2)^2 + (2)^2 + (1)^2 + (2)^2 + (2)^2 + (3)^2 +$$
$$(2)^2 + (2)^2 + (1)^2 + (2)^2 + (2)^2 + (2)^2 + (1)^2 + (1)^2 + (3)^2 +$$
$$(1)^2 + (4)^2 + (1)^2$$

$= 549.0079$

SS (TDD) $= \frac{\sum_{i=1}^{q}(\sum_{j=1}^{r}\sum_{p=1}^{n} Xpij)^2}{nr} - \frac{(\sum_{p=1}^{N} Xp)^2}{nqr}$

$= 433.0832 - 429.4083$

$= 3.6749$

SS (PFC) $= \frac{\sum_{j=1}^{r}(\sum_{i=1}^{q}\sum_{p=1}^{n} Xpij)^2}{nq} - \frac{(\sum_{p=1}^{N} Xp)^2}{nqr}$

$= 486.275 - 429.4083$

$= 56.8667$

SS (TDD×PFC) $= \dfrac{\sum_{i=1}^{q}\sum_{j=1}^{r}(\sum_{p=1}^{n} Xpij)^2}{n} - \dfrac{\sum_{i=1}^{q}(\sum_{j=1}^{r}\sum_{p=1}^{n} Xpij)^2}{nr} - \dfrac{\sum_{j=1}^{r}(\sum_{i=1}^{q}\sum_{p=1}^{n} Xpij)^2}{nq} + \dfrac{(\sum_{p=1}^{N} Xp)^2}{nqr}$

$= 227 - 433.0832 - 486.275 + 429.4083$

$= 0.6$

S(W) $= (\sum_{p=1}^{N} Xp)^2 - \dfrac{\sum_{i=1}^{q}\sum_{j=1}^{r}(\sum_{p=1}^{n} Xpij)^2}{n}$

$= 549.0079 - 490.55$

$= 58.4579$

SS (Total) = SS (TDD) + SS (PFC) + SS (TDD × PFC) + SS (W)

$= 3.6749 + 56.8667 + 0.6 + 58.45$

$= 119.5916$

df (TDD) = q 1

= 2 1

= 1

df (PFC) = r - 1

= 3 1

= 2

df (TDD × PFC) = (q 1) × (r - 1)

= (2 - 1) × (3 1)

= 2

df (W) $= q \times r \times (n \quad 1)$

$$= 2 \times 3 \times (20 - 1)$$

$$= 114$$

df (Total) $= (q \times r \times n) \quad 1$

$$= (2 \times 3 \times 20) \quad 1$$

$$= 119$$

MS (TDD) $= \dfrac{\text{SS (TDD)}}{\text{df (TDD)}}$

$$= \frac{3.6749}{1}$$

$$= 3.6749$$

MS (PFC) $= \dfrac{\text{SS (PFC)}}{\text{df (PFC)}}$

$$= \frac{56.8667}{2}$$

$$= 28.4333$$

MS (TDD × PFC) $= \dfrac{\text{SS (TDD} \times \text{PFC)}}{\text{df (TDD} \times \text{PFC)}}$

$$= \frac{0.6}{2}$$

$$= 0.3$$

$$\text{MS (W)} = \frac{\text{SS (W)}}{\text{df (W)}}$$

$$= \frac{58.45}{114}$$

$$= 0.5127$$

$$\text{F (TDD)} = \frac{\text{MS (TDD)}}{\text{MS (W)}}$$

$$= \frac{3.6749}{0.5127}$$

$$= 7.1677$$

$$\text{F (PFC)} = \frac{\text{MS (PFC)}}{\text{MS (W)}}$$

$$= \frac{28.4333}{0.5127}$$

$$= 55.4579$$

$$\text{F (TDD} \times \text{PFC)} = \frac{\text{MS (TDD} \times \text{PFC)}}{\text{MS (TDD} \times \text{PFC)}}$$

$$= \frac{0.3}{0.5127}$$

$$= 0.5851$$

$$\omega^2 \text{ (TDD)} = \frac{\text{SS (TDD)} - [(\text{df (TDD)}) \times \text{MS(W)}]}{\text{SS (Total)} + \text{MS (W)}}$$

$$= \frac{3.6749 - [(1)(0.5127)]}{119.5915 + 0.5127}$$

$$= \frac{3.1622}{120.1041}$$

$$= 0.0263$$

ω^2 (PFC) $$= \frac{SS(PFC) - [(df(PFC)) \times MS(W)]}{SS(Total) + MS(W)}$$

$$= \frac{56.8667 - [(2)(0.5127)]}{119.5915 + 0.5127}$$

$$= \frac{55.8413}{120.1042}$$

$$= 0.4649$$

Results of the Fixed-Effect ANOVA for Number of Errors

Source of Variation	Sum of Squares (SS)	degree of freedoms (df)	Mean Square (MS)	F observed
Type of Display Design	SS(TDD) = 3.6749	df(TDD) = 1	MS(TDD) = 3.6749	F(TDD) = 7.1677
Proposed Flight Conditions	SS(PFC) = 56.8667	df(PFC) = 2	MS(PFC) = 56.8667	F(PFC) = 55.4579
Interaction (Type of Display Design ×Proposed Flight Conditions)	SS(TDD × PFC) = 0.6	df(TDD × PFC) = 2	MS(TDD × PFC) = 0.3	F(TDD × PFC) = 0.5851
Within Group (Error)	SS(W) = 58.45	df(W) = 114	MS(W) = 0.5127	
Total	SS(Total) = 119.5916	df(Total) = 119		

APPENDIX J

GANTT CHART

GANTT CHART

AGATE PFD Conceptual Design	84 days	1/7/99 8 00	3/31/99 17 00	0	UL
Thesis Research & Systems Analysis Method	256 days	4/1/99 8 00	12/10/99 17 00	1	UL
- Abstract, Introduction	7 days	4/1/99 8 00	4/7/99 17 00	2	UL
- Method, Systems Analysis Method	12 days	4/8/99 8 00	4/19/99 17 00	3	UL
- Review of the Literature	30 days	4/20/99 8 00	5/19/99 17 00	4	UL
- Optimizing Model for the Cockpit Display Design	12 days	5/20/99 8 00	5/31/99 17 00	5	UL
- Design Experiment	61 days	6/1/99 8 00	7/30/99 17 00	6	UL
- Run Experiment & Results	37 days	8/1/99 8 00	9/7/99 17 00	7	UL
- Discussion & Recommendations	5 days	9/8/99 8 00	9/12/99 17 00	8	UL
- Table of Contents & Table of Figures	1 days	9/13/99 8 00	9/13/99 17 00	9	UL
- Acknowledgements	1 days	9/13/99 8 00	9/13/99 17 00	10	UL
Final Document - PFD Conceptual Design & Thesis Research	90 days	9/14/99 8 00	12/10/99 17 00	11	UL
Defense of Proposal	1 days	12/17/99 8 00	12/17/99 17 00	12	UL

APPENDIX K
SYSTEMS ANALYSIS METHOD DOCUMENT

SYSTEMS ANALYSIS METHOD

Introduction

This systems analysis document was created to identify and analyze a systematic approach and a mathematical approach for the AGATE PFD. Owing to a complex system of the AGATE aircraft, the use of systems analysis techniques will provide a conceptual framework of systematic and efficient approaches. The definition of systems analysis refers to the process of studying a system by partitioning the system (functions or objects) and determining how the parts relate to each other to understand the whole (LRC, 1996).

System analysis techniques for dealing with problems are labeled in many ways such as engineering economic analysis, operations research, operations analysis, benefit analysis, etc. Each model introduces the solution of solving problems in order to optimize the value of a production, expressly the aviation/aerospace production design. Management has always implemented the application of system technique. In particular, the AGATE NASA-funded project is comprised of the principle of systems engineering approach shown in forms of the systems engineering management plan. In the last several decades, system management techniques have been utilized, tailored to, and developed for numerous NASA-funded projects. NASA-funded projects have obviously contributed to the recent growth in the general body of knowledge and level of expertise surrounding systems management (ABT, 1968).

Management tasks occur often in the aviation/aerospace industry, cling to a need to design, develop, and build an aircraft or a spacecraft. Once the NASA administration desires to do so, management problems are encountered. There are three general management problems which NASA frequently faces and its contractors in general aviation practices: long-range planning, processor project development, and operational procedures.

First, long-range planning and objective must be initiated many years in advance of the aircraft's issuance. The time period of AGATE planning is approximately eight years for the initial design, development, and manufacturing phase. Hence, the complexity and size of the project is substantial. The personnel and cost needs of the project must also be estimated and taken into consideration. In spite of the fact that the long-range planning task must cope with difficulties of quantitative and optimization, it can always be solved by probabilistic long-range planning techniques, statistical decision-theory techniques, comprehensive cost-estimating systems, game-theory techniques, or even systematic forecasting tools (ABI, 1968). The last section of this document will address the optimizing model for a cockpit display design created and analyzed by the author.

Second, process and project development involves trade-offs of cost, schedule, and different performance criteria. Finally, operational procedures include data-handling and scheduling capability. The last two problems refer to the real core of organization activities. In addition to NASA projects, personnel and funding are mainly involved in the project design and development. Management techniques must be designed to achieve these problematic factors to ensure that systems are in effective and efficient way.

Management Information and Control Systems

Characterization of the AGATE aircraft system is a large and complicated system, and is comprised of various interrelated activities. Management information and control systems have been addressed to monitor, evaluate, and predict the consequences of several subsystem activities. These activities are integrated into one aircraft system. The information and control system serves as a systematic set of techniques and information flow. A set of elements used in the system are described as follows: internal flows of documents and data, flows of external environmental data, systematic procedures to digest, extract, and analyze the data, evaluation of the data with respect to the program objectives, and a feedback control mechanism (ABI, 1968). These elements are necessary for management to control a large and complex structure effectively. The interrelationship of the network starts from the point of data origination through the processing procedures to the decision-makers, then from the points of implementation of the decisions. The symbolic representation of the steps in the flow of information and its processing in the system is called "the systems flow chart" (Bocchino, 1972). The flow chart demonstrates how the information is processed in the channels of the system and assists management or system analysts to understand the information system in terms of the processing involved. This most useful technique will increase the effectiveness of the management information system and will be helpful in communicating with the different levels of personnel in the information processing.

Additionally, the above system activities are not evidently structural unless management control has been applied and implemented. Management control may be classified into many categories. These include personnel-management control, technical control, production control, and inventory control. Each individual category will organize the vast multifarious activities as well as optimize the system objectives. There are several techniques of system control in which management can implement their plans.

These plans are designed to allocate and utilize the resources of the organization. Examples of system control techniques are inventory control systems, critical path method (CPM), program evaluation and review technique (PERT), the learning curve, etc. In conclusion, management information and control systems will substantially develop in response to the specific requirements of management for time, precision, and value of data in order to plan, design, develop, analyze, and control the system activities within the loop.

Systems Engineering Concept

The AGATE project management plan was initially developed and effectively implemented by using the systems engineering approach. The project itself has been very large-scale and rather complicated. The use of systems engineering concept would not only be valuable, but also quintessential for adequate management. Systems engineering concept is defined as an "interdisciplinary collaborative approach to derive, evolve, and verify a life cycle balanced system solution which satisfies customer expectations and meets public acceptability" (Blanchard and Fabrycky, 1998). The systems engineering process involves the use of technologies and management methods in terms of "synthesis." Synthesis describes the combining of subsystems and components in one feasible system infrastructure and establishes their relationships among the subsystems or components. Systems engineering process is applicable in all phases of the system life cycle (i.e., conceptual design, preliminary design, detail design and development, production and/or construction, product use, phase-out, and eventually disposal phase). The overall goal is to influence design in the early stages through system requirement analysis, technical performance measures, and functional analysis and allocation as well as to ensure the proper integration of design requirements at the various levels of the program. The success of the systems engineering process is contingent upon the availability of equipment and technologies and the planning and implementation of systems engineering management. The methods of systems engineering management are documented in the systems engineering management plan (SEMP).

In the AGATE work, systems engineering management plan is a comprehensive document that identifies and describes the overall policies and methods for management of systems engineering for the AGATE project system assurance activities. The systems engineering management plan also describes the roles and responsibilities, engineering management planning, methods and processes; the specific system engineering tasks, and integration of specialty engineering disciplines (LRC, 1996). The systems engineering management plan is developed during the conceptual design phase to provide the integration of a number of individual design related program plans. Examples of the design related program plans are reliability program plan, maintainability program plan, human factors program plan, system safety program plan, logistics engineering plan, concurrent engineering plan, producibility plan, supplier engineering plan, and disposability and material recycling plan. The purpose of SEMP is also to promote the necessary communication skills with other top-level planning documentation (e.g., configuration management plan, test and evaluation master plan, total quality management plan, manufacturing program plan, integrated logistic support plan, affordability plan, and data management plan).

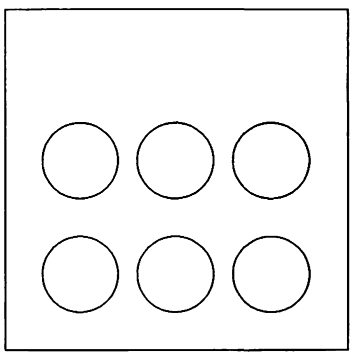
Systems Analysis Concept

The concept of systems analysis is to measure a system's operations and improve the total management information system. Systems analysis usually attempts to make the system fully operational, wherein the system's results are maximized. Systems analysis approach is known as "the scientific method of problem solving." The major steps in this method have been adapted to the realities of systems analysis. The steps include defining the problem, collecting the facts, analyzing the facts, developing alternatives, and applying the solution. The problems that are encountered by a systems analyst, especially in the air transportation system, are the long lead-times required for the construction of transportation facilities, planning, and the analytical procedures. The solution to solve these problems is to determine requirements and compare costs and benefits, and evaluate alternatives means of satisfying these requirements. The decision analysis might be implemented during the determining of solution phase. Furthermore, systems analysts have always been familiar with the basic tools of decision analysis. There are several systems analysis tools in the market such as a decision tree, utility theory, or statistical decision theory. The methods of decision analysis are mainly focused on quantifying the production or system with a complex set of decisions and alternatives. Outcomes will be measured on success or failure. No matter what the outcomes would be, the systems analyst approach will give the management of systems analysis a framework, which will guide him or her to the decision analysis tools and mathematical techniques to manipulate given problems.

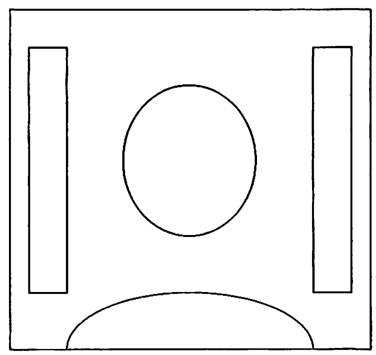
Optimizing Model for the Cockpit Display Design

In the last three decades, a concept of quantitative decision techniques, which refers to operations research or management science, has been developed The quantitative techniques and systems engineering concept are used to solve problems and optimize the operation of systems Operations Research is defined as a "scientific methodology - analytical, experimental, quantitative - which, by assessing the over-all implications of various alternative courses of action in a management system, provide an improved basis for management decisions" (Bocchino, 1972) Basically, the concept of operations research is derived from the inter-relationship among all functions and components of the system This inter-relationship is the concept of systems engineering If one element is changed, all other elements are also changed In order to improve decision making to meet these changes, project managers and systems engineers need to find out the results of a given change However, these results could be solved by a number of alternative solutions Therefore, both of them have to decide which alternative(s) is among the best Here is where the techniques of operations research apply They examine the number of alternatives to a problem and quantify the probable results Operations Research techniques such as a "classical optimization theory" or "non linear programming" can analyze and examine data precisely, as well as quantify the results accurately Optimization is the process of seeking the best (Blanchard and Fabrycky, 1998) This section will be concerned with analyzing data of the cockpit display that is addressed into two different displays design One of them is the instrument display that is used for a conventional general aviation aircraft Another is the primary flight display that is used for an AGATE aircraft The comparison between two displays by using this optimization theory will be a great help and guidance for NASA to apprehend the concept of optimization method, which is essential to the management systems engineer, or the systems analyst in determining the best series of cockpit display configurations for the AGATE aircraft. In the following section, research evaluation by the mathematical approach is addressed. This specific mathematical model may be derived for the evaluation of selecting the best alternative for the cockpit display.

The Decision Evaluation Function [8]



Analog Instrument Display



Primary Flight Display

Assume that each indicator is the same cost. Cost of cockpit display between analog instrument display and primary flight display that used in the AGATE aircraft and training device is

$$E = f\,(X,Y) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

E = Evaluation measure - Total First Cost (TFC)

X = Design variable of the spacing between indicators

[8] Concept from Blanchard, Benjamin S. and Fabrycky, Walter J. (1998). Systems Engineering and Analysis (3 rd ed., pp. 214-217). Prentice-Hall Inc.

Y = System parameters of the display unit length, the display area weight, the cost of display area, the cost of indicators per feet.

Equation 1 is the design evaluation function relevant to the evaluation of alternative design configurations, where design-dependent parameters arise in choosing the best alternative.

Let L = Display unit length (feet)

W = Display area weight (pounds per foot)

S = Spacing between indicators (feet)

C_D = Cost of display area (dollars per pound)

C_p = Installed cost of indicators (dollars per indicator)

Assume that the weight of the display area is linear over a certain indicator range, $W = YS + Z$, with the parameters Y and Z having been set up by a linear equation.

Consequently, the display area cost (DC) will be

$$DC = (YS + Z)(L)(C_D)$$

The total cost of indicators, SC, will be

$$SC = \left(\frac{L}{S} + 1\right)(C_p)$$

The total cost of first cost of the display unit is expressed as

$$TFC = DC + SC$$

$$= (YS + Z)(L)(C_D) + \left(\frac{L}{S} + 1\right)(C_p)$$

$$= YS\,LC_D + ZLC_D + \frac{L}{S}C_p + C_p \qquad \ldots 2$$

In order to find the optimum spacing between indicators, differentiate equation 2. with respect to S and equate the result to zero as follows:

$$\frac{d\,(TFC)}{d\,(S)} = YLC_D - \frac{LC_p}{S^2} = 0$$

$$S^* = \sqrt{\frac{Cp}{YC_D}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

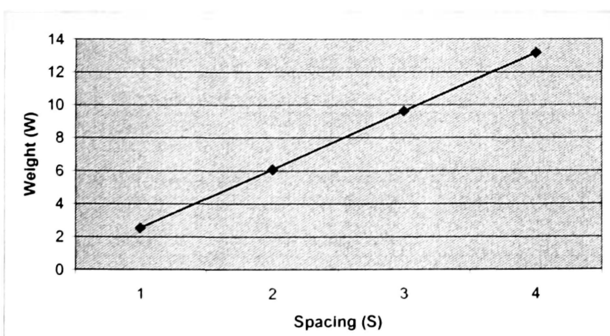
The minimum TFC for the display unit is found by substituting equation 3 from equation 2 to obtain

$$TFC^* = 2\sqrt{YCpL^2C_D} + ZLC_D + Cp \quad \ldots\ldots\ldots\ldots\ldots\ldots 4$$

Equation 3 can be used to find the optimal indicator spacing for a given display design.

Single Design Alternatives

Spacing (S)	Weight (W)
1	2.53
2	6.08
3	9.63
4	13.18



Assume that a display unit is 1.2 feet. For this design, the weight of the display area in pounds per foot is estimated to be linear regression (over a limited indicator spacing) and is expressed as W = 3.55S - 1.02. Also, assume that the display area is expected to cost $240 per pound. Indicators are anticipated to cost $100 each in place. From equation 3, the optimum spacing between indicators is found to be

$$S* = \sqrt{\frac{100}{(3.55)(240)}}$$

$$= 0.3426 \text{ feet}$$

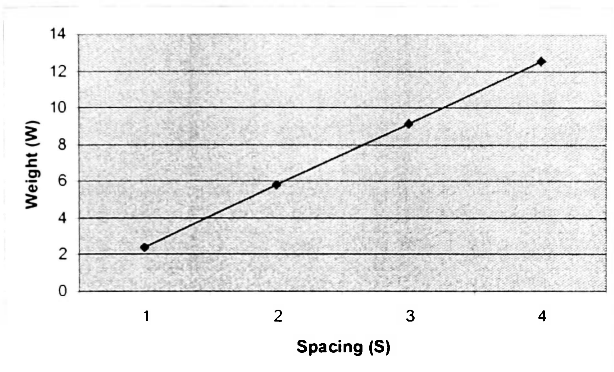
This result is a theoretical spacing, and must be adjusted to obtain an integer number of indicator. The required adjustment gives 4 indicators (3 spacing) for a total cost from equation 2 of $515.2. The spacing will be 0.4 feet, slightly greater than the theoretical minimum. A check can be made by considering 5 indicators (4 spacing) with each spacing being 0.3 feet. In this case, the total cost is lower ($512.96), so the 5-indicators design would be adopted. Total cost as a function of the indicator spacing (and number of indicators) is summarized in table 4. Note that a minimum occurs when 5 indicators are specified. The optimal indicator spacing is 0.3 feet

Table 1. TFC as a Function of the Spacing between Indicators

Spacing (Feet)	Number of Indicators	Indicator Cost	Display Area Cost	Total First Cost
1.2	2	$200	$933.12	$1,133.12
0.6	3	300	319.68	619.68
0.4	4	400	115.2	515.2
0.3	5	500	12.96	512.96

Multiple Design Alternatives

Spacing (S)	Weight (W)
1	2.39
2	5.78
3	9.17
4	12.56



To introduce optimal design for multiple alternatives, assume that there is another display area configuration under consideration for the display described in the preceding section. The weight in pounds per foot for the alternative configuration is estimated from a linear regression method to be $W = 3.3925S \quad 1.007$. Also, assume that all other factors are the same as for the previous design. For primary flight display, the optimum spacing between indicators is found from equation 3 to be

$$S* = \sqrt{\frac{100}{(3.3925)(240)}}$$

$$= 0.3505 \text{ feet}$$

The lowest cost integer number of indicators is found to be 4 (3 spacing) with a spacing of 0.4 feet. Table 5 summarizes this design by giving the total cost as a function of the number of indicators for each alternative. The theoretical total cost function for each alternative is exhibited in Figure 10 along with an indication of the number of indicators.

Table 2. TFC between two display design alternatives

Number of Indicators	Indicator Cost	Display Area Cost		Total First Cost	
		Analog Instrument Display	Primary Flight Display	Analog Instrument Display	Primary Flight Display
2	$200	$933.12	$882.43	$1,133.12	$1,082.43
3	300	319.68	296.21	619.68	596.21
4	400	115.2	100.8	515.2	500.8
5	500	12.96	3.096	512.96	503.096

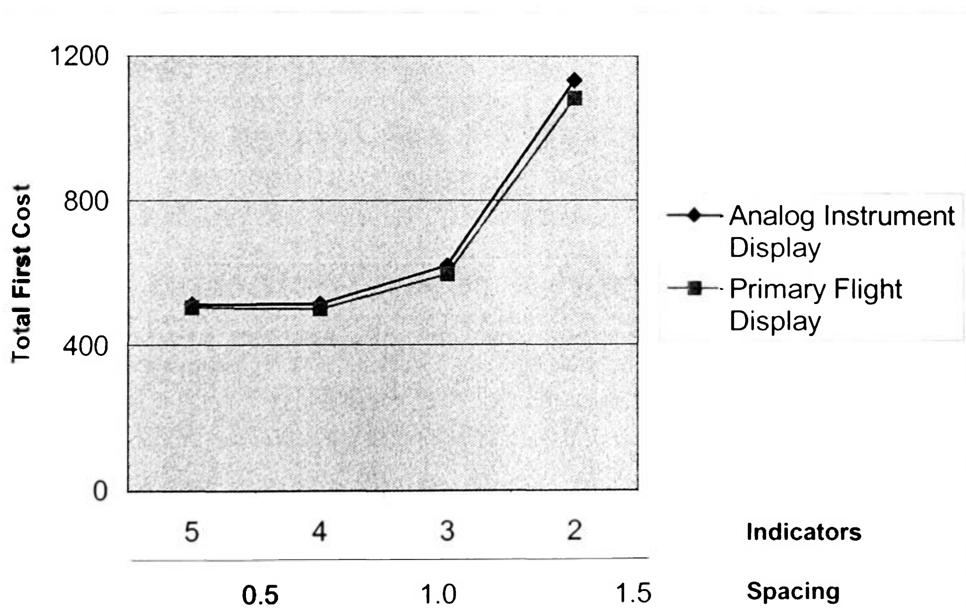


Figure 16. TFC between Two Display Design Alternatives

Optimizing Life-Cycle Cost [9]

The present equivalent life cycle cost (PELCC) as follows:

$$\text{PELCC} = \left[\, 2\sqrt{YC_P L^2 C_D} + ZLC_D + C_P \,\right] + M\left[\left(\frac{P/A, g', n}{(1+g)}\right)\right]$$

n = Anticipated service life of the display unit (years)

M = Maintenance cost of the display unit in the first year

g = Percentage increase in maintenance cost of the display in each subsequent year

Assume that the two display design alternatives differ in the maintenance cost.

Analog instrument display is estimated to cost $2,000 to maintain the first year with a 4 % increase in each subsequent year

Primary flight display will cost $1,500 to maintain in the first year with a 6 % increase in each subsequent year

If the interest rate is 7 %, the PELCC for analog instrument display as a function of its life, n, is

$$\text{PELCC} = \left[\, 2\sqrt{3.55\,(\$100)(1.2)^2(\$240)} + (-1.02)(1.2)(\$240) + \$100 \,\right] + \$2{,}000\left[\left(\frac{P/A, g', n}{(1+0.04)}\right)\right]$$

Where $g' = \left[\dfrac{1+i}{1+g}\right] \; 1$

$$= \left[\frac{1+0.07}{1+0.04}\right] \; 1$$

$$= 0.02885 \text{ or } 2.885\ \%$$

[9] Concept from Blanchard, Benjamin S. and Fabrycky, Walter J. (1998) Systems Engineering and Analysis (3 rd ed., pp 217-218) Prentice Hall Inc.

The PELCC for primary flight display as a function of its life, n, is

$$PELCC = [\ 2\sqrt{3.3925\,(\$100)(1.2)^2(\$240)}\ + (-1.007)(1.2)(\$240) + \$100\ ]$$

$$+\ \$1{,}500\ [\ (\frac{P/\ i,\ g',\ n}{(1 + 0.06)})]$$

Where $g' = [\frac{1+i}{1+g}]\ \ 1$

$$= [\frac{1 + 0.07}{1 + 0.06}]\ \ 1$$

$$= 0.0094 \text{ or } 0.94\ \%$$

Assume that a service life (n) is 25 years, the present equivalent cost for analog instrument display is

$$PELCC = \$506.777 + \$2{,}000\ [\ (\frac{\overset{P/A,\ 2.885,\ 25}{17.63}}{1.04})]$$

$$= \$506.777 + \$33{,}903.846$$

$$= \$34{,}410.623$$

A service life (n) is 25 years, the present equivalent cost for primary flight display is

$$PELCC = \$494.804 + \$1{,}500\ [\ (\frac{\overset{P/A,\ 0.94,\ 25}{22.18}}{1.06})]$$

$$= \$494.804 + \$31{,}386.792$$

$$= \$31{,}881.596$$

From the results, the primary flight display is the best alternative.

APPENDIX L

AGATE PFD CONCEPTUAL DESIGN DOCUMENT

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AGATE PRIMARY FLIGHT DISPLAY (PFD)

Conceptual Design

Final Copy
Version 1.0

UNGUL LAPTANED

EFFECTIVE DATE:
November 01, 1999

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The AGATE primary flight display (PFD) is a multicolor liquid crystal display (LCD), which provides flight path information as well as aircraft control information such as power setting aircraft attitude, aircraft heading, and computer derived flight path. The PFD also provides a perspective image of terrain/obstructions, weather, and traffic in the form of aircraft to greatly increase the pilot's situational awareness. In addition, the PFD provides flight control system mode annunciation, autopilot mode annunciation, attitude source annunciation, decision height annunciation, and radar altitude.

The AGATE PFD system is composed from the Small Aircraft Transportation System (SATS), AGATE aircraft system, fuselage/cabin system, integrated cockpit information system (ICIS), and PFD as shown in Figure 1-1. The PFD consists of fourteen operational requirements, which are decomposed into intended functions and smaller sub-functions. These functions interact with each other through the functional interface. The top-level functions and lower-level functions are allocated to a resource such as hardware, software, or human. The purpose of resource allocation is to perform its intended function at the levels of performance required. The decomposition of those functions is complete when additional decomposition cannot be achieved.

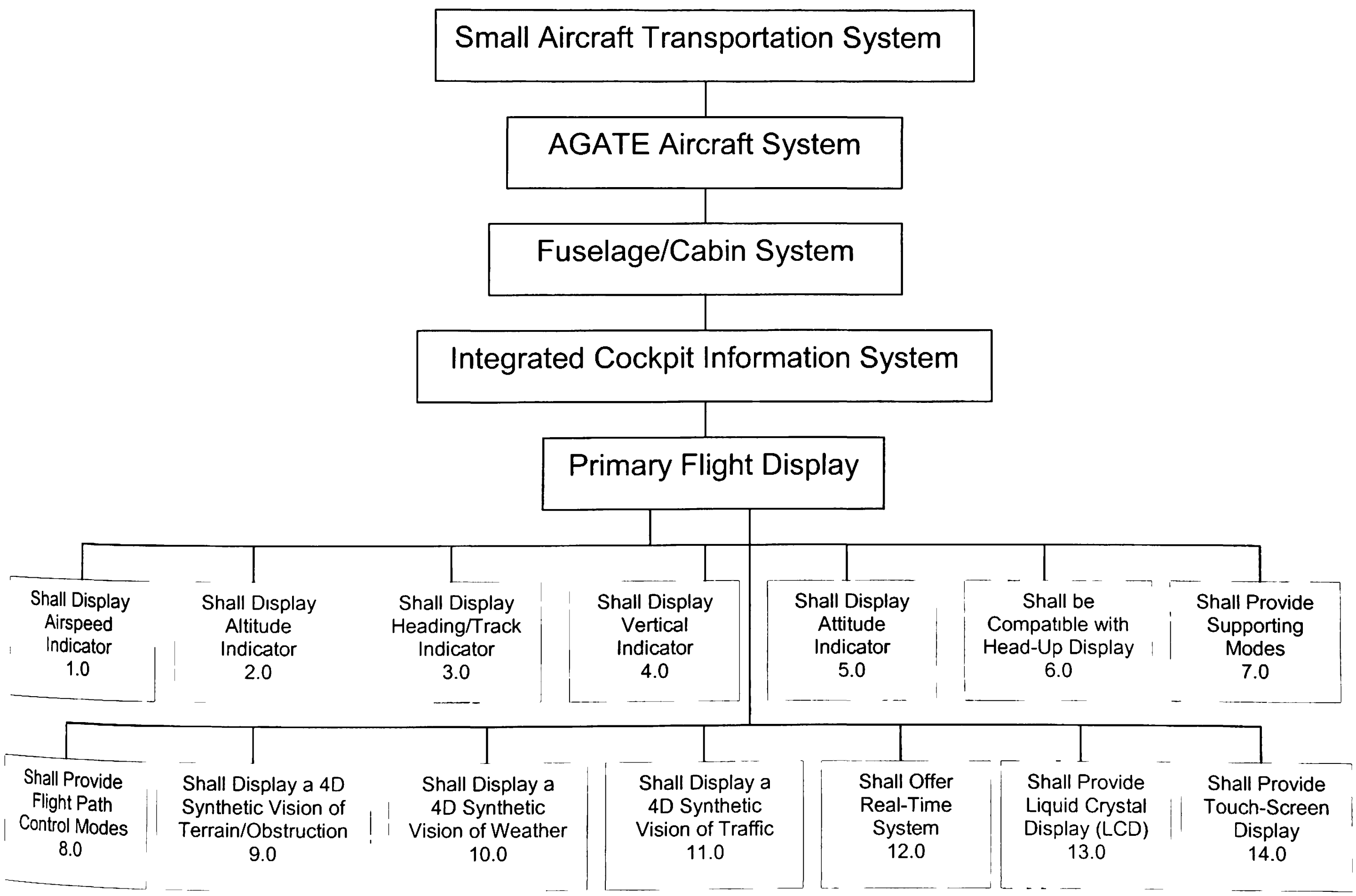


Figure 1.0 AGATE PFD Top-Level Requirements Hierarchy

This section includes the pictorial design of the PFD screen as follows: the conceptual PFD, Aquilas II LCD PFD, VFR conditions display, IFR conditions display, follow me boxes, and highway in the sky. The concept of requirements and functions is derived from these pictures as well as from the current PFD research studies.

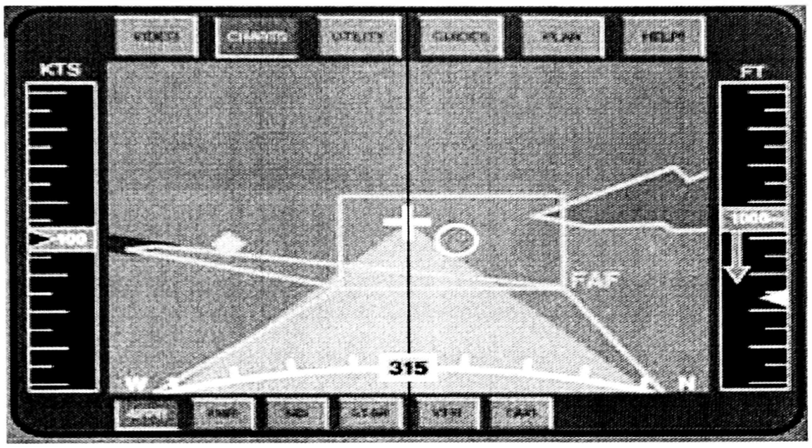


Figure 2.0 Conceptual AGATE PFD

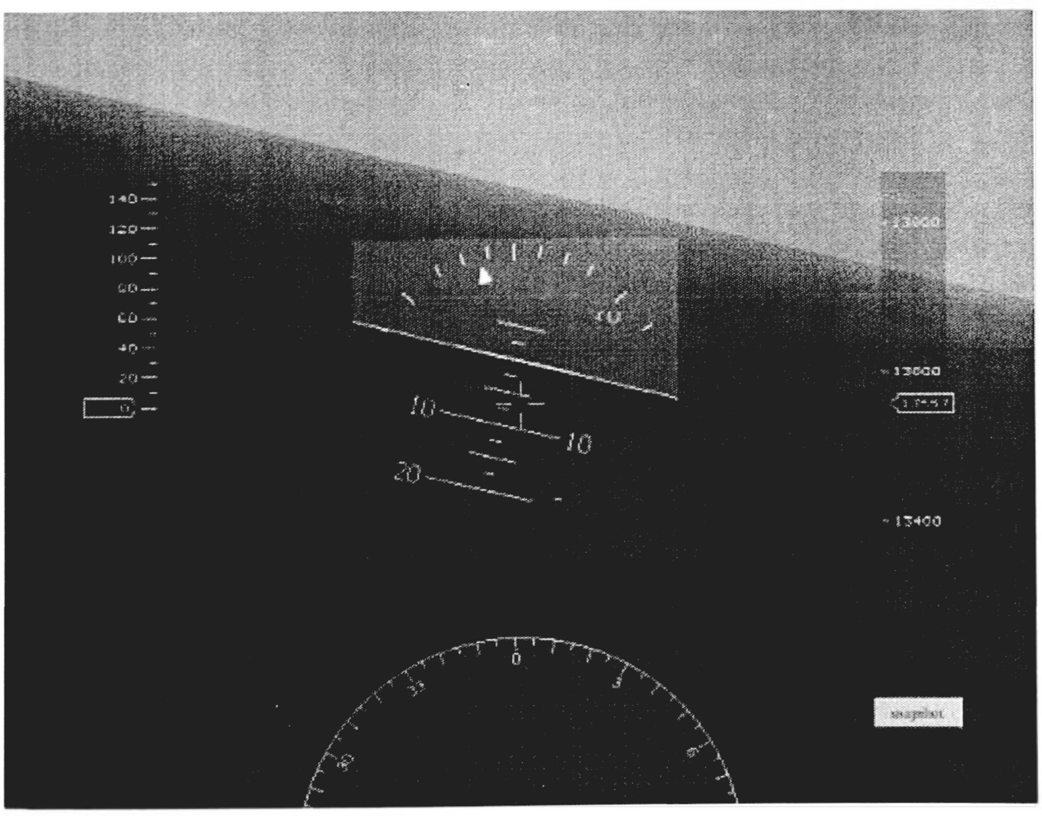


Figure 3.0 Aquilas II LCD PFD

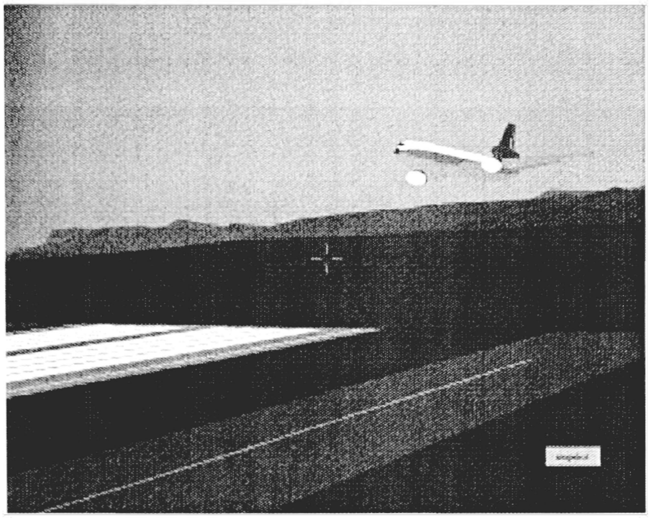


Figure 4.0 VFR Conditions Display

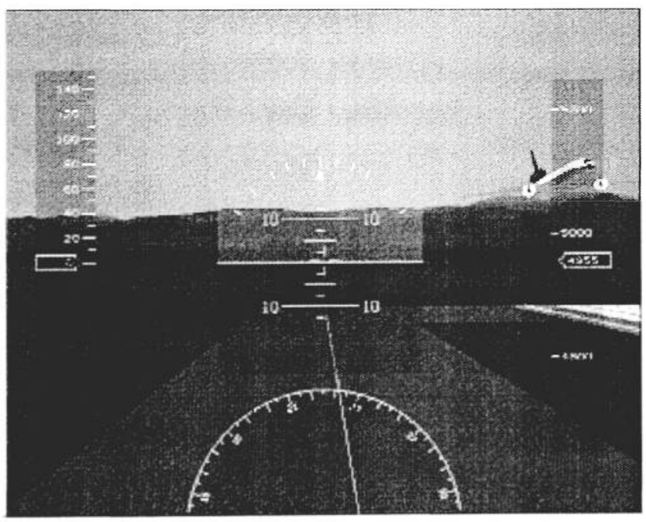


Figure 5.0 IFR Conditions Display

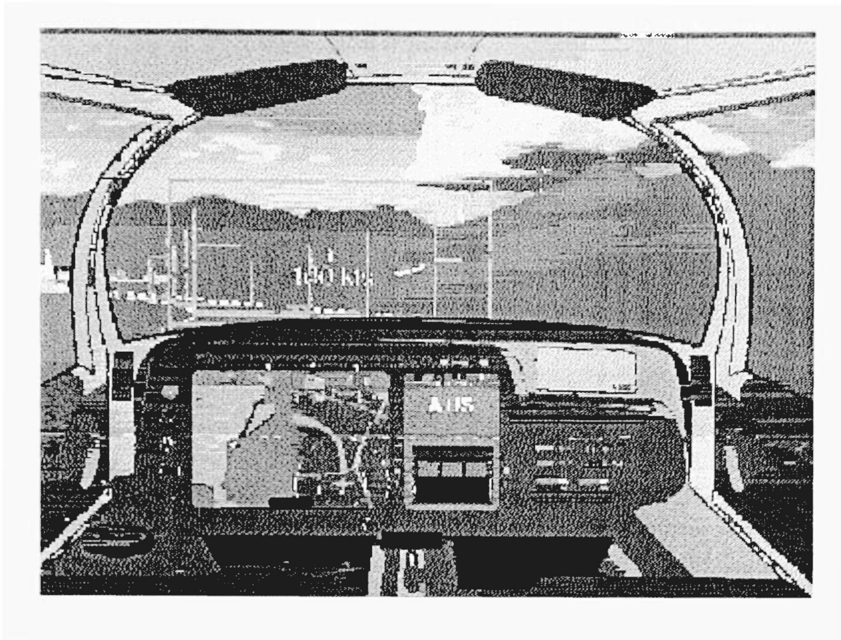


Figure 6.0 Follow Me Boxes

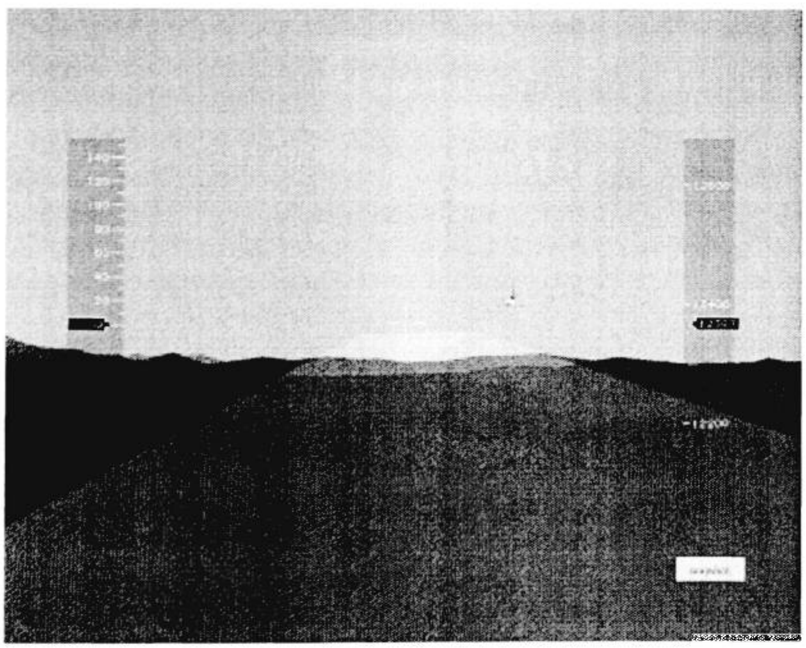


Figure 7.0 Highway in the Sky as seen on PFD

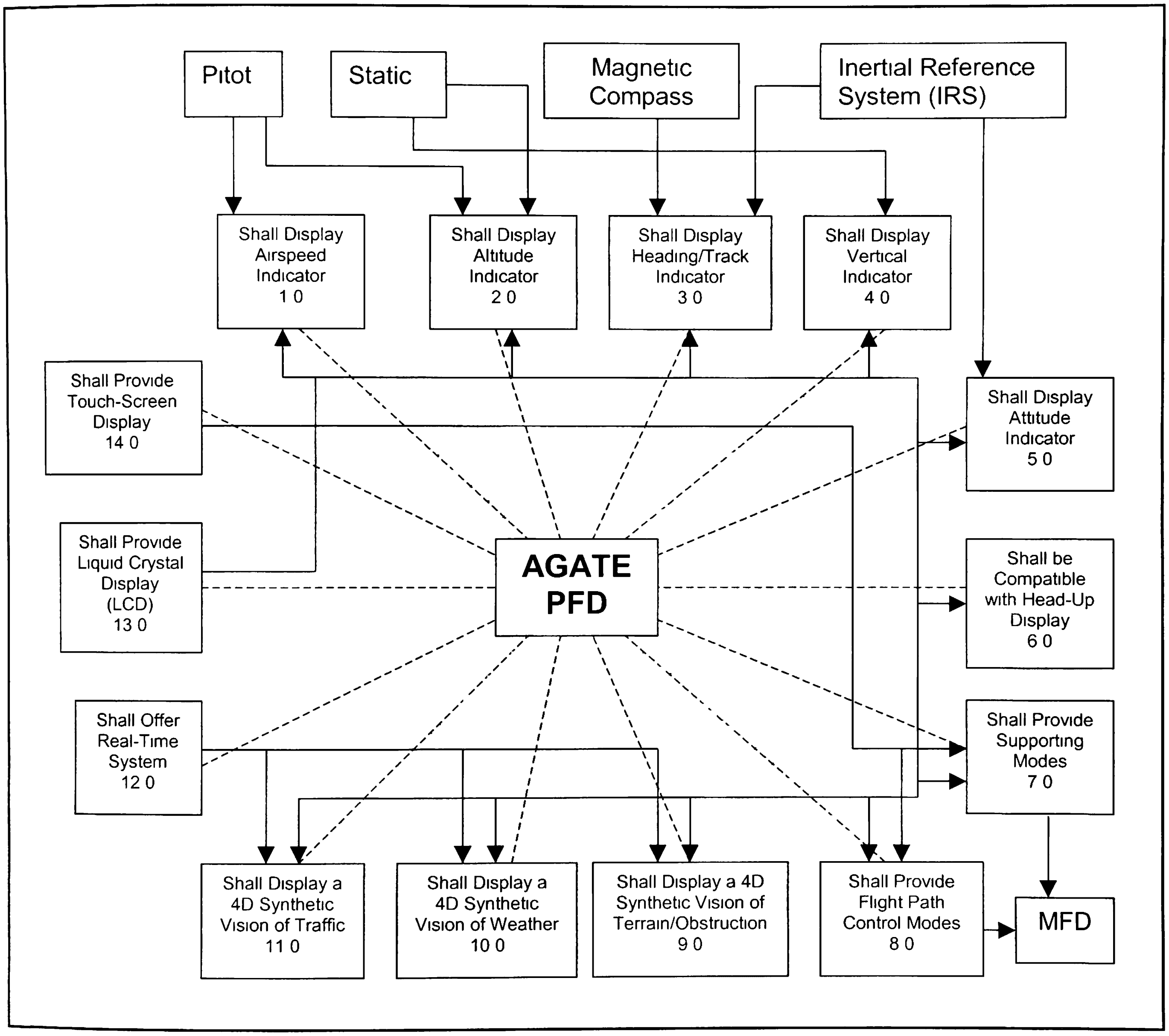


Figure 8 0 AGATE PFD Top-Level Requirements Diagram

ORIGINATING REQUIREMENTS

1.0 The System Shall Display Airspeed Indicator

Requirement Statement:

The airspeed indicator is a pitot-static system instrument that is connected to both the pitot pressure source and the static pressure sources. Pitot pressure is connected to inside of the diaphragm and static pressure to the outside. It measures the difference between these two pressures as indicated airspeed.

Traces To:

Function: 1.1 Display Selected Airspeed
Function: 1.2 Display Current Speed
Function: 1.3 Display Maximum Allowable Airspeed
Function: 1.4 Display Minimum Airspeed
Function: 1.5 Display Maximum/Minimum Maneuvering Speed
Function: 1.6 Display Speed Trend Vector
Function: 1.7 Display Selected Speed
Function: 1.8 Display TAS Digits
Function: 1.9 Display Speed/AOA Error
Function: 1.10 Display Load Factor

2.0 The system Shall Display Altitude Indicator

Requirement Statement:

The altitude indicator or altimeter measures the atmospheric pressure and displays it as altitude in feet. This instrument operates on the aneroid barometer principle and respond to changes in atmospheric pressure. The information provided by an altimeter range from important for Visual Flight Rules (VFR) flying to critical for an instrument approach. As an aircraft climbs though the earth's atmosphere, the pressure decreases. The altimeter detects this reduction in pressure and displays the reading by mechanical or electronic means to the pilot. Prior to takeoff, pilots will set the local altimeter reading (current atmospheric pressure provided by a weather station on the airfield and is measured by inches of mercury (Hg)). This will set the altimeter to the Mean Sea Level (MSL) of the airfield (also referred to as true altitude). Having the current local altimeter setting will provide the correct MSL altitude. After takeoff, if the aircraft is under Instrument Flight Rules (IFR) or radar control, the pilot will use the altimeter to climb to the assigned altitude.

Traces To:

Function: 2.1 Display Selected Altitude
Function: 2.2 Display Altitude Bug
Function: 2.3 Display Current Altitude
Function: 2.4 Display Baromin Pointer

Function: 2.5 Display Altitude Setting
Function: 2.6 Display Radar/Radio Altitude

3.0 The System Shall Display Heading/Track Indicator

Requirement Statement:

The heading and track indicator displays plane heading and track references. The heading indicator uses the principle of rigidity in space for its operation. The Gyro is mounted such that it registers changes around the vertical axis. (i.e., direction changes) Advantages of the heading indicator are its steadiness in turbulence and various aircraft movements and unaffected by turns, acceleration, and deceleration and by turbulence.

Traces To:

Function: 3.1 Display Heading Pointer
Function: 3.2 Display Heading Bug
Function: 3.3 Display Heading/Track Reference
Function: 3.4 Display Selected Heading/Track
Function: 3.5 Display Selected Course
Function: 3.6 Display Ground Track
Function: 3.7 Display Track Line

4.0 The System Shall Display Vertical Speed Indicator

Requirement Statement:

The vertical speed indicator, also known as rate of climb indicator is designed to indicate the rate of attitude change from the change of static pressure alone. Air from the static port enters both the measuring and overpressure diaphragms directly and goes into the case through a diffuser, a very fine calibrated leak when the airplane ascends or descends, the pressure inside the diaphragms changes immediately, while that in the case changes more slowly. This creates a differential pressure, which causes the pointer to more over the dial to indicate the rate of pressure change.

Traces To:

Function: 4.1 Display Vertical Speed Pointer
Function: 4.2 Display Vertical Speed Bug
Function: 4.3 Display Vertical Speed

5.0 The System Shall Display Attitude Indicator

Requirement Statement:

The attitude indicator shows relation about both the longitudinal axis to indicate the degree of bank, and about the lateral axis to indicate pitch (nose up, level, or nose down). If utilizes the rigidity characteristic of the gyro. It is gimbaled to permit about the lateral axis indicating pitch attitude, and about the longitudinal axis to indicate roll attitude.

Traces To:

Function: 5.1 Display Fixed Aircraft Symbol
Function: 5.2 Display Flight Director
Function: 5.3 Display Pitch and Bank Command Bars
Function: 5.4 Display Slip/Skid Indicator (Inclinometer)
Function: 5.5 Display Bank Pointer
Function: 5.6 Display Horizon Line
Function: 5.7 Display Pitch Scale
Function: 5.8 Display V Bar
Function: 5.9 Display Autopilot Indicator

6.0 The System Shall be Compatible with Head-Up Display

Requirement Statement:

The Head-Up Display (HUD) used in the AGATE aircraft represents a development of the conventional Attitude Display Indicator (ADI) or Artificial Horizon. The HUD presents attitude information that is pitch and roll information. This information is projected onto a transparent screen behind the windshield or onto the windshield itself in the pilot's line of sight. It is accompanied by projection of related instrument information (e.g., airspeed, and altitude). The purpose is to allow the pilot to take in information from the HUD instruments without taking eyes off the outside scene. The major concerns with HUD symbology are generating a large amount of display clutter and the use of color. Presentation of symbology on a HUD allows for two advantages: visual scanning and optical techniques. HUD must be integrated into the cockpit. The HUD data should be displayed in a format compatible with Head-Down Instruments. The purpose of compatibility is to facilitate cross checking. The flight procedures and control strategies between HUD and PFD should be compatible. The instrument crosscheck should be considered as well. The HUD and PFD should use the same mode switch and data sources to ensure that they are operating coherently.

Traces To:

Function: 6.1 Display Pitch Ladder
Function: 6.2 Display Flight Director Cue
Function: 6.3 Display Guidance Cue (Follow Me Box)
Function: 6.4 Display Synthetic Runway Cue

Function: 6.5 Display CDM/FPM
Function: 6.6 Display Course Deviation

7.0 The System Shall Provide Supporting Modes

Requirement Statement:

The supporting modes in the AGATE aircraft are perhaps located on the top of the PFD screen. The system configuration is essentially designed to support the PFD flight instrument and its functionality. A pilot is able to manipulate each particular mode through the touch-screen display system.

Traces To:

Function: 7.1 Provide VIDEO Mode
Function: 7.2 Provide CHARTS Mode
Function: 7.3 Provide UTILITY Mode
Function: 7.4 Provide GUIDES Mode
Function: 7.5 Provide PLAN Mode
Function: 7.6 Provide HELPS Mode
Function: 7.7 Provide EMERGENCY Mode

8.0 The System Shall Provide Flight Path Control Modes

Requirement Statement:

The flight path control modes in the AGATE aircraft are perhaps located on the bottom of the PFD screen. The system configuration is essentially designed in controlling a line, course, or track along with an aircraft is flying or tended to be flown. Each mode demonstrates how a pilot navigates an aircraft from or to the airport. A pilot is able to manipulate each particular mode through the touch-screen display system.

Traces To:

Function: 8.1 Provide APPROACH Mode
Function: 8.2 Provide FMS Mode
Function: 8.3 Provide SID Mode
Function: 8.4 Provide STAR Mode
Function: 8.6 Provide TAXI Mode
Function: 8.5 Provide VFR Mode

9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction

Requirement Statement:

The PFD gives a pilot the opportunity to visualize the terrain and other obstacles even in the worst conditions. Any terrain within 1000m of the planned/actual flight path shall be displayed in graphics proximity of terrain and aircraft attitude, which relative to the MEA will be displayed by icon color code, attitude tape mark, etc. Information shall be displayed on a 100-meter resolution map.

Traces To:

Function: 9.1 Display Terrain
Function: 9.2 Display Mountainous Obscuration
Function: 9.3 Display Hidden Obstacles
Function: 9.4 Display Hazard Materials
Function: 9.5 Display Obstruction

10.0 The System Shall Display a 4D Synthetic Vision of Weather

Requirement Statement:

The weather displays shall provide graphical presentation of precipitation, lightning, ceilings & visibility, wind speed & direction, icing potential, turbulence which are being displayed at the current time. All weather displays using color shall demonstrate a legend identifying the color meanings/values on the display.

Traces To:

Function: 10.1 Display Precipitation
Function: 10.2 Display Thunderstorm
Function: 10.3 Display Lightning
Function: 10.4 Display Ceiling
Function: 10.5 Display Visibility
Function: 10.6 Display Wind Speed and Direction
Function: 10.7 Display Surface and Upper Air
Function: 10.8 Display Icing Potential
Function: 10.9 Display Convection
Function: 10.10 Display Turbulence
Function: 10.11 Display Volcanic Ash

11.0 The System Shall Display a 4D Synthetic Vision of Traffic

Requirement Statement:

The traffic is defined as a term used by a controller to transfer radar identification of an aircraft to another controller for the purpose of coordinating separation action. Traffic is normally issued in response to a handoff or point out, in anticipation of a handoff or point out, and in conjunction with a request for control of an aircraft.

Traces To:

Function: 11.1 Display Ground Traffic Flow
Function: 11.2 Display Air Traffic Flow
Function: 11.3 Display Traffic Flow during Approach
Function: 11.4 Display Traffic Conflict Area
Function: 11.5 Display Collision Zones

12.0 The System Shall Offer Real-Time System

Requirement Statement:

The PFD offers real-time updates of both graphical and alphanumeric data. The purpose of real-time updates is to enhance general aviation safety and enable the pilot to perform at a low-end approach. The real-time updates is defined as how often it needs to be updated, such as 1 time per minute or 10 times per minute in accordance with time critical specification of heading to maintain aircraft status or time of low-end approach.

Traces To:

Function: 12.1 Provide Real-Time Hardware
Function: 12.2 Provide Real-Time Operating Systems
Function: 12.3 Provide Real-Time Software
Function: 12.4 Provide Real-Time Database

13.0 The System Shall Provide Liquid Crystal Display (LCD)

Requirement Statement:

The LCD in the AGATE aircraft is used in the Primary Flight Display (PFD) and Multi Function Display (MFD). The structure of a LCD consists of two glass plates coated on their inner surfaces with a thin film of transparent conducting material. The material on the front plate is etched to form the seven segments, each of which forms an electrode. A mirror image is also etched into the oxide coating of the back glass plate. The space between the plates is filled with a liquid crystal compound, and the complete assembly is hermetically sealed with a special thermoplastic material. A LCD may be of either the dynamic-scattering type of the field-effect type. This may produce either a transmissive or reflective read-out. The color effects of LCD can be achieved by the proper placement of color films on the front surface of the display.

Traces To:

Function: 13.1 Provide High Solution
Function: 13.2 Provide Contrast in High Ambient Light
Function: 13.3 Provide High Brightness
Function: 13.4 Provide High Gray Scale
Function: 13.5 Provide High Modulation
Function: 13.6 Provide High Uniformity
Function: 13.7 Provide Wide Viewing Angle
Function: 13.8 Reproduce Photo-Realistic on Display Screen
Function: 13.9 Provide Automatic Blink Symbol/String
Function: 13.10 Provide Discriminatory Shading on Graphics
Function: 13.11 Provide Stable Display in Wide Range of Temperature

14.0 The System Shall Provide Touch-Screen Display

Requirement Statement:

A type of display screen that has a touch-sensitive transparent panel covering the screen. Pilots can use his/her finger to point directly to the functional buttons on the display screen. A touch-screen provides a natural interface for computer novices. The screen registers touch on any area of its display and sets off an action based on that event or trigger. The touch-screen computer uses a low voltage matrix interface on the screen to pinpoint a human touch using X, Y coordinates to set the location that correlates to the graphical interface presented on the computer screen by a program at any preprogrammed location.

Traces To:

Function: 14.1 Provide Forward-Backward Capability
Function: 14.2 Separate Critical Markers
Function: 14.3 Provide Protection of Finger Oils
Function: 14.4 Provide Adequate Spacing between Markers
Function: 14.5 Provide Rapid Response to Specific Pressure
Function: 14.6 Provide Touch Sensitive Panel

REQUIREMENTS CRITERIA

Criteria	*Unit*

Requirement 1.0

Display size	inches, cm
Display weight	ounces/lbs
Display area	mm/inches
- Operating temperatures	Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	- unity magnification
- Power requirements	- volt
- Data speed	- bits per second
- Pixel density	- per/inch
Luminance	FL
- Contrast ratio	- ratio
Reflectance	- %
- Storage temperature	- Celcius
Brightness	FL
- Object beam angle	- degrees
- Fault tolerance	- percent dead pixels
- Clutter	- number or variety of symbols
- Symbol Priority	- higher or lower priority symbol

Requirement 2.0

Display size	- inches, cm
Display weight	- ounces/lbs
Display area	mm/inches
- Operating temperatures	Celcius
Vibration	Hz
Essential information field of view	degrees from center of view
Total field of view	degree
Horizontal field of view	degree
Required sight lines	degrees in the vertical
Viewing distance	inches
Information size-distance constancy	unity magnification
Power requirements	volt
- Data speed	bits per second
Pixel density	- per/inch

Luminance	FL
- Contrast ratio	- ratio
Reflectance	- %
Storage temperature	- Celcius
Brightness	FL
- Object beam angle	- degrees
Fault tolerance	- percent dead pixels
- Clutter	- number or variety of symbols
Symbol Priority	higher or lower priority symbol

Requirement 3.0

Display size	- inches, cm
Display weight	- ounces/lbs
Display area	- mm/inches
- Operating temperatures	- Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	unity magnification
- Power requirements	volt
Data speed	bits per second
Pixel density	- per/inch
Luminance	FL
- Contrast ratio	- ratio
Reflectance	- %
- Storage temperature	- Celcius
Brightness	FL
- Object beam angle	- degrees
Fault tolerance	- percent dead pixels
- Clutter	- number or variety of symbols
- Symbol Priority	higher or lower priority symbol

Requirement 4.0

Display size	- inches, cm
- Display weight	- ounces/lbs
- Display area	- mm/inches
Operating temperatures	- Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree

Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	- unity magnification
Power requirements	- volt
Data speed	- bits per second
Pixel density	- per/inch
Luminance	FL
Contrast ratio	- ratio
Reflectance	- %
- Storage temperature	- Celcius
Brightness	FL
- Object beam angle	- degrees
Fault tolerance	- percent dead pixels
- Clutter	- number or variety of symbols
- Symbol Priority	- higher or lower priority symbol

Requirement 5.0

Display size	- inches, cm
Display weight	- ounces/lbs
Display area	- mm/inches
- Operating temperatures	- Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	- unity magnification
Power requirements	volt
Data speed	- bits per second
Pixel density	- per/inch
Luminance	FL
- Contrast ratio	- ratio
Reflectance	%
- Storage temperature	Celcius
Brightness	FL
- Object beam angle	degrees
Fault tolerance	- percent dead pixels
Clutter	- number or variety of symbols
Symbol Priority	higher or lower priority symbol

Requirement 6.0

Display size	- inches, cm
Display weight	- ounces/lbs

Display area	- mm/inches
Operating temperatures	- Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	- unity magnification
Power requirements	- volt
Data speed	bits per second
Pixel density	- per/inch
Luminance	FL
Contrast ratio	- ratio
Reflectance	- %
- Storage temperature	- Celcius
Brightness	FL
- Object beam angle	- degrees
Fault tolerance	- percent dead pixels
- Clutter	- number or variety of symbols
Symbol Priority	higher or lower priority symbol

Requirement 7.0

Display size	- inches, cm
Display weight	- ounces/lbs
Display area	- mm/inches
- Operating temperatures	Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	- unity magnification
Power requirements	- volt
Data speed	bits per second
Pixel density	- per/inch
Luminance	FL
- Contrast ratio	- ratio
Reflectance	%
- Storage temperature	- Celcius
Brightness	FL
- Object beam angle	degrees
Fault tolerance	- percent dead pixels
Interchangeability	Interchangeable modes

Requirement 8.0

Display size	inches, cm
Display weight	ounces/lbs
Display area	mm/inches
- Operating temperatures	- Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	- unity magnification
Power requirements	- volt
Data speed	bits per second
Pixel density	- per/inch
Luminance	FL
- Contrast ratio	- ratio
Reflectance	- %
- Storage temperature	- Celcius
Brightness	FL
- Object beam angle	- degrees
Fault tolerance	- percent dead pixels
Interchangeability	Interchangeable modes

Requirement 9.0

Display size	inches, cm
Display weight	ounces/lbs
Display area	- mm/inches
- Operating temperatures	Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	- unity magnification
Power requirements	- volt
Data speed	- bits per second
Refresh rate	Hz
Pixel density	- per/inch
Luminance	FL
- Contrast ratio	- ratio
Reflectance	- %
- Storage temperature	- Celcius

IFOV	- degrees
Fault tolerance	- percent dead pixels
3D rendering	triangles per second/pixels
- 3D renderer performance	- milliseconds and fps

Requirement 10.0

Display size	- inches, cm
Display weight	- ounces/lbs
Display area	- mm/inches
Operating temperatures	- Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	- unity magnification
Power requirements	- volt
Data speed	bits per second
Refresh rate	Hz
Pixel density	- per/inch
Luminance	FL
- Contrast ratio	- ratio
Reflectance	- %
Storage temperature	- Celcius
IFOV	- degrees
Fault tolerance	- percent dead pixels
3D rendering	- triangles per second/pixels
3D renderer performance	- milliseconds and fps

Requirement 11.0

Display size	- inches, cm
Display weight	- ounces/lbs
Display area	- mm/inches
- Operating temperatures	- Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	inches
Information size-distance constancy	- unity magnification
Power requirements	volt
Data speed	bits per second

Refresh rate	Hz
Pixel density	- per/inch
Luminance	FL
Contrast ratio	- ratio
Reflectance	%
- Storage temperature	- Celcius
IFOV	- degrees
Fault tolerance	- percent dead pixels
- 3D rendering	- triangles per second/pixels
3D renderer performance	- milliseconds and fps

Requirement 12.0

Refresh rate	Hz
Update rates	- ms
Data speed	bits per second
Power requirements	volt
- Storage temperature	Celcius
- Operating temperatures	Celcius

Requirement 13.0

- Display size	- inches, cm
- Display weight	- ounces/lbs
Display area	mm/inches
- Operating temperatures	- Celcius
Vibration	Hz
Power requirements	- volt
Data speed	- bits per second
Refresh rate	Hz
Pixel density	- per/inch
Luminance	FL
- Contrast ratio	- ratio
Reflectance	%
- Storage temperature	- Celcius
LCD and backlight power	- watts/VDC
LCD and Backlight heater power	- watts/VDC
Accuracy	- mrad
Brightness	FL
Fault tolerance	- percent dead pixels
EMI	level of electric and magnetic field
- Cooling requirements	Fahrenheit or Celcius
Warm-up time	second

Requirement 14.0

Display size	- inches, cm
Display weight	- ounces/lbs
Display area	- mm/inches
- Operating temperatures	- Celcius
Vibration	Hz
Essential information field of view	- degrees from center of view
Total field of view	- degree
Horizontal field of view	- degree
Required sight lines	- degrees in the vertical
Viewing distance	- inches
Information size-distance constancy	unity magnification
Power requirements	- volt
Data speed	bits per second
Pixel density	- per/inch
Luminance	FL
Contrast ratio	- ratio
Reflectance	%
- Storage temperature	- Celcius
Brightness	FL
- Object beam angle	- degrees
Fault tolerance	- percent dead pixels

REQUIREMENTS TRACEABILITY MATRIX

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
1.0 THE SYSTEM SHALL DISPLAY AIRSPEED INDICATOR			AIAA p 17– p 19
1 1 Display Selected Airspeed	SW	Display a digital selected airspeed symbol on the electronic airspeed indicator	Boeing 777 Web page
1 2 Display Current Airspeed	SW	Display a digital current airspeed symbol on the electronic airspeed indicator	Boeing 777 Web page
1 3 Display Maximum Allowable Airspeed	SW	Display a digital maximum allowable airspeed symbol on the electronic airspeed indicator	AIS p 11 – p 12
1 4 Display Minimum Airspeed	SW	Display a digital minimum airspeed symbol on the electronic airspeed indicator	Boeing 777 Web page
1 5 Display Maximum/Minimum Maneuvering Airspeed	SW	Display a digital maximum/minimum maneuvering airspeed symbol on the electronic airspeed indicator	Boeing 777 Web page
1 6 Display Speed Trend Vector	SW	Display a digital speed trend vector symbol on the electronic airspeed indicator	Boeing 777 Web page
1 7 Display Selected Speed	SW	Display a digital selected speed symbol on the electronic airspeed indicator	Boeing 777 Web page
1 8 Display TAS Digits	SW	Display a digital TAS digits symbol on the electronic airspeed indicator	Boeing 777 Web page

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
1 9 Display Speed/AOA Error	SW	Display a digital speed/AOA error symbol on the electronic airspeed indicator	HUD p 96
1 10 Display Load Factor	SW	Display a digital load factor symbol on the electronic airspeed indicator	HUD p 95
2.0 THE SYSTEM SHALL DISPLAY ALTITUDE INDICATOR			AIAA p 14 – p 15
2 1 Display Selected Altitude	SW	Display a digital selected altitude symbol on the electronic altitude indicator	AIS p 7
2 2 Display Altitude Bug	SW	Display a digital altitude bug symbol on the electronic altitude indicator	Boeing 777 Web page
2 3 Display Current Altitude	SW	Display a digital current altitude symbol on the electronic altitude indicator	Boeing 777 Web page
2 4 Display Baromin Pointer	SW	Display a digital baromin pointer symbol on the electronic altitude indicator	Boeing 777 Web page
2 5 Display Altitude Setting	SW	Display a digital altitude setting symbol on the electronic altitude indicator	AIM/FAR 1999 p 290
2 6 Display Radar/Radio Altitude	SW	Display a digital radar/radio altitude symbol on the electronic altitude indicator	AIAA p 141

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
3.0 THE SYSTEM SHALL DISPLAY HEADING/TRACK INDICATOR			Geocities Web page
3 1 Display Heading Pointer	SW	Display a digital heading pointer symbol on the electronic heading/track indicator	Boeing 777 Web page
3 2 Display Heading Bug	SW	Display a digital heading bug symbol on the electronic heading/track indicator	Boeing 777 Web page
3 3 Display Track Line	SW	Display a digital track line symbol on the electronic heading/track indicator	Boeing 777 Web page
3 4 Display Heading/Track Reference	SW	Display a digital heading/track reference symbol on the electronic heading/track indicator	Boeing 777 Web page
3 4 1 Display Magnetic North	SW	Display a digital magnetic north on the heading/track reference	AGN p 332
3 4 2 Display True North	SW	Display a digital true north on the heading/track reference	AGN p 334
3 5 Display Selected Heading/Track	SW	Display a digital selected heading/track symbol on the heading/track indicator	Boeing 777 Web page

Requirements/Functions	**Proposed Allocation HW/SW/HU**	**Allocation Discussion**	**References**
3 6 Dısplay Selected Course	SW	Dısplay a dıgıtal selected course symbol on the electronıc headıng/track ındıcator	AGN p 330
3 7 Dısplay Ground Track	SW	Dısplay a dıgıtal ground track symbol on the electronıc headıng/track ındıcator	AGN p 334
4.0 THE SYSTEM SHALL DISPLAY VERTICAL SPEED INDICATOR			AI p 99, AIS p 14
4 1 Dısplay Vertıcal Speed Poınter	SW	Dısplay a dıgıtal vertıcal speed poınter symbol on the electronıc vertıcal speed ındıcator	Boeıng 777 Web page
4 2 Dısplay Vertıcal Speed Bug	SW	Dısplay a dıgıtal vertıcal speed bug symbol on the electronıc vertıcal speed ındıcator	Boeıng 777 Web page
4 3 Dısplay Vertıcal Speed	SW	Dısplay a dıgıtal vertıcal speed symbol on the electronıc vertıcal speed ındıcator	Boeıng 777 Web page

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
5.0 THE SYSTEM SHALL DISPLAY ATTITUDE INDICATOR			Geocities Web page
5 1 Display Fixed Aircraft Symbol	SW	Display a digital fixed aircraft symbol on the electronic attitude indicator	AK P 107-108
5 2 Display Flight Director	SW	Display a digital flight director symbol on the electronic attitude indicator	Allstar Network Web page
5 3 Display Pitch and Bank Command Bars	SW	Display a digital pitch and bank command bars symbol on the electronic attitude indicator	Allstar Network Web page
5 4 Display Slip/Skid Indicator	SW	Display a digital slip/slid indicator on the electronic attitude indicator	AK p 102-103
5 5 Display Bank Pointer	SW	Display a digital bank pointer symbol on the electronic attitude indicator	Boeing 777 Web page
5 6 Display Horizon Line	SW	Display a digital horizon line symbol on the electronic attitude indicator	Boeing 777 Web page
5 7 Display Pitch Scale	SW	Display a digital pitch scale symbol on the electronic attitude indicator	Boeing 777 Web page
5 8 Display V Bar	SW	Display a digital V bar symbol on the electronic attitude indicator	UL

Requirements/Functions	**Proposed Allocation HW/SW/HU**	**Allocation Discussion**	**References**
5 9 Display Autopilot Indicator	SW	Display a digital autopilot indicator on the electronic attitude indicator	Boeing 777 Web page
6.0 THE SYSTEM SHALL BE COMPATIBLE WITH HEAD-UP DISPLAY			HUD p 218
6 1 Display Pitch Ladder	SW	Display a digital pitch ladder symbol on the electronic primary flight display	HUD p 237, p 89 – p 91
6 2 Display Flight Director Cue	SW	Display a digital flight director cue symbol on the electronic primary flight display	HUD p 114
6 3 Display Guidance Cue (Follows Me Box)	SW	Display a digital guidance cue symbol on the electronic primary flight display	HUD p 111, 114
6 4 Display Synthetic Runway Cue	SW	Display a digital synthetic runway cue symbol on the electronic primary flight display	HUD p 115
6 5 Display CDM/FPM	SW	Display a digital CDM/FPM symbol on the electronic primary flight display	HUD p 134
6 6 Display Course Deviation	SW	Display a digital course deviation symbol on the electronic primary flight display	HUD p 234

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
7.0 THE SYSTEM SHALL PROVIDE SUPPORTING MODES			UL
7 1 Provide VIDEO Mode	SW	Display an electronic video map on the MFD screen	AIM/FAR 1999 p 345
7 2 Provide CHARTS Mode	SW	Display electronic charts on the MFD screen	UL
7.2.1 Provide Instrument Approach Procedure Chart	SW	Display an electronic instrument approach procedure chart on the MFD screen	AIM/FAR 1999 p 314
7.2.2 Provide SMGCS Chart	SW	Display an electronic SMGCS chart on the MFD screen	AIM/FAR 1998 p 275
7.2.3 Provide SID Chart	SW	Display an electronic SID chart on the MFD screen	AIM/FAR 1998 p 273, 274
7.2.4 Provide STAR Chart	SW	Display an electronic STAR chart on the MFD screen	AIM/FAR 1998 p 275, 282
7.2.5 Provide VFR Terminal Chart	SW	Display an electronic VFR terminal chart on the MFD screen	AIM/FAR 1999 p 285
7.2.6 Provide Airport Taxi Chart	SW	Display an electronic airport taxi chart on the MFD screen	AIM/FAR 1999 p. 286
7 3 Provide UTILITY Mode	HW/SW		UL
7.3.1 Provide Reversionary/Back Up Mode	HW	The reversionary and back up system of the PFD	PFD – ER Labs
7.3 2 Provide Mode Interchange (PFD/MFD)	HW	The interchangeable switch between PFD and MFD	UL
7.3.3 Provide Mode Interchange (PFD/HUD)	HW	The interchangeable switch between PFD and HUD	UL

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
7.3 4 Implement Testing	SW	The testing software program is provided for a pilot to test the entire system	AIM/FAR 1998 p 304
7 3 5 Run Simulation	SW	The simulation software program is capable of simulating the flight operations	The Concise Oxford Dictionary of Current English
7 4 Provide GUIDES Mode	SW	Display electronic instructions on the MFD screen	UL
7 4.1 Demonstrate Aircraft Instrument Indicators Instruction	SW	Display electronic aircraft instrument indicators instructions on the MFD screen	UL
7 4.2 Demonstrate Terrain Display Instruction	SW	Display electronic terrain display instructions on the MFD screen	UL
7.4 3 Demonstrate Weather Display Instruction	SW	Display electronic weather display instructions on the MFD screen	UL
7.4 4 Demonstrate Traffic Display Instruction	SW	Display electronic traffic display instructions on the MFD screen	UL
7 5 Provide PLAN Mode	SW	Display planning of the flight rules on the MFD screen	AIM/FAR 1998 p 476
7.5.1 Demonstrate IFR Planning	SW	Display planning of the instrument flight rules on the MFD screen	AIM/FAR 1998 p 476 – p 480
7.5.2 Demonstrate VFR Planning	SW	Display planning of the visual flight rules on the MFD screen	AIM/FAR 1998 p 474 – p 475
7 6 Provide HELPS Mode	SW	Display information necessary for the basic guidance	UL

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
7 7 Provide EMERGENCY Mode	HW/SW	The back up system is used in case of the main system failed The purpose is to increase safety and reliability	AK p 392
7 7 1 Supply Alternate Power	HW	The alternate power unit is used in case of the main system failed	PFD – ER Labs
7 7 2 Supply Aircraft Master Caution/ Master Warning	HW	The master caution/warning unit is used in case of emergency	PFD – ER Labs
7 7 3 Supply Alternate Memory	SW	The alternate memory unit is used in case of the main system failure	PFD – ER Labs
8.0 THE SYSTEM SHALL PROVIDE FLIGHT PATH CONTROL MODES			AIM/FAR 1999 P 310
8 1 Provide APPROACH Mode	SW	Display an electronic instrument approach on the MFD screen	AIM/FAR 1999 p 291
8 1 1 Demonstrate Initial Approach	SW	Display an electronic initial approach on the MFD screen	AIM/FAR 1999 p 291
8 1 2 Demonstrate Intermediate Approach	SW	Display an electronic intermediate approach on the MFD Screen	AIM/FAR 1999 p 291
8 1 3 Demonstrate Final Approach	SW	Display an electronic final approach on the MFD screen	AIM/FAR 1999 p 291
8 1 4 Demonstrate Missed Approach	SW	Display an electronic missed approach on the MFD screen	AIM/FAR 1999 p 291
8 2 Provide FMS Mode	HW/SW	Integrate all display units and flight navigation system	AGATE C 2 1 5 1, p 41
8 3 Provide SID Mode	SW	Display an electronic departure procedure on the MFD screen	AIM/FAR 1999 p 337

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
8.3.1 Demonstrate Pilot Navigation SIDs	SW	Display a pilot navigation SID procedure on the MFD screen	AIM/FAR 1998 p 158
8.3.2 Demonstrate Vector SIDs	SW	Display a vector SID procedure on the MFD screen	AIM/FAR 1998 p 158
8 4 Provide STAR Mode	SW	Display an electronic arrival procedure on the MFD screen	AIM/FAR 1999 p 337
8.4.1 Demonstrate Descend Via (Lateral/Vertical Navigation)	SW	Display a lateral/vertical navigation procedure on the MFD screen	AIM/FAR 1998 p 166 – p 167
8.4.2 Demonstrate Descend Via (Vertical Navigation)	SW	Display a vertical navigation procedure on the MFD screen	AIM/FAR 1998 p 167
8 5 Provide VFR Mode	SW	Provide a pilot to change from IFR to VFR	AIM/FAR 1999 p. 344, AW p D-21, AIAA p 200
8.5.1 Demonstrate MVFR	SW	An electronic marginal VFR information	AIM/FAR 1999 p. 344
8 5.2 Demonstrate VFR	SW	An electronic VFR information	AIM/FAR 1999 p 344
8 6 Provide TAXI Mode	SW	Display an electronic taxi way relative to the aircraft's position	AIM/FAR 1999 p 339
8.6.1 Demonstrate Taxi prior to Departure	SW	Display taxi prior to departure relative to the aircraft's position	AIM/FAR 1998 p 126 – p 127
8.6.2 Demonstrate Taxi after Landing	SW	Display taxi after landing relative to the aircraft's position	AIM/FAR 1998 p 126 – p 127

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
9.0 THE SYSTEM SHALL DISPLAY A 4D SYNTHETIC VISION OF TERRAIN/ OBSTRUCTION			AGATE TRD 3 2 4 4, p 90
9 1 Display Terrain	SW	Display an electronic enhanced vision or out of the window of the terrain display	AW p 177
9 2 Display Mountainous Obscuration	SW	Display an electronic enhanced vision or out of the window of the mountainous obscuration display	AW p D-13
9 3 Display Hidden Obstacles	SW	Display an electronic enhanced vision or out of the window of the hidden obstacles display	AIM/FAR 1999 p 324
9 4 Display Hazard Materials	SW	Display an electronic enhanced vision or out of the window of the hazard materials display	PFD ER Labs
9 5 Display Obstruction	SW	Display an electronic enhanced vision or out of the window of the obstruction display	AK p 177
10.0 THE SYSTEM SHALL DISPLAY A 4D SYNTHETIC VISION OF WEATHER			AGATE TRD 3 2 6 1, p 23
10 1 Display Precipitation	SW	Display an electronic enhanced vision or out of the window of the precipitation display	AK p 190, AIM/FAR 1999 p 327
10 2 Display Thunderstorm	SW	Display an electronic enhanced vision or out of the window of the thunderstorm display	AW p 9-10, p 9-18

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
10 3 Display Lightning	SW	Display an electronic enhanced vision or out of the window of the lightning display	AW p 9-10, p 9-18
10 4 Display Ceiling	SW	Display an electronic enhanced vision or out of the window of the ceiling display	AK P 190
10 5 Display Visibility	SW	Display an electronic enhanced vision or out of the window of the visibility display	AK P 190
10 5 1 Display Flight Visibility	SW	Display an electronic enhanced vision or out of the window of the flight visibility display	AIM/FAR 1998 p 341
10 5 2 Display Ground Visibility	SW	Display an electronic enhanced vision or out of the window of the ground visibility display	AIM/FAR 1998 p 341
10 5 3 Display RVR	SW	Display an electronic enhanced vision or out of the window of the RVR display	AIM/FAR 1998 p 341
10 6 Display Wind Speed and Direction	SW	Display an electronic enhanced vision or out of the window of the wind speed and direction display	AW p 4-2
10 7 Display Surface and Upper Air	SW	Display an electronic enhanced vision or out of the window of the surface and upper air display	AW p 19, 21

Requirements/Functions	**Proposed Allocation HW/SW/HU**	**Allocation Discussion**	**References**
10 8 Display Icing Potential	SW	Display an electronic enhanced vision or out of the window of the icing potential display	AGATE C 5 3 2 7, p 90
10 8 1 Display Structure Icing	SW	Display an electronic enhanced vision or out of the window of the structure icing display	AW p 13 2 – p 13 4
10 8 2 Display Induction Icing	SW	Display an electronic enhanced vision or out of the window of the induction icing display	AW p 13 2 – p 13 4
10 9 Display Convection	SW	Display an electronic enhanced vision or out of the window of the convection display	AK p 174 – p 175
10 10 Display Turbulence	SW	Display an electronic enhanced vision or out of the window of the turbulence display	AGATE C 5 3 2 6, p 90
10 11 Display Volcanic Ash	SW	Display an electronic enhanced vision or out of the window of the volcanic ash display	AIM/FAR 1999 p 260

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
11 3 Display Traffic Flow during Approach	SW	Display an electronic enhanced vision or out of the window of the traffic flow during approach display	AIM/FAR 1999 p 338
11.3.1 Display Upwind Leg Approach	SW	Display an electronic enhanced vision or out of the window of the upwind leg	AIM/FAR 1999 p 338
11.3.2 Display Crosswind Leg Approach	SW	Display an electronic enhanced vision or out of the window of the crosswind leg	AIM/FAR 1999 p 338
11.3 3 Display Base Leg Approach	SW	Display an electronic enhanced vision or out of the window of the base leg	AIM/FAR 1999 p 338
11 3 4 Display Final Approach	SW	Display an electronic enhanced vision or out of the window of the final approach	AIM/FAR 1999 p 338
11 4 Display Traffic Conflict Area	SW	Display an electronic enhanced vision or out of the window of the traffic conflict area display	AIM/FAR 1998 p 74, 253
11 5 Display Collision Zones	SW	Display an electronic enhanced vision or out of the window of the collision zones display	AIM/FAR 1998 p 83

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
12.0 THE SYSTEM SHALL OFFER REAL-TIME SYSTEM			PFD ER Labs
12 1 Provide Real-Time Hardware	HW	The hardware components of a real-time system	RTS p 1, 2
12 2 Provide Real-Time Operating Systems	SW	The operating systems program of a real-time system	RTS p 69
12 3 Provide Real-Time Software	SW	The software program of a real-time system	RTS p 121, 122
12 4 Provide Real-Time Database	SW	The database of a real-time System	RTS p 198, 199
12 4 1 Provide Terrain/Obstruction Database	SW	The terrain/obstruction database of a real-time system	AGATE C 1 3 3 2, p 54
12 4 2 Provide Weather Database	SW	The weather database of a real-time system	AGATE C 1 3 3 2, p 54
12 4 3 Provide Traffic Database	SW	The traffic database of a real-time system	AGATE C 1 3 3 2, p 54
13.0 THE SYSTEM SHALL PROVIDE LIQUID CRYSTAL DISPLAY (LCD)			CD II, CD III
13 1 Provide High Resolution	HW/SW	Review highly detailed information of the LCD screen	CD III p 188
13 2 Provide Contrast in High Ambient Light	HW/SW	Provide the maximum contrast ratio	CD III p 188
13 3 Provide High Brightness	HW/SW	Display high magnitude of the subjective sensation	CD III p 188
13 4 Provide High Gray Scale	HW/SW	Depict high variations in gray level	CD III p 188

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
13 5 Provide High Modulation	HW/SW	Measure vertical bars	CD III p 188
13 6 Provide High Uniformity	HW/SW	The LCD backlight uniformity	CD III p 54
13 7 Provide Wide Viewing Angle	HW/SW	Enable a wide angle view	PFD ER Labs
13 8 Reproduce Photo-Realistic on Display Screen	HW/SW	Display photo-realistic on the PFD screen	PFD ER Labs
13 9 Provide Automatic Blink Symbol/String	HW/SW	The symbol and string should be self-automatic blinking	SDSCA p 54 – p 55
13 10 Provide Discriminatory Shading on Graphics	HW/SW	Distinguish between objects on display	PFD ER Labs
13 11 Provide Stable Display in Wide Range of Temperature	HW/SW	The display will be stable constantly to internal and external temperature changes during normal flight operations	CD III p 306
14.0 THE SYSTEM SHALL PROVIDE TOUCH-SCREEN DISPLAY			PFD ER Labs
14 1 Provide Forward-Backward Capability	HW	Aid a pilot to operate the display panel easily	PFD ER Labs
14 2 Separate Critical Markers	SW	Each marker is greatly separated from each other, which essential for a pilot to perceive an Image clearly	PFD ER Labs
14 3 Provide Protection of Finger Oils	HW	The display panel is designed to protect oils to eliminate display errors	PFD ER Labs

Requirements/Functions	Proposed Allocation HW/SW/HU	Allocation Discussion	References
14 4 Provide Adequate Spacing between Markers	SW	Provide enough spacing to be distinguished from each marker	PFD ER Labs
14 5 Provide Rapid Response to Specific Pressure	SW	The high feedback from a display panel	PFD ER Labs
14 6 Provide Touch Sensitive Panel	HW	The display panel is sensitive, which provided for a pilot to manipulate the display screen easily and precisely	PFD ER Labs

FUNCTIONAL BEHAVIOR MODELS

Part I - Function List

1.1 Display Selected Airspeed
1.2 Display Current Speed
1.3 Display Maximum Allowable Airspeed
1.4 Display Minimum Airspeed
1.5 Display Maximum/Minimum Maneuvering Speed
1.6 Display Speed Trend Vector
1.7 Display Selected Speed
1.8 Display TAS Digits
1.9 Display Speed/AOA Error
1.10 Display Load Factor
2.1 Display Selected Altitude
2.2 Display Altitude Bug
2.3 Display Current Altitude
2.4 Display Baromin Pointer
2.5 Display Altitude Setting
2.6 Display Radar/Radio Altitude
3.1 Display Heading Pointer
3.2 Display Heading Bug
3.3 Display Heading/Track Reference
3.3.1 Display Magnetic North
3.3.2 Display True North
3.4 Display Selected Heading/Track
3.5 Display Selected Course
3.6 Display Ground Track
3.7 Display Track Line
4.1 Display Vertical Speed Pointer
4.2 Display Vertical Speed Bug
4.3 Display Vertical Speed
5.1 Display Fixed Aircraft Symbol
5.2 Display Flight Director
5.3 Display Pitch and Bank Command Bars

5.4 Display Slip/Skid Indicator (Inclinometer)

5.5 Display Bank Pointer

5.6 Display Horizon Line

5.7 Display Pitch Scale

5.8 Display V Bar

5.9 Display Autopilot Indicator

6.1 Display Pitch Ladder

6.2 Display Flight Director Cue

6.3 Display Guidance Cue (Follow Me Box)

6.4 Display Synthetic Runway Cue

6.5 Display CDM/FPM

6.6 Display Course Deviation

7.1 Provide VIDEO Mode

7.2 Provide CHARTS Mode

7.2.1 Provide Instrument Approach Procedure Chart

7.2.2 Provide SMGCS Chart

7.2.3 Provide SID Chart

7.2.4 Provide STAR Chart

7.2.5 Provide VFR Terminal Chart

7.2.6 Provide Airport Taxi Chart

7.3 Provide UTILITY Mode

7.3.1 Provide Reversionary/Back Up Mode

7.3.2 Provide Mode Interchange (PFD/MFD)

7.3.3 Provide Mode Interchange (PFD/HUD)

7.3.4 Implement Testing

7.3.5 Run Simulation

7.4 Provide GUIDES Mode

7.4.1 Demonstrate Aircraft Instrument Indicators Instruction

7.4.2 Demonstrate Terrain/Obstruction Display Instruction

7.4.3 Demonstrate Weather Display Instruction

7.4.4 Demonstrate Traffic Display Instruction

7.5 Provide PLAN Mode

7.5.1 Demonstrate IFR Planning

7.5.2 Demonstrate VFR Planning

7.6 Provide HELPS Mode
7.7 Provide EMERGENCY Mode
7.7.1 Supply Alternate Power
7.7.2 Supply Aircraft Master Caution/Master Warning
7.7.3 Supply Alternate Memory
8.1 Provide APPROACH Mode
8.1.1 Demonstrate Initial Approach
8.1.2 Demonstrate Intermediate Approach
8.1.3 Demonstrate Final Approach
8.1.4 Demonstrate Missed Approach
8.2 Provide FMS Mode
8.3 Provide SID Mode
8.3.1 Demonstrate Pilot Navigation SIDs
8.3.2 Demonstrate Vector SIDs
8.4 Provide STAR Mode
8.4.1 Demonstrate Descent Via (Lateral/Vertical Navigation)
8.4.2 Demonstrate Descent Via (Vertical Navigation)
8.5 Provide VFR Mode
8.5.1 Demonstrate MVFR
8.5.2 Demonstrate VFR
8.6 Provide TAXI Mode
8.6.1 Demonstrate Taxi prior to Departure
8.6.2 Demonstrate Taxi after Landing
9.1 Display Terrain
9.2 Display Mountainous Obscuration
9.3 Display Hidden Obstacles
9.4 Display Hazard Materials
9.5 Display Obstruction
10.1 Display Precipitation
10.2 Display Thunderstorm
10.3 Display Lightning
10.4 Display Ceiling
10.5 Display Visibility
10.5.1 Display Flight Visibility

10.5.2 Display Ground Visibility

10.5.3 Display RVR

10.6 Display Wind Speed and Direction

10.7 Display Surface and Upper Air

10.8 Display Icing Potential

10.8.1 Display Structure Icing

10.8.2 Display Induction Icing

10.9 Display Convection

10.10 Display Turbulence

10.11 Display Volcanic Ash

11.1 Display Ground Traffic Flow

11.1.1 Display Traffic on Ramp

11.1.2 Display Traffic during Taxi

11.1.3 Display Traffic during Holding

11.1.4 Display Traffic during Takeoff

11.2 Display Air Traffic Flow

11.2.1 Display Traffic during Climb

11.2.2 Display Traffic during Cruise

11.2.3 Display Traffic during Descend

11.3 Display Traffic Flow during Approach

11.3.1 Display Upwind Leg Approach

11.3.2 Display Crosswind Leg Approach

11.3.3 Display Base Leg Approach

11.3.4 Display Final Approach

11.4 Display Traffic Conflict Area

11.5 Display Collision Zones

12.1 Provide Real-Time Hardware

12.2 Provide Real-Time Operating Systems

12.3 Provide Real-Time Software

12.4 Provide Real-Time Database

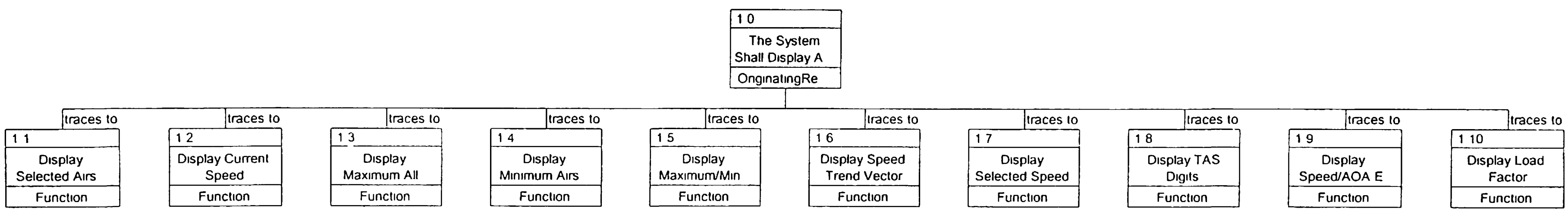
12.4.1 Provide Terrain/Obstruction Database

12.4.2 Provide Weather Database

12.4.3 Provide Traffic Database

13.1 Provide High Solution

13.2 Provide Contrast in High Ambient Light
13.3 Provide High Brightness
13.4 Provide High Gray Scale
13.5 Provide High Modulation
13.6 Provide High Uniformity
13.7 Provide Wide Viewing Angle
13.8 Reproduce Photo-Realistic on Display Screen
13.9 Provide Automatic Blink Symbol/String
13.10 Provide Discriminatory Shading on Graphics
13.11 Provide Stable Display in Wide Range of Temperature
14.1 Provide Forward-Backward Capability
14.2 Separate Critical Markers
14.3 Provide Protection of Finger Oils
14.4 Provide Adequate Spacing between Markers
14.5 Provide Rapid Response to Specific Pressure
14.6 Provide Touch Sensitive Panel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1 6
Display Speed Trend Vector
Function
1 7
Display Selected Speed
Function
1 8
Display TAS Digits
Function
1 9
Display Speed/AOA E
Function
1 10
Display Load Factor
Function

Part II - Behavioral Models

1.1 Display Selected Airspeed

Description:

The airspeed selected in the Flight Management Computer (FMC) computed airspeed.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

1.2 Display Current Speed

Description:

The current Inertial Reference System (IRS) airspeed.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

1.3 Display Maximum Allowable Airspeed

Description:

The maximum airspeed that is allowable a pilot to fly an aircraft within the margin of safety.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

1.4 Display Minimum Airspeed

Description:

The minimum airspeed that is allowable a pilot to fly an aircraft without stalling.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

1.5 Display Maximum/Minimum Maneuvering Speed

Description:

The maximum maneuvering speed allows a pilot to fly an aircraft within the limited speed so that the airplane would not stall while maneuvering. The minimum maneuvering speed allows pilots to be able to maneuver the airplane with a certain RPM.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

1.6 Display Speed Trend Vector

Description:

The predicted airspeed in any number of seconds based on current acceleration or deceleration.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

1.7 Display Selected Speed

Description:

The selected speed displays the airspeed selected in the Mode Control Panel (MCP) indicated airspeed window or the Flight Management Computer (FMC) computed airspeed when the window is blank.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

1.8 Display TAS Digits

Description:

The digits of speed that an aircraft moves through the air taking into consideration pressure altitude and temperature.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

1.9 Display Speed/AOA Error

Description:

The alpha-error bracket or speedworm could be driven by airspeed error in place of angle of attack error.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator

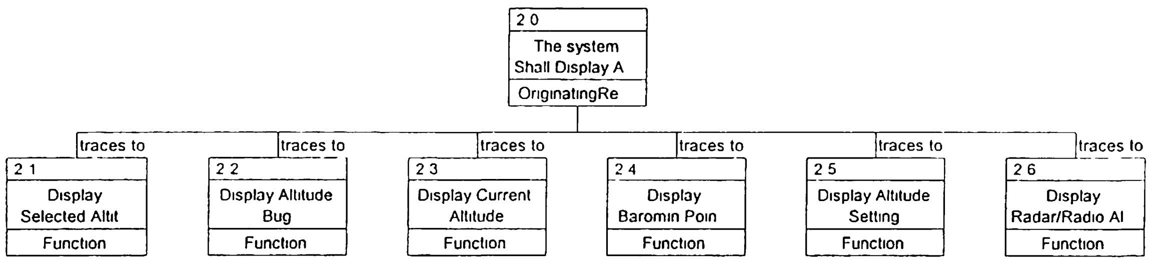
1.10 Display Load Factor

Description:

The normal load factor should be shown digitally, followed by the letter 'g.' the resolution should be 0.1 g (e.g., 2.5 g). load factor will normally be displayed only on tactical aircraft.

Traced From:

Originating Requirement: 1.0 The System Shall Display Airspeed Indicator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Function
2 5
Display Altitude Setting
Function
2 6
Display Radar/Radio Al
Function

2.1 Display Selected Altitude

Description:

The selected altitude displays the altitude set in the Mode Control Panel altitude window.

Traced From:

Originating Requirement: 2.0 The System Shall Display Altitude Indicator

2.2 Display Altitude Bug

Description:

The altitude bug displays the altitude set in the Mode Control Panel altitude window. When the selected altitude is off scale, the bug is stowed at the top or bottom of the tape with half the bug visible.

Traced From:

Originating Requirement: 2.0 The System Shall Display Altitude Indicator

2.3 Display Current Altitude

Description:

The current Inertial Reference System altitude.

Traced From:

Originating Requirement: 2.0 The System Shall Display Altitude Indicator

2.4 Display Baromin Pointer

Description:

When BARO minimums are displayed, the number is represented as a pointer and line on the altitude scale.

Traced From:

Originating Requirement: 2.0 The System Shall Display Altitude Indicator

2.5 Display Altitude Setting

Description:

The value to which the scale of a pressure altimeter is set so as to read true altitude at field evaluation.

Traced From:

Originating Requirement: 2.0 The System Shall Display Altitude Indicator

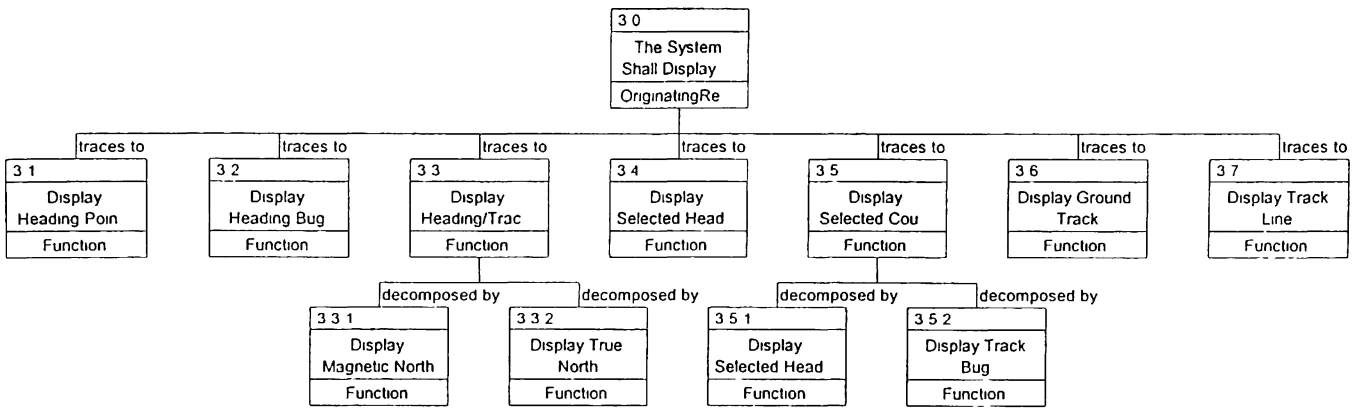
2.6 Display Radar/Radio Altitude

Description:

A radio, which measures the aircraft's height above ground level (AGL) with an accuracy of about 5-ft. during IRF, approaches. The usable range for a radar altimeter extends up to 2,500 ft. The radar altimeter uses antennas that are installed on the belly of the aircraft. The transmitter sends out radio waves at 4.3 GHz which strike the earth and bounce back to the received antenna. By measuring the travel time for the radio waves, an accuracy calculation can be made of AGL altitude.

Traced From:

Originating Requirement: 2.0 The System Shall Display Altitude Indicator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Display Ground Track
Function
3 7
Display Track Line
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decomposed by
3 3 1
Display Magnetic North
Function
3 3 2
Display True North
Function
3 5 1
Display Selected Head
Function
3 5 2
Display Track Bug
Function

3.1 Display Heading Pointer

Description:

The heading pointer indicates the current Inertial Reference System heading.

Traced From:

Originating Requirement: 3.0 The System Shall Display Heading/Track Indicator

3.2 Display Heading Bug

Description:

The selected heading bug is displayed on the outside of the bug compass rose. It selected heading exceeds display range, the bug parks on the side of the compass rose in the direction of the shorter turn to the heading.

Traced From:

Originating Requirement: 3.0 The System Shall Display Heading/Track Indicator

3.3 Display Heading/Track Reference

Description:

The heading/track reference displays the manually and automatic selected heading and track reference.

Traced From:

Originating Requirement: 3.0 The System Shall Display Heading/Track Indicator

3.3.1 Display Magnetic North

Description:

The earth's magnetic north pole, which located at approximately 73 N, 110 W.

3.3.2 Display True North

Description:

One end of the axis about which the earth rotates.

3.4 Display Selected Heading/Track

Description:

The digital display of the selected heading and track bug.

Traced From:

Originating Requirement: 3.0 The System Shall Display Heading/Track Indicator

3.5 Display Selected Course

Description:

The intended direction of flight, measured normally either by reference to true or magnetic north, but sometimes by reference to grid north.

Traced From:

Originating Requirement: 3.0 The System Shall Display Heading/Track Indicator

3.6 Display Ground Track

Description:

The actual ground track made by an aircraft.

Traced From:

Originating Requirement: 3.0 The System Shall Display Heading/Track Indicator

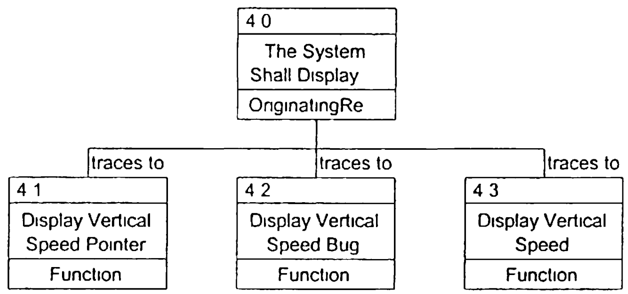
3.7 Display Track Line

Description:

The current Flight Management Computer (FMC) track.

Traced From:

Originating Requirement: 3.0 The System Shall Display Heading/Track Indicator



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4 1
Display Vertical Speed Pointer
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4 2
Display Vertical Speed Bug
Function
4 3
Display Vertical Speed
Function

4.1 Display Vertical Speed Pointer

Description:

The current vertical speed.

Traced From:

Originating Requirement: 4.0 The System Shall Display Vertical Speed Indicator

4.2 Display Vertical Speed Bug

Description:

The speed selected in the Mode Control Panel vertical speed window with the vertical speed pitch mode engaged.

Traced From:

Originating Requirement: 4.0 The System Shall Display Vertical Speed Indicator

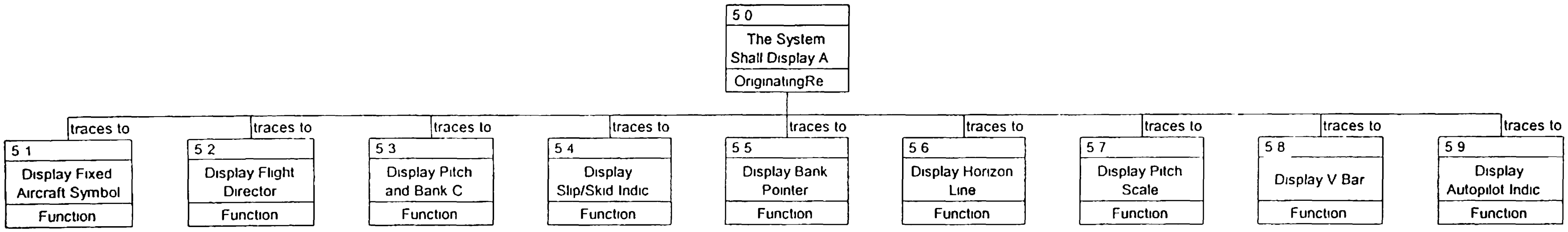
4.3 Display Vertical Speed

Description:

The vertical deviation displays Inertial Reference System vertical speed when more than any number of feet per min. the display is located above the vertical speed indication when climbing and below when descending)

Traced From:

Originating Requirement: 4.0 The System Shall Display Vertical Speed Indicator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Display Flight Director
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5 3
Display Pitch and Bank C
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5 4
Display Slip/Skid Indic
Function
5 5
Display Bank Pointer
Function
5 6
Display Horizon Line
Function
5 7
Display Pitch Scale
Function
5 8
Display V Bar
Function
5 9
Display Autopilot Indic
Function

5.1 Display Fixed Aircraft Symbol

Description:

The aircraft symbol and flight command bars show the aircraft's attitude relative to the natural horizon. The pilot can adjust the symbol to one of the flight modes. To fly the aircraft with the command bars armed, the pilot simply inserts the aircraft symbol between the command bars.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator

5.2 Display Flight Director

Description:

A flight director system combines many of the previously described instruments to provide an easily interpreted display of the aircraft's flight path. The pre-programmed path, automatically computed, furnishes the steering commands necessary to obtain and hold a desired path.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator

5.3 Display Pitch and Bank Command Bars

Description:

The command bars move up for a climb or down for descent, and roll left or right to provide lateral guidance. They display the computed angle of bank for standard-rate turns to enable the pilot to reach and fly a selected beading or track. The bars also show pitch commands that allow the pilot to capture and fly an ILS glide slope, a preselected pitch attitude, or maintain a selected barometric altitude. To comply with the directions indicated by the command bars, the pilot maneuvers the aircraft to align the fixed symbol with the command bars. When not using the bars, the pilot can move them out of view.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator

5.4 Display Slip/Skid Indicator (Inclinometer)

Description:

A flight instrument consisting of a rate gyro, to indicate the rate of yaw, and a curved glass inclinometer, to indicate the relationship between gravity and centrifugal force. It indicates the relationship between angle of bank and rate of yaw.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator

5.5 Display Bank Pointer

Description:

The bank pointer indicates Inertial Reference System bank in reference to the bank scale.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator

5.6 Display Horizon Line

Description:

The horizon line establishes the position of a horizontal plane passing through the aircraft at approximate eye level. The length of the horizon line should provide enough differentiation from the balance of the ladder lines.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator

5.7 Display Pitch Scale

Description:

The pitch scale is measured in any number of increments.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator

5.8 Display V Bar

Description:

The V bar symbol is located between the horizon line and the fixed aircraft symbol. Before taking off an aircraft, the pilot can set up the V bar in a certain degree of pitch up or bank.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator

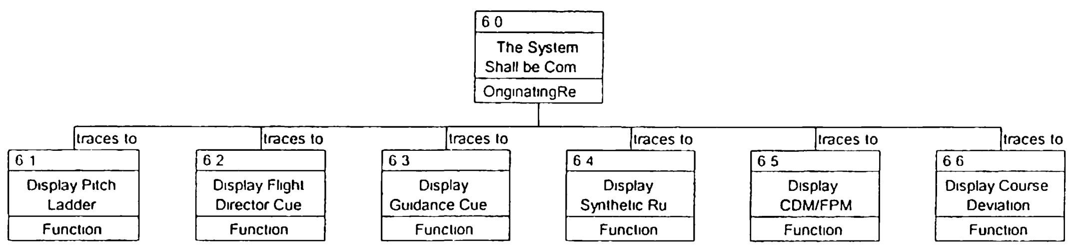
5.9 Display Autopilot Indicator

Description:

The autopilot indicator indicates the Autopilot Flight Director System (AFDS) is on.

Traced From:

Originating Requirement: 5.0 The System Shall Display Attitude Indicator



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6 3
Display Guidance Cue
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traces to
6 4
Display Synthetic Ru
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traces to
6 5
Display CDM/FPM
Function
traces to
6 6
Display Course Deviation
Function

6.1 Display Pitch Ladder

Description:

A set of conventional pitch reference symbols (pitch lines, pitch scale, or climb-dive ladder) showing increments of angles to the horizon.

Traced From:

Originating Requirement: 6.0 The System Shall be Compatible with Head-Up Display

6.2 Display Flight Director Cue

Description:

The steering information which, when followed, will place the aircraft on a trajectory to intercept and maintain a preselected computed path through space.

Traced From:

Originating Requirement: 6.0 The System Shall be Compatible with Head-Up Display

6.3 Display Guidance Cue (Follow Me Box)

Description:

The center of the box is the on-course location. The dimensions of the box present a cue for the maximum acceptable deviation.

Traced From:

Originating Requirement: 6.0 The System Shall be Compatible with Head-Up Display

6.4 Display Synthetic Runway Cue

Description:

This is a particular cue of a runway outline, which is drawn to overlie the real-world runway. The perspective cue allows the pilot to fly quite precise approaches using visual techniques.

Traced From:

Originating Requirement: 6.0 The System Shall be Compatible with Head-Up Display

6.5 Display CDM/FPM

Description:

The use of air-mass data allows direct integration of aerodynamic information and critical information such as height alpha or engine-out situations.

Traced From:

Originating Requirement: 6.0 The System Shall be Compatible with Head-Up Display

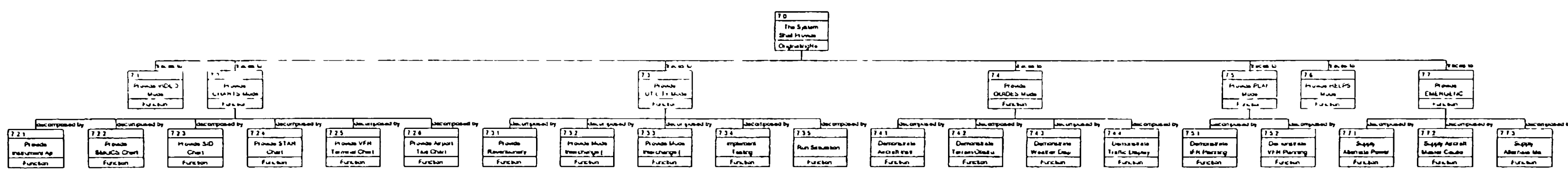
6.6 Display Course Deviation

Description:

The course deviation or lateral deviation is the aircraft displacement (left-right) from a desired track (GPS).

Traced From:

Originating Requirement: 6.0 The System Shall be Compatible with Head-Up Display



7.0
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GUIDES Mode
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7.2.1
Provide
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7.2.2
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Chart
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7.2.3
Provide SID
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7.2.4
Provide STAR
Chart
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7.2.5
Provide VFR
Terminal Chart
Function
7.2.6
Provide Airport
Taxi Chart
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7.3.1
Provide
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7.3.2
Provide Mode
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7.3.3
Provide Mode
Interchange
Function
7.3.4
Implement
Testing
Function
7.3.5
Run Simulation
Function
7.4.1
Demonstrate
Function
7.4.2
Demonstrate
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7.4.3
Demonstrate
Weather Disp
Function
7.4.4
Demonstrate
Traffic Display
Function
7.5.1
Demonstrate
IFR Planning
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7.5.2
Demonstrate
VFR Planning
Function
7.7.1
Supply
Alternate Power
Function
7.7.2
Supply Aircraft
Function
7.7.3
Supply
Function

7.1 Provide VIDEO Mode

Description:

An electronically displayed map on the radar display that may depict data such as airports, heliports, runway centerline extensions, hospital emergency landing areas, NAV AIDs and fixes, reporting points, airway/route boundaries, handoff point, special use tracks, obstructions, prominent geographic features, map alignment indicators, range accuracy marks, minimum vectoring altitudes.

Traced From:

Originating Requirement: 7.0 The System Shall Provide Supporting Modes

7.2 Provide CHARTS Mode

Description:

The chart mode is designed to display the special or auxiliary chart aside from the Multi Function Display (MFD). This chart mode assists a pilot with the flight navigation control and flight planning.

Traced From:

Originating Requirement: 7.0 The System Shall Provide Supporting Modes

7.2.1 Provide Instrument Approach Procedure Chart

Description:

A chart by reference to flight instruments with specified protection from obstacles from the initial approach fix, or where applicable, from the beginning of a defined arrival route to a point from which a landing can be completed and thereafter, if a landing is not completed, to a position at which landing or en-route obstacle clearance criteria apply.

7.2.2 Provide SMGCS Chart

Description:

A SMGCS chart is designed to expedite the efficient and safe flow of ground traffic under low visibility conditions. This chart represents a specific airport layout.

7.2.3 Provide SID Chart

Description:

A SID chart is designed to expedite clearance delivery and to facilitate transition between takeoff and en-route operations. This chart furnishes pilot's departure routing clearance information in graphic and textual form.

7.2.4 Provide STAR Chart

Description:

A STAR chart is designed to expedite ATC arrival procedures and to facilitate transition between en-route and instrument approach operations. This chart represents preplanned IFR ATC arrival procedures in graphic and textual form. Each STAR procedure is presented as a separate chart and may serve a single airport of more than one airport in a given geographic location.

7.2.5 Provide VFR Terminal Chart

Description:

The chart depicts topographic information and aeronautical information, which includes visual and radio. The VFR terminal chart is a depict class B airspace, which provides for the control or segregation of all the aircraft within class B airspace.

7.2.6 Provide Airport Taxi Chart

Description:

An airport taxi chart is designed to expedite the efficient and safe flow of ground traffic at an airport and identified by the official airport name.

7.3 Provide UTILITY Mode

Description:

The utility mode represents the operational mode used in reviewing or switching the functions of instruments or displays.

Traced From:

Originating Requirement: 7.0 The System Shall Provide Supporting Modes

7.3.1 Provide Reversionary/Back Up Mode

Description:

This is a condition where the pilot has the choice of reviewing the flight mode at any point of flight operation, if he or she desires to.

7.3.2 Provide Mode Interchange (PFD/MFD)

Description:

The Primary Flight Display (PFD) and Multi Function Display (MFD) mode shall be interchangeable via the mode switching.

7.3.3 Provide Mode Interchange (PFD/HUD)

Description:

The Primary Flight Display (PFD) and Head-Up Display (HUD) mode shall be interchangeable via the mode switching.

7.3.4 Implement Testing

Description:

The procedure for critical evaluation or investigating the operation/flight characteristics of an aircraft or aircraft component.

7.3.5 Run Simulation

Description:

The procedure designed to simulate the operating of flight indicators and displays.

7.4 Provide GUIDES Mode

Description:

A guide mode provides instructions for all PFD systems from database. A pilot would be able to simply follow the instructions guided to his or her decision making and able to perform tasks properly and accurately.

Traced From:

Originating Requirement: 7.0 The System Shall Provide Supporting Modes

7.4.1 Demonstrate Aircraft Instrument Indicators Instruction

Description:

The instructions are provided for all aircraft electronic indicators, such as airspeed, altitude, heading/track, vertical, and attitude indicator.

7.4.2 Demonstrate Terrain/Obstruction Display Instruction

Description:

The instructions are provided for terrain and obstruction display, which guide pilots to understand the classification or type of terrain display.

7.4.3 Demonstrate Weather Display Instruction

Description:

The instructions are provided for weather display, which guide pilots to understand the classification or type of weather display.

7.4.4 Demonstrate Traffic Display Instruction

Description:

The instructions are provided for traffic display, which guide pilots to understand the classification or type of traffic display.

7.5 Provide PLAN Mode

Description:

The plan mode is designed for preflight and en-route flight planning for both Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) condition.

Traced From:

Originating Requirement: 7.0 The System Shall Provide Supporting Modes

7.5.1 Demonstrate IFR Planning

Description:

The IFR planning is provided for pilots to operate an aircraft from set of rules governing the conduct of flight under instrument meteorological conditions.

7.5.2 Demonstrate VFR Planning

Description:

The VFR planning is provided for a pilot in the weather conditions that are equal to or better than the minimum for flight under visual flight rules.

7.6 Provide HELPS Mode

Description:

The HELPS icon is provided for guidance and assistance of how to operate or manipulate the system efficiently. The HELPS function is contained the information of all PFD systems to be reviewed by the pilot.

Traced From:

Originating Requirement: 7.0 The System Shall Provide Supporting Modes

7.7 Provide EMERGENCY Mode

Description:

An emergency refers to a condition that could affect flight safety resulted from a distress condition or an urgency condition. This mode represents a secondary or redundant system used for improving pilot safety.

Traced From:

Originating Requirement: 7.0 The System Shall Provide Supporting Modes

7.7.1 Supply Alternate Power

Description:

An alternate or independent power source is set up and shall be reliable every time a main power source fails. The alternate power source will provide redundancy of the system.

7.7.2 Supply Aircraft Master Caution/Master Warning

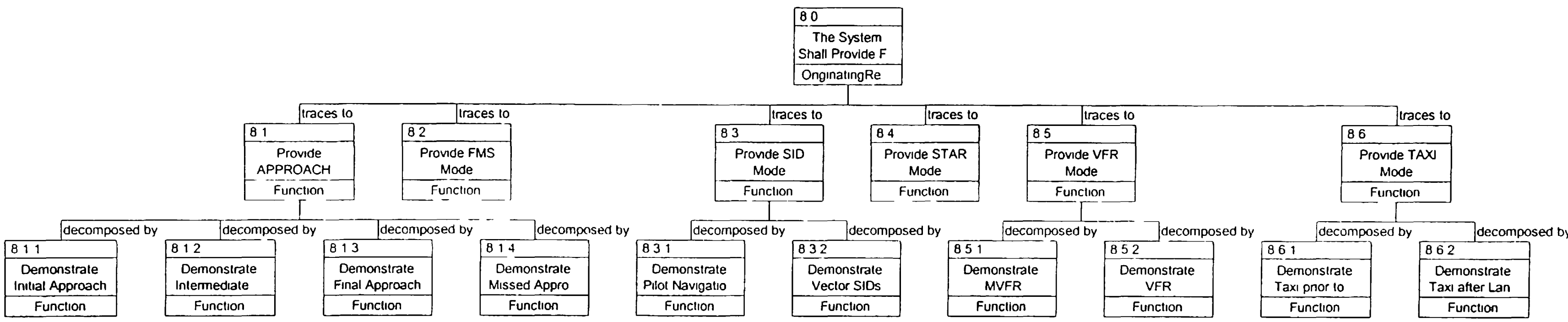
Description:

A master caution or master warning is set up with audio and visual in case of emergency situations.

7.7.3 Supply Alternate Memory

Description:

As a main memory unit fails, it will cause a loss of flight data or aircraft data. An alternate memory unit will provide redundancy. Therefore, data in the alternate memory unit shall be updated simultaneously while updating data in the main memory unit.



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8 3
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8 4
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8 5
Provide VFR Mode
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8 6
Provide TAXI Mode
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8 1 2
Demonstrate Intermediate
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8 1 3
Demonstrate Final Approach
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8 1 4
Demonstrate Missed Appro
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8 3 1
Demonstrate Pilot Navigatio
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8 3 2
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8 5 1
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8 5 2
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8 6 1
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8 6 2
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8.1 Provide APPROACH Mode

Description:

Authorization by ATC for a pilot to conduct an instrument approach. The type of instrument approach for which a clearance and other pertinent information is provided in the approach clearance when required.

Traced From:

Originating Requirement: 8.0 The System Shall Provide Flight Path Control Modes

8.1.1 Demonstrate Initial Approach

Description:

The segment between the initial approach fix and the intermediate fix or the point, where the aircraft is established on the intermediate course of final approach course.

8.1.2 Demonstrate Intermediate Approach

Description:

The segment between the intermediate fix or point and the final approach fix.

8.1.3 Demonstrate Final Approach

Description:

The segment between the final approach fix or point and the runway, airport, or missed approach point.

8.1.4 Demonstrate Missed Approach

Description:

The segment between the missed approach pointer and the point of arrival at decision height and the missed approach fix at the prescribed altitude.

8.2 Provide FMS Mode

Description:

A computer system that uses a large database to allow routes to be preprogrammed and fed into the system by means or a data loader the system is constantly updated with respect to position accuracy by reference to conventional navigation aids. The sophisticated program and its associated database insure that the most appropriate aids are automatically selected during the information update cycle.

Traced From:

Originating Requirement: 8.0 The System Shall Provide Flight Path Control Modes

8.3 Provide SID Mode

Description:

A preplanned instrument flight rule (IFR) air traffic control departure procedure printed for pilot use in graphic and/or textual form. SIDs provides transition from the terminal to the appropriate en-route structure.

Traced From:

Originating Requirement: 8.0 The System Shall Provide Flight Path Control Modes

8.3.1 Pilot Navigation SIDs

Description:

This procedure is established where the pilot is primarily responsible for navigation on the SID route. They are established for airports when terrain and safety related factors indicate the necessity for a pilot NAV SID. Some pilot NAV SIDs may contain vector instructions which pilots are expected to comply with until instructions are received to resume normal navigation on the field/assigned route or SID procedure.

8.3.2 Vector SIDs

Description:

This procedure is established where ATC will provide radar navigational guidance to a field/assigned route or to a fix depicted on the SID.

8.4 Provide STAR Mode

Description:

A preplanned instrument flight rule (IFR) air traffic control arrival procedure published for pilot use in graphic and/or textual form. STARs provide transition from the en-route structure to an outer or an instrument fix/arrival waypoint in the terminal area.

Traced From:

Originating Requirement: 8.0 The System Shall Provide Flight Path Control Modes

8.4.1 Descent Via (Lateral/Vertical Navigation)

Description:

The authorization is via a normal descent clearance. This authorizes pilots to lateral navigate and vertical navigate, in accordance with the depicted procedure, to meet published restrictions.

8.4.2 Descent Via (Vertical Navigation)

Description:

The authorization is via a normal descent clearance. This authorizes pilots to clear for vertical navigation. Pilots shall inform ATC upon initial contact with a new frequency.

8.5 Provide VFR Mode

Description:

Weather conditions are equal to or better than the minimum for flight under visual flight rules. The term may used as an ATC clearance/instruction only when:

a. an IFR aircraft requests a climb/descent in VFR conditions

b. the clearance will result in noise abatement benefits when part of the

IFR departure route does not confirm to a FAA approved noise abatement route or altitude

c. a pilot has requested a practice instrument approach and is not on an

IFR flight plan.

Traced From:

Originating Requirement: 8.0 The System Shall Provide Flight Path Control Modes

8.5.1 MVFR

Description:

Ceiling is measured from 1,000 to 3,000 feet and/or visibility is measured from 3 to 5 miles inclusively.

8.5.2 VFR

Description:

Ceiling is greater than 3,000 feet and visibility is greater than 5 miles; includes sky clear.

8.6 Provide TAXI Mode

Description:

The movement of an airplane under its own power on the surface of an airport.

Traced From:

Originating Requirement: 8.0 The System Shall Provide Flight Path Control Modes

8.6.1 Demonstrate Taxi prior to Departure

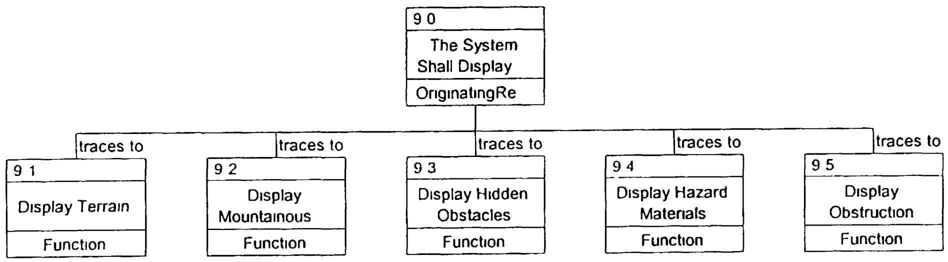
Description:

The movement of an aircraft to taxi onto or cross the assigned takeoff runway before departure from any airport.

8.6.2 Demonstrate Taxi after Landing

Description:

The movement of an aircraft to taxi onto or cross the assigned takeoff runway after landing at any airport.



9 0
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9 1
Display Terrain
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9 2
Display Mountainous
Function
9 3
Display Hidden Obstacles
Function
9 4
Display Hazard Materials
Function
9 5
Display Obstruction
Function

9.1 Display Terrain

Description:

A terrain is a fixed geographical location such as bluffs, hills, or mountains where causes a considerable turbulence. Between hills or mountains, where there is a canyon or narrow valley, the wind generally veers from its normal course and flows through the passage with increased velocity and turbulence.

Traced From:

Originating Requirement: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction

9.2 Display Mountainous Obscuration

Description:

A mountain hidden by surface-based obscuring phenomena and vertical visibility restricted overhead.

Traced From:

Originating Requirement: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction

9.3 Display Hidden Obstacles

Description:

A hidden obstacle or hidden object of natural growth which may be expected at a location within a prescribed area with reference to which vertical clearance is or must be provided during flight operation obstruction.

Traced From:

Originating Requirement: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction

9.4 Display Hazard Materials

Description:

The system shall provide an emergency alerting system for hazard information during ground operations.

Traced From:

Originating Requirement: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction

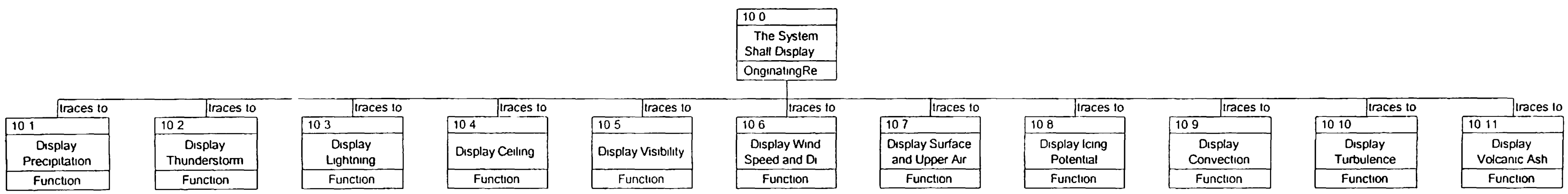
9.5 Display Obstruction

Description:

The obstruction is the buildings around an airport such as control tower, aircraft hanger, or airport facilities, where obstruct the wind direction. When the wind flows around an obstruction, it breaks into eddies or gusts with sudden changes in speed and direction that could be carried along some distance from the obstruction.

Traced From:

Originating Requirement: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction



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10 1
Display Precipitation
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10 2
Display Thunderstorm
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10 3
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10 4
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10 5
Display Visibility
Function
10 6
Display Wind Speed and Di
Function
10 7
Display Surface and Upper Air
Function
10 8
Display Icing Potential
Function
10 9
Display Convection
Function
10 10
Display Turbulence
Function
10 11
Display Volcanic Ash
Function

10.1 Display Precipitation

Description:

Any or all forms of water particles (rain, sleet, hail, or snow) that fall from the atmosphere and reach the surface.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.2 Display Thunderstorm

Description:

Thunderstorm is a local storm produced by a cumulonimbus cloud, and always accompanied by lightning and thunder. It typically produces strong wind gusts, heavy rain, hail, or tornadoes.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.3 Display Lightning

Description:

Lightning is the visible electric discharge produced by a thunderstorm. It occurs in several forms, including in-cloud, cloud-to-cloud, cloud-to-ground lightening, and between the cloud and clear air.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.4 Display Ceiling

Description:

Ceiling is the height above the surface of the base of the lowest layer of clouds or obscuring phenomena that is reported as broken overcast, or obscuration, and not classified as thin or partial.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.5 Display Visibility

Description:

Visibility is defined as the greatest horizontal distance at which prominent objects can be distinguished with the naked eye. Visibility and ceiling are included in hourly weather reports and in aviation forecasts.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.5.1 Display Flight Visibility

Description:

The visibility forward from the cockpit of an aircraft in flight.

10.5.2 Display Ground Visibility

Description:

The visibility at an aerodrome as reported by an accredited observer.

10.5.3 Display RVR

Description:

The range over which the pilot of an aircraft on the centerline of a runway can see the runway surface markings or the lights delineating the runway or identifying its center line.

10.6 Display Wind Speed and Direction

Description:

Wind speed is the magnitude of the wind velocity express in nautical miles per hour (knots), statue miles per hour (MPH), kilometers per hour, or meter per second. Wind direction is the direction from which the wind is blowing, measured in degrees, or to eight or sixteen points of the compass, clock wise from true north (360 degree).

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.7 Display Surface and Upper Air

Description:

The upper air is measured at 1.5 meters (about 5 feet) above the ground and is chanted by the height or pressure level.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.8 Display Icing Potential

Description:

The effects of Ice on aircraft are cumulative thrust is reduced, drag increases, lift lessens, and weight increases. The results are an increase in stall speed and a deterioration of aircraft performance. In extreme cases, 2 to 3 inches of ice can form on the leading edge of the airfoil in less than 5 minutes. It takes but 1/2 inch of ice to reduce the lifting power of some aircraft by 50 percent and increases the frictional drag by an equal percentage.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.8.1 Display Structure Icing

Description:

The accumulation of ice on the exterior of the aircraft. It includes ice on the wing and tail surfaces, propellers, radio antennas, wind screen, pitot tube, and static ports. The major effect of structural icing is loss of aerodynamic efficiency of the aircraft. The primary cause of structure icing is the freezing of water droplets on the skin of the aircraft as it passes through a cloud.

10.8.2 Display Induction Icing

Description:

The induction icing affects the powerplant operation. It includes icing on air intakes and carburator icing. The main effect of induction icing is power loss due to the blocking of the air before it enters the engine. Ice develops on air intake (for example, on screens and air scoops) under the condition as structure icing.

10.9 Display Convection

Description:

Convection is the uneven heating of the air, which causes small local circulation. Convection currents cause the bumpiness when pilots often experience flying at altitudes in warmer weather and difficulty in making landings, since convection affects the rate of descent. In the daytime, convection currents form onshore winds and on the other hand produce offshore winds at night.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

10.10 Display Turbulence

Description:

Turbulence encountered in air when no clouds are present. The term is most commonly used to describe high-altitude turbulence associated with wind shear and operations near the jet stream.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather

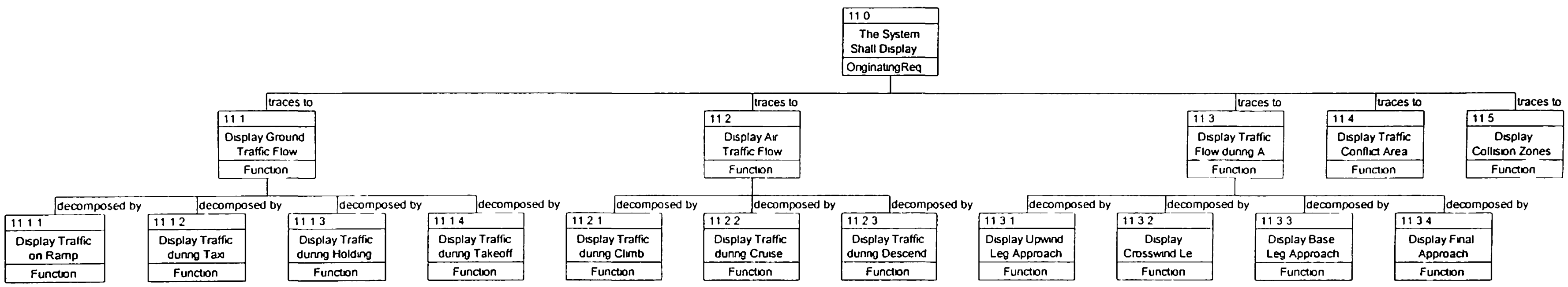
10.11 Display Volcanic Ash

Description:

Volcanic ash occurs from severe volcanic eruptions, which send ash into the upper atmosphere. Flying into a volcanic ash cloud can be exceedingly dangerous. Piston-powered aircraft would be likely to lose power, if aircraft encountered with severe damage conditions from a volcanic ash. The ash plume may not be visible, especially in instrument conditions or at night, and even if visible, it is difficult to distinguish visually between an ash cloud and an ordinary weather cloud. Volcanic ash clouds are not displayed on ATC radar.

Traced From:

Originating Requirement: 10.0 The System Shall Display a 4D Synthetic Vision of Weather



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Display Ground Traffic Flow
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11 1 1
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11 1 2
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11 1 3
Display Traffic during Holding
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11 1 4
Display Traffic during Takeoff
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11 2 1
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11 2 2
Display Traffic during Cruise
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11 2 3
Display Traffic during Descend
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11 3 1
Display Upwind Leg Approach
Function
11 3 2
Display Crosswind Le
Function
11 3 3
Display Base Leg Approach
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11 3 4
Display Final Approach
Function

11.1 Display Ground Traffic Flow

Description:

The traffic flow is prescribed for an aircraft on the ground operations.

Traced From:

Originating Requirement: 11.0 The System Shall Display a 4D Synthetic Vision of Traffic

11.1.1 Display Traffic on Ramp

Description:

The traffic flow is prescribed for an aircraft during parking.

11.1.2 Display Traffic during Taxi

Description:

The traffic flow is prescribed for an aircraft during taxi.

11.1.3 Display Traffic during Holding

Description:

The traffic flow is prescribed for an aircraft during holding.

11.1.4 Display Traffic during Takeoff

Description:

The traffic flow is prescribed for an aircraft during takeoff.

11.2 Display Air Traffic Flow

Description:

The traffic flow is prescribed for an aircraft during flying.

Traced From:

Originating Requirement: 11.0 The System Shall Display a 4D Synthetic Vision of Traffic

11.2.1 Display Traffic during Climb

Description:

The traffic flow is prescribed for an aircraft during climb.

11.2.2 Display Traffic during Cruise

Description:

The traffic flow is prescribed for an aircraft during cruise.

11.2.3 Display Traffic during Descend

Description:

The traffic flow is prescribed for an aircraft during descend.

11.3 Display Traffic Flow during Approach

Description:

The traffic flow is prescribed for an aircraft during approach, especially the landing approach.

Traced From:

Originating Requirement: 11.0 The System Shall Display a 4D Synthetic Vision of Traffic

11.3.1 Display Upwind Leg Approach

Description:

A flight path parallel to the landing runway in the direction of landing

11.3.2 Display Crosswind Leg Approach

Description:

A flight path at right angles to the landing runway off its upwind end

11.3.3 Display Base Leg Approach

Description:

A flight path parallel to the landing runway in the direction opposite to landing. The downwind leg normally extends between the crosswind leg and the base leg.

11.3.4 Display Final Approach

Description:

A flight path in the direction of landing along the extended runway centerline. The final approach normally extends from the base leg to the runway. An aircraft making a straight-in approach VFR is also considered to be on final approach.

11.4 Display Traffic Conflict Area

Description:

The potential conflict area that is extreme congestion. The purpose is to alert pilots to avoid other aircraft and all traffic in the aircraft' proximity.

Traced From:

Originating Requirement: 11.0 The System Shall Display a 4D Synthetic Vision of Traffic

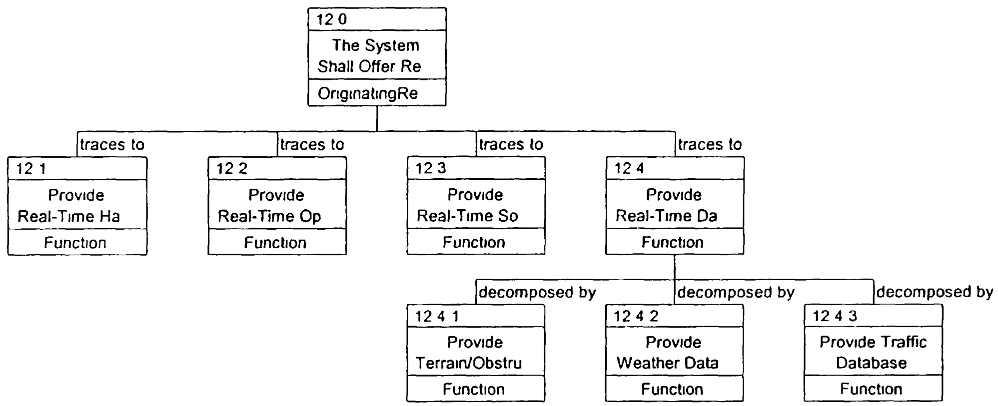
11.5 Display Collision Zones

Description:

The collision zones may be hazardous to nonparticipating aircraft. The purpose of such collision zones display is to warn nonparticipating pilots of the potential danger.

Traced From:

Originating Requirement: 11.0 The System Shall Display a 4D Synthetic Vision of Traffic



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12 4 3
Provide Traffic Database
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12.1 Provide Real-Time Hardware

Description:

Hard real-time architectures are used in the control of critical processes. The logical organization of hard real-time architecture consists of central cluster, peripheral cluster, and sensors and actuator layer. The outermost layer consists of the sensors, actuators, and displays that from the interface between the computer and the outside world. The middle layer is the peripheral cluster consisting of the interface between the special purpose devices of the outermost layer and the processors in the central cluster. The real-time workload is run on the central cluster. Three important attributes of hard real-time architectures are high reliability, high predictability, and the transparency of reliability mechanisms. The memory system must be designed for meeting of hard deadlines such as cache memories, which are small and fast memories. The design for hard real- time shall meet standard features of a general purpose of the computer systems and contribute to a significant increase in speed.

Traced From:

Originating Requirement: 12.0 The System Shall Offer Real-Time System

12.2 Provide Real-Time Operating Systems

Description:

Real-time operating systems provide a controlled environment in which software tasks are executed and system resources are managed. The important task of a real-time operating system is to provide a modicum of predictability which means the most critical real-time must meet their deadlines and timing constraints. Real-time operating systems should be taken into considerations for three main reasons:

a. time constraints are considered explicitly

b. predictable task executions are easy to ensure

c. tasks with complex characteristics (with precedence constraints and resource requirements) are handled explicitly.

Traced From:

Originating Requirement: 12.0 The System Shall Offer Real-Time System

12.3 Provide Real-Time Software

Description:

The two complementary approaches for considering real-time software are the modular and redundancy. In the first, the software should be made as modular as possible, with detailed and careful checks of each module. Object-oriented programming should be introduced because of the tremendous promise in constructing modular and easily maintainable software. The second approach is the redundancy of software program, which is created from the multiple facets from different programmers with the same overall specifications. Additionally, the timing of software is also important in real-time systems given that hard real-time systems depend on meeting hard deadlines for their survival.

Traced From:

Originating Requirement: 12.0 The System Shall Offer Real-Time System

12.4 Provide Real-Time Database

Description:

Real-time databases are any database systems with deadlines imposed on insertion, query processing, database maintenance, and deletion. Such database can be integrated into aircraft avionics such as in the PFD system. Terrain recognition is a particular application area, where the terrain under an aircraft must be matched against a reference terrain. The design of a database is concentrated on the data model. A data model determines the logical arrangement of data in the database, which is categorized into three basic data models: the hierarchical, the network, and the relational. A real-time database has strict, real-time constraints in responding to queries, processing transactions, and in database maintenance, such as integrity enforcement, view management, and database insertions, deletions, and updates. The purpose of the time- constrained query is to get the amount of information with a certain period of time units. Time-constrained queries use hard time or soft time constraints, and may occur in centralized/distributed and single.

Traced From:

Originating Requirement: 12.0 The System Shall Offer Real-Time System

12.4.1 Provide Terrain/Obstruction Database

Description:

A database used for terrain and obstruction displayed. A computerized terrain and obstruction database consists of a collection of records stored in a file. Each record contains the same fact types arranged in the same order. In a computerized database, these fact types are known as fields, and the facts contained in each field are referred to as data. Each field is given a length and a type (numeric and character).

12.4.2 Provide Weather Database

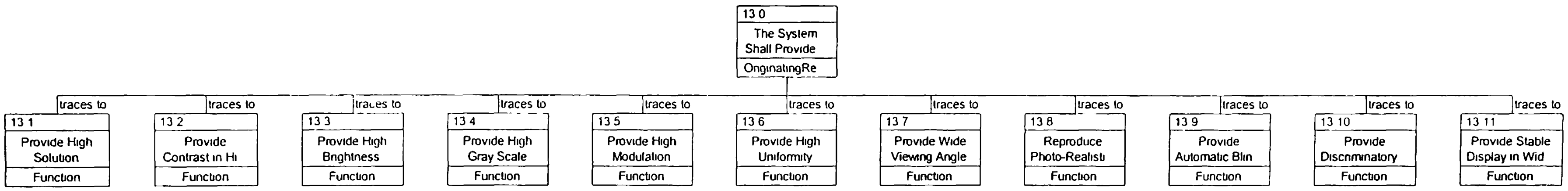
Description:

A database used for weather displayed. A computerized weather database consists of a collection of records stored in a file. Each record contains the same fact types arranged in the same order. In a computerized database, these fact types are known as fields, and the facts contained in each field are referred to as data. Each field is given a length and a type (numeric and character).

12.4.3 Provide Traffic Database

Description:

A database used for traffic displayed. A computerized traffic database consists of a collection of records stored in a file. Each record contains the same fact types arranged in the same order. In a computerized database, these fact types are known as fields, and the facts contained in each field are referred to as data. Each field is given a length and a type (numeric and character).



13 0
The System Shall Provide
OriginatingRe
traces to
13 1
Provide High Solution
Function
13 2
Provide Contrast in Hi
Function
13 3
Provide High Brightness
Function
13 4
Provide High Gray Scale
Function
13 5
Provide High Modulation
Function
13 6
Provide High Uniformity
Function
13 7
Provide Wide Viewing Angle
Function
13 8
Reproduce Photo-Realisti
Function
13 9
Provide Automatic Blin
Function
13 10
Provide Discriminatory
Function
13 11
Provide Stable Display in Wid
Function

13.1 Provide High Solution

Description:

Resolution is a measure of how much information detail may be reviewed. Resolution is closely to modulation in that it defines the smallest feature of an image.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.2 Provide Contrast in High Ambient Light

Description:

The term is used to describe contrast in the LCD is “maximum contrast ratio”. This is the ratio in the luminance achieved from the brightest feature versus the darkest feature at the lowest spatial frequency.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.3 Provide High Brightness

Description:

Brightness is the magnitude of the subjective sensation produced by visible light. It is often approximated as log luminance or luminance powered to ½ to 1/3. Display shall be readable with the brightness more than 100 lumens. Luminance is a measure of light obtained from a projection or direct view screen of a given size and gain.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.4 Provide High Gray Scale

Description:

Gray scale is the ability of a display to depict variations in gray levels, which is defined by the standard square root of 2 rule. A given gray level is the point in a gray scale spectrum, where the brightness changes by a factor of square root of 2 from a neighboring gray level. The number of gray levels is the number of times the gray scale can be divided by square root of 2.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.5 Provide High Modulation

Description:

Modulation is the ability to resolve detail at a specific spatial frequency. It is obtained by measuring vertical bars, representing the brightest and darkest features.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.6 Provide High Uniformity

Description:

Uniformity of the system is a function of the backlight uniformity and the LCD uniformity.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.7 Provide Wide Viewing Angle

Description:

The display should be easy for pilots to read the different view and different angle. Display screen provides view in different ways on starring from either right and left seats or back seats.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.8 Reproduce Photo-Realistic on Display Screen

Description:

The display should reproduce a real image same as terrain and scenery outside an aircraft. Brightness, color, contrast, and hue of an image on the screen will also be provided to replicate an image as a photograph.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.9 Provide Automatic Blink Symbol/String

Description:

An automatic blink visual entity that carries some specific meaning.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

13.10 Provide Discriminatory Shading on Graphics

Description:

Shading on graphics should be discriminated in order to provide clarity for the pilot. A pilot is able to describe color or hue of graphics.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)

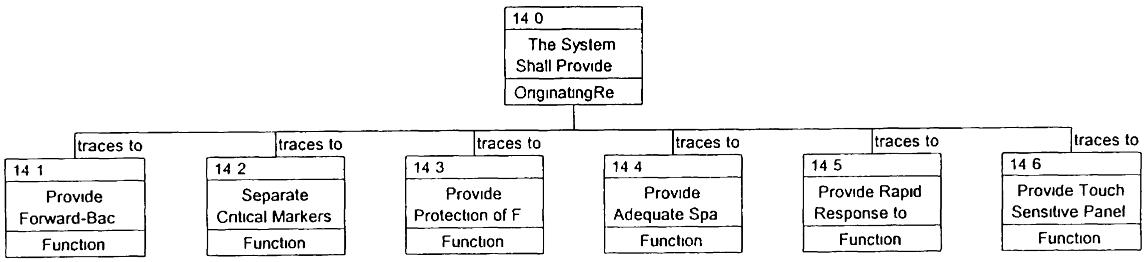
13.11 Provide Stable Display in Wide Range of Temperature

Description:

The operating temperature is approximately between -40 F to +131 F. A LCD display should provide the best level of performance and stable display across the widest possible temperature range.

Traced From:

Originating Requirement: 13.0 The System Shall Provide Liquid Crystal Display (LCD)



14 0
The System Shall Provide
OriginatingRe
traces to
14 1
Provide Forward-Bac
Function
14 2
Separate Critical Markers
Function
14 3
Provide Protection of F
Function
14 4
Provide Adequate Spa
Function
14 5
Provide Rapid Response to
Function
14 6
Provide Touch Sensitive Panel
Function

14.1 Provide Forward-Backward Capability

Description:

The system function should allow the pilot to operate with ease and shall give him or her the freedom of moving back or forth within the touch-screen system.

Traced From:

Originating Requirement: 14.0 The System Shall Provide Touch-Screen Display

14.2 Separate Critical Markers

Description:

Critical markers that are used frequently and are vital to the operation of the system need to be separated considerably in their spacing.

Traced From:

Originating Requirement: 14.0 The System Shall Provide Touch-Screen Display

14.3 Provide Protection of Finger Oils

Description:

The system function should allow the system to operate without using special equipment. It can be used with bare fingers.

Traced From:

Originating Requirement: 14.0 The System Shall Provide Touch-Screen Display

14.4 Provide Adequate Spacing between Markers

Description:

The system function is necessary, especially to avoid errors that could occur during turbulence.

Traced From:

Originating Requirement: 14.0 The System Shall Provide Touch-Screen Display

14.5 Provide Rapid Response to Specific Pressure

Description:

The pilot shall expect a quick response from the system using a touch screen. A touch screen should be able to operate and collect data within different ranges of human finger pressure.

Traced From:

Originating Requirement: 14.0 The System Shall Provide Touch-Screen Display

14.6 Provide Touch Sensitive Panel

Description:

The display screen should have a touch-sensitive transparent panel covering the screen. The pilot can use a finger to point directly to objects on the screen.

Traced From:

Originating Requirement: 14.0 The System Shall Provide Touch-Screen Display

INTERFACE

1.0 - The System Shall Display Airspeed Indicator

Interface Characteristics	Source / Destination
Selected Airspeed Data **Description** The data of a selected airspeed that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 1 Display Selected Airspeed
Current Airspeed Data **Description** The data of a current airspeed that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 2 Display Current Speed
Maximum Allowable Airspeed Data **Description** The data of a maximum allowable airspeed that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 3 Display Maximum Allowable Airspeed
Minimum Airspeed Data **Description** The data of a minimum airspeed that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 4 Display Minimum Airspeed
Maximum/Minimum Maneuvering Speed Data **Description** The data of a maximum/minimum maneuvering speed that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 5 Display Maximum/Minimum Maneuvering Speed

Interface Characteristics	Source / Destination
Speed Trend Vector Data **Description** The data of a speed trend vector that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 6 Display Speed Trend Vector
Selected Speed Data **Description** The data of a selected speed that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 7 Display Selected Speed
TAS Digits Data **Description** The data of TAS digits that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 8 Display TAS Digits
Speed/AOA Error Data **Description** The data of a speed/AOA error that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 9 Display Speed/AOA Error
Load Factor Data **Description** The data of a load factor that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 10 Display Load Factor

1.1 Display Selected Airspeed

Interface Characteristics	Source / Destination
Selected Airspeed Data **Description** The data of a selected airspeed that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 1 Display Selected Airspeed

1.2 Display Current Speed

Interface Characteristics	Source / Destination
Current Airspeed Data **Description**: The data of a current airspeed that provided for the airspeed indicator. **Type**: Digital **Media**. Computer Data Files	**Input To**: 1.0 The System Shall Display Airspeed Indicator **Output From**: 1.2 Display Current Speed

1.3 Display Maximum Allowable Airspeed

Interface Characteristics	Source / Destination
Maximum Allowable Airspeed Data **Description**: The data of a maximum allowable airspeed that provided for the airspeed indicator. **Type**: Digital **Media**: Computer Data Files	**Input To**: 1.0 The System Shall Display Airspeed Indicator **Output From**: 1.3 Display Maximum Allowable Airspeed

1.4 Display Minimum Airspeed

Interface Characteristics	Source / Destination
Minimum Airspeed Data **Description**: The data of a minimum airspeed that provided for the airspeed indicator. **Type**: Digital **Media**: Computer Data Files	**Input To**: 1.0 The System Shall Display Airspeed Indicator **Output From**: 1.4 Display Minimum Airspeed

1.5 Display Maximum/Minimum Maneuvering Speed

Interface Characteristics	Source / Destination
Maximum/Minimum Maneuvering Speed Data **Description**: The data of a maximum/minimum maneuvering speed that provided for the airspeed indicator. **Type**: Digital **Media**: Computer Data Files	**Input To** 1.0 The System Shall Display Airspeed Indicator **Output From**: 1.5 Display Maximum/Minimum Maneuvering Speed

1.6 Display Speed Trend Vector

Interface Characteristics	Source / Destination
Speed Trend Vector Data **Description**: The data of a speed trend vector that provided for the airspeed indicator. **Type**: Digital **Media**: Computer Data Files	**Input To**: 1.0 The System Shall Display Airspeed Indicator **Output From**: 1.6 Display Speed Trend Vector

1.7 Display Selected Speed

Interface Characteristics	Source / Destination
Selected Speed Data **Description**: The data of a selected speed that provided for the airspeed indicator. **Type**: Digital **Media**: Computer Data Files	**Input To**: 1.0 The System Shall Display Airspeed Indicator **Output From**: 1.7 Display Selected Speed

1.8 Display TAS Digits

Interface Characteristics	Source / Destination
TAS Digits Data **Description** The data of TAS digits that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 8 Display TAS Digits

1.9 Display Speed/AOA Error

Interface Characteristics	Source / Destination
Speed/AOA Error Data **Description** The data of a speed/AOA error that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 9 Display Speed/AOA Error

1.10 Display Load Factor

Interface Characteristics	Source / Destination
Load Factor Data **Description** The data of a load factor that provided for the airspeed indicator **Type** Digital **Media** Computer Data Files	**Input To** 1 0 The System Shall Display Airspeed Indicator **Output From** 1 10 Display Load Factor

2.0 - The System Shall Display Altitude Indicator

Interface Characteristics	Source / Destination
Selected Altitude Data **Description** The data of a selected altitude that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 1 Display Selected Altitude
Altitude Bug Data **Description** The data of an altitude bug that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 2 Display Altitude Bug
Current Attitude Data **Description** The data of a current altitude that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 3 Display Current Altitude
Baromin Pointer Data **Description** The data of a baromin pointer that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 4 Display Baromin Pointer
Altitude Setting Data **Description** The data of an altitude setting that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 5 Display Altitude Setting
Radar/Radio Altitude Data **Description** The data of a radar/radio altitude that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 6 Display Radar/Radio Altitude

2.1 Display Selected Altitude

Interface Characteristics	Source / Destination
Selected Altitude Data **Description**. The data of a selected altitude that provided for the altitude indicator. **Type**: Digital **Media**: Computer Data Files	**Input To**. 2 0 The System Shall Display Altitude Indicator **Output From** 2.1 Display Selected Altitude

2.2 Display Altitude Bug

Interface Characteristics	Source / Destination
Altitude Bug Data **Description** The data of an altitude bug that provided for the altitude indicator. **Type**· Digital **Media**· Computer Data Files	**Input To**: 2.0 The System Shall Display Altitude Indicator **Output From**: 2.2 Display Altitude Bug

2.3 Display Current Altitude

Interface Characteristics	Source / Destination
Current Attitude Data **Description**· The data of a current altitude that provided for the altitude indicator. **Type**: Digital **Media**· Computer Data Files	**Input To**· 2.0 The System Shall Display Altitude Indicator **Output From** 2.3 Display Current Altitude

2.4 Display Baromin Pointer

Interface Characteristics	Source / Destination
Baromin Pointer Data **Description** The data of a baromin pointer that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 4 Display Baromin Pointer

2.5 Display Altitude Setting

Interface Characteristics	Source / Destination
Altitude Setting Data **Description** The data of an altitude setting that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 5 Display Altitude Setting

2.6 Display Radar/Radio Altitude

Interface Characteristics	Source / Destination
Radar/Radio Altitude Data **Description** The data of a radar/radio altitude that provided for the altitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 2 0 The System Shall Display Altitude Indicator **Output From** 2 6 Display Radar/Radio Altitude

3.0 - The System Shall Display Heading/Track Indicator

Interface Characteristics	Source / Destination
Heading Pointer Data **Description** The data of a heading pointer that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 1 Display Heading Pointer
Heading Bug Data **Description** The data of a heading bug that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 2 Display Heading Bug
Heading/Track Reference Data **Description** The data of a heading/track reference that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 3 Display Heading/Track Reference
Selected Heading/Track Data **Description** The data of a selected heading/track that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 4 Display Selected Heading/Track
Selected Course Data **Description** The data of a selected course that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 5 Display Selected Course
Ground Track Data **Description** The data of a ground track that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 6 Display Ground Track

Interface Characteristics	Source / Destination
Track Line Data **Description** The data of a track line that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 7 Display Track Line

3.1 Display Heading Pointer

Interface Characteristics	Source / Destination
Heading Pointer Data **Description** The data of a heading pointer that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 1 Display Heading Pointer

3.2 Display Heading Bug

Interface Characteristics	Source / Destination
Heading Bug Data **Description** The data of a heading bug that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 2 Display Heading Bug

3.3 Display Heading/Track Reference

Interface Characteristics	Source / Destination
Heading/Track Reference Data **Description** The data of a heading/track reference that provided for the heading/track indicator **Type** Digital **Media** Computer Data Files	**Input To** 3 0 The System Shall Display Heading/Track Indicator **Output From** 3 3 Display Heading/Track Reference

Interface Characteristics	Source / Destination
Magnetic North Data **Description** The data of direction of magnetic north that provided for heading/track reference **Type** Digital **Media** Computer Data Files	**Input To** 3 3 Display Heading/Track Reference **Output From** 3 3 1 Display Magnetic North
True North Data **Description** The data of direction of true north that provided for heading/track reference **Type** Digital **Media** Computer Data Files	**Input To** 3 3 Display Heading/Track Reference **Output From** 3 3 2 Display True North

3.3.1 Display Magnetic North

Interface Characteristics	Source / Destination
Magnetic North Data **Description** The data of direction of magnetic north that provided for heading/track reference **Type** Digital **Media** Computer Data Files	**Input To** 3 3 Display Heading/Track Reference **Output From** 3 3 1 Display Magnetic North

3.3.2 Display True North

Interface Characteristics	Source / Destination
True North Data **Description** The data of direction of true north that provided for heading/track reference **Type** Digital **Media** Computer Data Files	**Input To** 3 3 Display Heading/Track Reference **Output From** 3 3 2 Display True North

3.4 Display Selected Heading/Track

Interface Characteristics	Source / Destination
Selected Heading/Track Data **Description**: The data of a selected heading/track that provided for the heading/track indicator **Type**: Digital **Media**: Computer Data Files	**Input To**. 3.0 The System Shall Display Heading/Track Indicator **Output From**: 3 4 Display Selected Heading/Track

3.5 Display Selected Course

Interface Characteristics	Source / Destination
Selected Course Data **Description**: The data of a selected course that provided for the heading/track indicator. **Type**: Digital **Media**. Computer Data Files	**Input To**: 3.0 The System Shall Display Heading/Track Indicator **Output From**: 3.5 Display Selected Course

3.6 Display Ground Track

Interface Characteristics	Source / Destination
Ground Track Data **Description** The data of a ground track that provided for the heading/track indicator. **Type**. Digital **Media**· Computer Data Files	**Input To**: 3.0 The System Shall Display Heading/Track Indicator **Output From**: 3.6 Display Ground Track

3.7 Display Track Line

Interface Characteristics	Source / Destination
Track Line Data **Description** The data of a track lıne that provıded for the headıng/track ındıcator **Type** Dıgıtal **Media** Computer Data Fıles	**Input To** 3 0 The System Shall Dısplay Headıng/Track Indıcator **Output From** 3 7 Dısplay Track Lıne

4.0 - The System Shall Display Vertical Speed Indicator

Interface Characteristics	Source / Destination
Vertical Speed Pointer Data **Description** The data of a vertical speed pointer that provided for the vertical speed indicator **Type** Digital **Media** Computer Data Files	**Input To** 4 0 The System Shall Display Vertical Speed Indicator **Output From** 4 1 Display Vertical Speed Pointer
Vertical Speed Bug Data **Description** The data of a vertical speed bug that provided for the vertical speed indicator **Type** Digital **Media** Computer Data Files	**Input To** 4 0 The System Shall Display Vertical Speed Indicator **Output From** 4 2 Display Vertical Speed Bug
Vertical Speed Data **Description** The data of a vertical speed that provided for the vertical speed indicator **Type** Digital **Media** Computer Data Files	**Input To** 4 0 The System Shall Display Vertical Speed Indicator **Output From** 4 3 Display Vertical Speed

4.1 Display Vertical Speed Pointer

Interface Characteristics	Source / Destination
Vertical Speed Pointer Data **Description** The data of a vertical speed pointer that provided for the vertical speed indicator **Type** Digital **Media** Computer Data Files	**Input To** 4 0 The System Shall Display Vertical Speed Indicator **Output From** 4 1 Display Vertical Speed Pointer

4.2 Display Vertical Speed Bug

Interface Characteristics	Source / Destination
Vertical Speed Bug Data **Description** The data of a vertical speed bug that provided for the vertical speed indicator **Type** Digital **Media** Computer Data Files	**Input To** 4 0 The System Shall Display Vertical Speed Indicator **Output From** 4 2 Display Vertical Speed Bug

4.3 Display Vertical Speed

Interface Characteristics	Source / Destination
Vertical Speed Data **Description** The data of a vertical speed that provided for the vertical speed indicator **Type** Digital **Media** Computer Data Files	**Input To** 4 0 The System Shall Display Vertical Speed Indicator **Output From** 4 3 Display Vertical Speed

5.0 - The System Shall Display Flight Director Indicator

Interface Characteristics	Source / Destination
Fixed Aircraft Symbol Data **Description** The data of a fixed aircraft symbol that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 1 Display Fixed Aircraft Symbol
Flight Director Data **Description** The data of a flight director cue that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 2 Display Flight Director
Pitch and Bank Command Bars Data **Description** The data of pitch and bank command bars that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 3 Display Pitch and Bank Command Bars
Attitude Bug Data **Description** The data of an attitude bug that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 4 Display Attitude Bug
Slip/Skid Indicator Data **Description** The data of a slip/skid indicator that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 5 Display Slip/Skid Indicator (Inclinometer)
Bank Pointer Data **Description** The data of a bank pointer that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 6 Display Bank Pointer

Interface Characteristics	Source / Destination
Horizon Line Data **Description**· The data of a horizon line that provided for the attitude indicator **Type**: Digital **Media**· Computer Data Files	**Input To**. 5 0 The System Shall Display Flight Director Indicator **Output From**: 5.7 Display Horizon Line
Pitch Scale Data **Description**: The data of a pitch scale that provided for the attitude indicator **Type**: Digital **Media**: Computer Data Files	**Input To**: 5 0 The System Shall Display Flight Director Indicator **Output From**: 5 8 Display Pitch Scale
V Bar Data **Description**· The data of a V bar that provided for the attitude indicator **Type**: Digital **Media**: Computer Data Files	**Input To**: 5.0 The System Shall Display Flight Director Indicator **Output From**: 5.9 Display V Bar
Autopilot Indicator Data **Description**. The data of an autopilot indicator that provided for the attitude indicator **Type**: Digital **Media**: Computer Data Files	**Input To**· 5.0 The System Shall Display Flight Director Indicator **Output From**. 5.10 Display Autopilot Indicator

5.1 Display Fixed Aircraft Symbol

Interface Characteristics	Source / Destination
Fixed Aircraft Symbol Data **Description**: The data of a fixed aircraft symbol that provided for the attitude indicator **Type**: Digital **Media**: Computer Data Files	**Input To** 5.0 The System Shall Display Flight Director Indicator **Output From**: Display Fixed Aircraft Symbol

5.2 Display Flight Director

Interface Characteristics	Source / Destination
Flight Director Data **Description**: The data of a flight director cue that provided for the attitude indicator **Type**: Digital **Media**. Computer Data Files	**Input To**: 5 0 The System Shall Display Flight Director Indicator **Output From**: 5.2 Display Flight Director

5.3 Display Pitch and Bank Command Bars

Interface Characteristics	Source / Destination
Pitch and Bank Command Bars Data **Description**: The data of a pitch and bank command bars that provided for the attitude indicator. **Type**: Digital **Media**: Computer Data Files	**Input To**: 5 0 The System Shall Display Flight Director Indicator **Output From**: 5.3 Display Pitch and Bank Command Bars

5.4 Display Slip/Skid Indicator (Inclinometer)

Interface Characteristics	Source / Destination
Slip/Skid Indicator Data **Description** The data of a slip/skid indicator that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5.0 The System Shall Display Flight Director Indicator **Output From** 5.4 Display Slip/Skid Indicator (Inclinometer)

5.5 Display Bank Pointer

Interface Characteristics	Source / Destination
Bank Pointer Data **Description** The data of a bank pointer that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5.0 The System Shall Display Flight Director Indicator **Output From** 5.5 Display Bank Pointer

5.6 Display Horizon Line

Interface Characteristics	Source / Destination
Horizon Line Data **Description** The data of a horizon line that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5.0 The System Shall Display Flight Director Indicator **Output From** 5.6 Display Horizon Line

5.7 Display Pitch Scale

Interface Characteristics	Source / Destination
Pitch Scale Data **Description** The data of a pitch scale that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 7 Display Pitch Scale

5.8 Display V Bar

Interface Characteristics	Source / Destination
V Bar Data **Description** The data of a V bar that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 8 Display V Bar

5.9 Display Autopilot Indicator

Interface Characteristics	Source / Destination
Autopilot Indicator Data **Description** The data of an autopilot indicator that provided for the attitude indicator **Type** Digital **Media** Computer Data Files	**Input To** 5 0 The System Shall Display Flight Director Indicator **Output From** 5 9 Display Autopilot Indicator

6.0 - The System Shall be Compatible with Head-Up Display

Interface Characteristics	Source / Destination
Pitch Ladder Data **Description** The data of a pitch ladder are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 1 Display Pitch Ladder
Flight Director Cue Data **Description** The data of a flight director cue are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 2 Display Flight Director Cue
Guidance Cue Data **Description** The data of a guidance cue are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 3 Display Guidance Cue (Follow Me Box)
Synthetic Runway Cue Data **Description** The data of a synthetic runway cue are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 4 Display Synthetic Runway Cue
CDM/FPM Data **Description** The data of a CDM/FPM are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 5 Display CDM/FPM
Course Deviation Data **Description** The data of course deviation or lateral aviation are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 6 Display Course Deviation

6.1 Display Pitch Ladder

Interface Characteristics	Source / Destination
Pitch Ladder Data **Description**: The data of a pitch ladder are integrated with the HUD. **Type**: Digital **Media**: Computer Data Files	**Input To**: 6 0 The System Shall be Compatible with Head-Up Display **Output From**: 6.1 Display Pitch Ladder

6.2 Display Flight Director Cue

Interface Characteristics	Source / Destination
Flight Director Cue Data **Description**: The data of a flight director cue are integrated with the HUD. **Type**: Digital **Media**: Computer Data Files	**Input To**: 6.0 The System Shall be Compatible with Head-Up Display **Output From**: 6.2 Display Flight Director Cue

6.3 Display Guidance Cue (Follow Me Box)

Interface Characteristics	Source / Destination
Guidance Cue Data **Description**: The data of a guidance cue are integrated with the HUD. **Type**: Digital **Media**: Computer Data Files	**Input To**: 6 0 The System Shall be Compatible with Head-Up Display **Output From**: 6.3 Display Guidance Cue (Follow Me Box)

6.4 Display Synthetic Runway Cue

Interface Characteristics	Source / Destination
Synthetic Runway Cue Data **Description** The data of a synthetic runway cue are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 4 Display Synthetic Runway Cue

6.5 Display CDM/FPM

Interface Characteristics	Source / Destination
CDM/FPM Data **Description** The data of a CDM/FPM are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 5 Display CDM/FPM

6.6 Display Course Deviation

Interface Characteristics	Source / Destination
Course Deviation Data **Description** The data of course deviation or lateral aviation are integrated with the HUD **Type** Digital **Media** Computer Data Files	**Input To** 6 0 The System Shall be Compatible with Head-Up Display **Output From** 6 6 Display Course Deviation

7.0 - The System Shall Provide Supporting Modes

Interface Characteristics	Source / Destination
VIDEO Text/Graphical Data **Description** The text and graphical data of a video system that provided for displaying the aircraft situations on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 1 Provide VIDEO Mode
Input Signal (7.0-7.1) **Description** A pilot inputs the electronic signal by pushing a button through the VIDEO mode **Type** Analog **Media** Electronic Signal	**Input To** 7 1 Provide VIDEO Mode **Output From** 7 0 The System Shall Provide Supporting Modes
CHARTS Text/Graphical Data **Description** The text and graphical data of charts system that provided for displaying the navigation charts on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 2 Provide CHARTS Mode
Input Signal (7.0-7.2) **Description** A pilot inputs the electronic signal by pushing a button through the CHARTS mode **Type** Analog **Media** Electronic Signal	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 0 The System Shall Provide Supporting Modes
UTILITY Text/Graphical Data **Description** The text and graphical data of a utility system that provided in supporting the aircraft system **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 3 Provide UTILITY Mode

Interface Characteristics	Source / Destination
Input Signal (7.0-7.3) **Description** A pilot inputs the electronic signal by pushing a button through the UTILITY mode **Type** Analog **Media** Electronic Signal	**Input To** 7 3 Provide UTILITY Mode **Output From** 7 0 The System Shall Provide Supporting Modes
GUIDES Text Data **Description** The text data of guides system that provided for displaying the instructions on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 4 Provide GUIDES Mode
Input Signal (7.0-7.4) **Description** A pilot inputs the electronic signal by pushing a button through the GUIDES mode **Type** Analog **Media** Electronic Signal	**Input To** 7 4 Provide GUIDES Mode **Output From** 7 0 The System Shall Provide Supporting Modes
PLAN Text/Graphical Data **Description** The text and graphical data of a plan system that provided for displaying the navigation planning on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 - The System Shall Provide Supporting Modes **Output From** 7 5 Provide PLAN Mode
Input Signal (7.0-7.5) **Description** A pilot inputs the electronic signal by pushing a button through the PLAN mode **Type** Analog **Media** Electronic Signal	**Input To** 7 5 Provide PLAN Mode **Output From** 7 0 The System Shall Provide Supporting Modes
HELPS Text/Graphical Data **Description** The text and graphical data of an assisted information that displayed on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 6 Provide HELPS Mode

Interface Characteristics	Source / Destination
Input Signal (7.0-7.6) **Description** A pilot inputs the electronic signal by pushing a button through the HELPS mode **Type** Analog **Media** Electronic Signal	**Input To** 7 6 Provide HELPS Mode **Output From** 7 0 The System Shall Provide Supporting Modes

7.1 Provide VIDEO Mode

Interface Characteristics	Source / Destination
VIDEO Text/Graphical Data **Description** The text and graphical data of a video system that provided for displaying the aircraft situations on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 1 Provide VIDEO Mode
Input Signal (7.0-7.1) **Description** A pilot inputs the electronic signal by pushing a button through the VIDEO mode **Type** Analog **Media** Electronic Signal	**Input To** 7 1 Provide VIDEO Mode **Output From** 7 0 The System Shall Provide Supporting Modes

7.2 Provide CHARTS Mode

Interface Characteristics	Source / Destination
CHARTS Text/Graphical Data **Description**: The text and graphical data of charts system, used for displaying the navigation charts on the MFD screen. **Type** Digital **Media**: Computer Data Files	**Input To**: 7.0 The System Shall Provide Supporting Modes **Output From**: 7.2 Provide CHARTS Mode
Input Signal (7.0-7.2) **Description**: A pilot inputs the electronic signal by pushing a button through the CHARTS mode **Type**: Analog **Media**: Electronic Signal	**Input To**: 7.2 Provide CHARTS Mode **Output From**. 7.0 The System Shall Provide Supporting Modes
Instrument Approach Procedure Graphical Data **Description**: The graphical data of instrument approach procedure that provided for the navigation charts **Type**: Digital **Media**· Computer Data Files	**Input To**: 7.2 Provide CHARTS Mode **Output From**: 7.2.1 Provide Instrument Approach Procedure Chart
SMGCS Graphical Data **Description**: The graphical data of SMGCS that provided for the navigation charts **Type**: Digital **Media**: Computer Data Files	**Input To**: 7.2 Provide CHARTS Mode **Output From**: 7.2.2 Provide SMGCS Chart
SID Text/Graphical Data **Description**: The text and graphical data of SID that provided for the navigation charts **Type**: Digital **Media**: Computer Data Files	**Input To**: 7.2 Provide CHARTS Mode **Output From**: 7.2.3 Provide SID Chart

Interface Characteristics	Source / Destination
STAR Text/Graphical Data **Description** The text and graphical data of STAR that provided for the navigation charts **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 4 Provide STAR Chart
VFR Terminal Graphical Data **Description** The graphical data of VFR terminal that provided for the navigation charts **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 5 Provide VFR Terminal Chart
Airport Taxi Graphical Data **Description** The graphical data of traffic flow during taxing **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 6 Provide Airport Taxi Chart

7.2.1 Provide Instrument Approach Procedure Chart

Interface Characteristics	Source / Destination
Instrument Approach Procedure Graphical Data **Description** The graphical data of instrument approach procedure that provided for the navigation charts **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 1 Provide Instrument Approach Procedure Chart

7.2.2 Provide SMGCS Chart

Interface Characteristics	Source / Destination
SMGCS Graphical Data **Description** The graphical data of SMGCS that provided for the navigation charts **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 2 Provide SMGCS Chart

7.2.3 Provide SID Chart

Interface Characteristics	Source / Destination
SID Text/Graphical Data **Description** The text and graphical data of SID that provided for the navigation charts **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 3 Provide SID Chart

7.2.4 Provide STAR Chart

Interface Characteristics	Source / Destination
STAR Text/Graphical Data **Description** The text and graphical data of STAR that provided for the navigation charts **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 4 Provide STAR Chart

7.2.5 Provide VFR Terminal Chart

Interface Characteristics	Source / Destination
VFR Terminal Graphical Data **Description** The graphical data of VFR terminal that provided for the navigation charts **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 5 Provide VFR Terminal Chart

7.2.6 Provide Airport Taxi Chart

Interface Characteristics	Source / Destination
Airport Taxi Graphical Data **Description** The graphical data of traffic flow during taxing **Type** Digital **Media** Computer Data Files	**Input To** 7 2 Provide CHARTS Mode **Output From** 7 2 6 Provide Airport Taxi Chart

7.3 Provide UTILITY Mode

Interface Characteristics	Source / Destination
UTILITY Text/Graphical Data **Description** The text and graphical data of a utility system that provided in supporting the aircraft system **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 3 Provide UTILITY Mode
Input Signal (7.0-7.3) **Description** A pilot inputs the electronic signal by pushing a button through the UTILITY mode **Type** Analog **Media** Electronic Signal	**Input To** 7 3 Provide UTILITY Mode **Output From** 7 0 The System Shall Provide Supporting Modes
Reversionary/Back Up Supporting Unit **Description** The reversionary and back up unit that provided for reviewing the flight mode **Type** Physical **Media** Reversionary and Back Up	**Input To** 7 3 Provide UTILITY Mode **Output From** 7 3 1 Provide Reversionary/Back Up Mode
PFD and MFD Interchangeable Switch **Description** The switch is used to interchange between a PFD and a MFD **Type** Analog **Media** Switching Unit	**Input To** 7 3 Provide UTILITY Mode **Output From** 7 3 2 Provide Mode Interchange (PFD/MFD)
PFD and HUD Interchangeable Switch **Description** The switch is used to interchange between a PFD and a HUD **Type** Analog **Media** Switching Unit	**Input To** 7 3 Provide UTILITY Mode **Output From** 7 3 3 Provide Mode Interchange (PFD/HUD)

Interface Characteristics	Source / Destination
Test Procedures **Description** The procedures of testing the flight operation. **Type**: Digital **Media**· Computer Data Files	**Input To** 7 3 Provide UTILITY Mode **Output From** 7.3.4 Implement Testing
Simulating Procedures **Description**: The procedures of simulation, designed to simulate the flight operations **Type**: Digital **Media** Computer Data Files	**Input To**. 7.3 Provide UTILITY Mode **Output From** 7.3.5 Run Simulation

7.3.1 Provide Reversionary/Back Up Mode

Interface Characteristics	Source / Destination
Reversionary/Back Up Supporting Unit **Description** The reversionary and back up unit that provided for reviewing the flight mode. **Type** Physical **Media**· Reversionary and Back Up	**Input To**: 7.3 Provide UTILITY Mode **Output From**: 7.3.1 Provide Reversionary/Back Up Mode

7.3.2 Provide Mode Interchange (PFD/MFD)

Interface Characteristics	Source / Destination
PFD and MFD Interchangeable Switch **Description**: The switch is used to interchange between a PFD and a MFD **Type**: Analog **Media**: Switching Unit	**Input To**. 7.3 Provide UTILITY Mode **Output From**: 7.3.2 Provide Mode Interchange (PFD/MFD)

7.3.3 Provide Mode Interchange (PFD/HUD)

Interface Characteristics	Source / Destination
PFD and HUD Interchangeable Switch **Description**: The switch is used to interchange between a PFD and a HUD **Type**: Analog **Media**: Switching Unit	**Input To**: 7.3 Provide UTILITY Mode **Output From**: 7.3.3 Provide Mode Interchange (PFD/HUD)

7.3.4 Implement Testing

Interface Characteristics	Source / Destination
Test Procedures **Description**: The procedures of testing the flight operation. **Type**: Digital **Media**: Computer Data Files	**Input To**: 7.3 Provide UTILITY Mode **Output From**: 7.3.4 Implement Testing

7.3.5 Run Simulation

Interface Characteristics	Source / Destination
Simulating Procedures **Description**: The procedures of simulation, designed to simulate the flight operations **Type**: Digital **Media**: Computer Data Files	**Input To**: 7.3 Provide UTILITY Mode **Output From**: 7.3.5 Run Simulation

7.4 Provide GUIDES Mode

Interface Characteristics	Source / Destination
GUIDES Text Data **Description** The text data of guides system that provided for displaying the instructions on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 4 Provide GUIDES Mode
Input Signal (7.0-7.4) **Description** A pilot inputs the electronic signal by pushing a button through the GUIDES mode **Type** Analog **Media** Electronic Signal	**Input To** 7 4 Provide GUIDES Mode **Output From** 7 0 The System Shall Provide Supporting Modes
Aircraft Instrument Indicators Instructions **Description** The instructions provided for a pilot how to interpret/read the aircraft instrument indicators **Type** Digital **Media** Computer Data Files	**Input To** 7 4 Provide GUIDES Mode **Output From** 7 4 1 Demonstrate Aircraft Instrument Indicators Instruction
Terrain/Obstruction Display Instructions **Description** The instructions of terrain/obstruction display, guided for a pilot while flying near the terrain/obstruction **Type** Digital **Media** Computer Data Files	**Input To** 7 4 Provide GUIDES Mode **Output From** 7 4 2 Demonstrate Terrain/Obstruction Display Instruction
Weather Display Instructions **Description** The instructions of weather display, guided for a pilot while flying **Type** Digital **Media** Computer Data Files	**Input To** 7 4 Provide GUIDES Mode **Output From** 7 4 3 Demonstrate Weather Display Instruction

Interface Characteristics	Source / Destination
Traffic Display Instructions **Description** The instructions of traffic display, guided for a pilot while flying **Type** Digital **Media** Computer Data Files	**Input To** 7 4 Provide GUIDES Mode **Output From** 7 4 4 Demonstrate Traffic Display Instruction

7.4.1 Demonstrate Aircraft Instrument Indicators Instruction

Interface Characteristics	Source / Destination
Aircraft Instrument Indicators Instructions **Description** The instructions provided for a pilot how to interpret/read the aircraft instrument indicators **Type** Digital **Media** Computer Data Files	**Input To** 7 4 Provide GUIDES Mode **Output From** 7 4 1 Demonstrate Aircraft Instrument Indicators Instruction

7.4.2 Demonstrate Terrain/Obstruction Display Instruction

Interface Characteristics	Source / Destination
Terrain/Obstruction Display Instructions **Description** The instructions of terrain/obstruction display, guided for a pilot while flying near the terrain/obstruction **Type** Digital **Media** Computer Data Files	**Input To** 7 4 Provide GUIDES Mode **Output From** 7 4 2 Demonstrate Terrain/Obstruction Display Instruction

7.4.3 Demonstrate Weather Display Instruction

Interface Characteristics	Source / Destination
Weather Display Instructions **Description**: The instructions of weather display, guided for a pilot while flying. **Type**: Digital **Media** Computer Data Files	**Input To**· 7.4 Provide GUIDES Mode **Output From** 7.4.3 Demonstrate Weather Display Instruction

7.4.4 Demonstrate Traffic Display Instruction

Interface Characteristics	Source / Destination
Traffic Display Instructions **Description** The instructions of traffic display, guided for a pilot while flying. **Type**. Digital **Media**: Computer Data Files	**Input To**: 7.4 Provide GUIDES Mode **Output From**. 7.4.4 Demonstrate Traffic Display Instruction

7.5 Provide PLAN Mode

Interface Characteristics	Source / Destination
PLAN Text/Graphical Data **Description**. The text and graphical data of a plan system that provided for displaying the navigation planning on the MFD screen **Type** Digital **Media**. Computer Data Files	**Input To**. 7.0 The System Shall Provide Supporting Modes **Output From**: 7.5 Provide PLAN Mode
Input Signal (7.0-7.5) **Description**: A pilot inputs the electronic signal by pushing a button through the PLAN mode. **Type**: Analog **Media**: Electronic Signal	**Input To**· 7.5 Provide PLAN Mode **Output From**: 7.0 The System Shall Provide Supporting Modes

Interface Characteristics	Source / Destination
IFR Planning Procedures **Description**: The procedures of IFR planning that displayed on the MFD screen **Type**. Digital **Media**: Computer Data Files	**Input To**· 7.5 Provide PLAN Mode **Output From**. 7.5.1 Demonstrate IFR Planning
VFR Planning Procedures **Description**: The procedures of VFR planning that displayed on the MFD screen. **Type**: Digital **Media**· Computer Data Files	**Input To**: 7.5 Provide PLAN Mode **Output From**: 7.5.2 Demonstrate VFR Planning

7.5.1 Demonstrate IFR Planning

Interface Characteristics	Source / Destination
IFR Planning Procedures **Description**: The procedures of IFR planning that displayed on the MFD screen. **Type**: Digital **Media**: Computer Data Files	**Input To**: 7.5 Provide PLAN Mode **Output From**: 7.5.1 Demonstrate IFR Planning

7.5.2 Demonstrate VFR Planning

Interface Characteristics	Source / Destination
VFR Planning Procedures **Description**. The procedures of VFR planning that displayed on the MFD screen **Type**: Digital **Media**: Computer Data Files	**Input To**: 7.5 Provide PLAN Mode **Output From**: 7.5.2 Demonstrate VFR Planning

7.6 Provide HELPS Mode

Interface Characteristics	Source / Destination
HELPS Text/Graphical Data **Description** The text and graphical data of an assisted information that displayed on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 6 Provide HELPS Mode
Input Signal (7.0-7.6) **Description** A pilot inputs the electronic signal by pushing a button through the HELPS mode **Type** Analog **Media** Electronic Signal	**Input To** 7 6 Provide HELPS Mode **Output From** 7 0 The System Shall Provide Supporting Modes

7.7 Provide EMERGENCY Mode

Interface Characteristics	Source / Destination
Emergency Text Data **Description** The text data of an emergency system that displayed on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 7 0 The System Shall Provide Supporting Modes **Output From** 7 7 Provide EMERGENCY Mode
Input Signal (7.0-7.7) **Description** A pilot inputs the electronic signal by pushing a button through the EMERGENCY mode **Type** Analog **Media** Electronic Signal	**Input To** 7 7 Provide EMERGENCY Mode **Output From** 7 0 The System Shall Provide Supporting Modes
Alternate Power Unit **Description** The alternate power or back up unit of the AGATE aircraft system, which increases the safety level of operations **Type** Physical **Media** Electronic and Electric	**Input To** 7 7 Provide EMERGENCY Mode **Output From** 7 7 1 Supply Alternate Power

Interface Characteristics	Source / Destination
Master Caution/Master Warning Unit **Description** The aircraft master caution/master warning unit of the AGATE aircraft system that provided for in case of emergency situations **Type** Physical **Media** Caution/Warning Unit	**Input To** 7 7 Provide EMERGENCY Mode **Output From** 7 7 2 Supply Aircraft Master Caution/Master Warning
Alternate Memory Unit **Description** The alternate memory of the AGATE aircraft system, which increases the safety level of operations **Type** Physical **Media** Electronic and Electric	**Input To** 7 7 Provide EMERGENCY Mode **Output From** 7 7 3 Supply Alternate Memory

7.7.1 Supply Alternate Power

Interface Characteristics	Source / Destination
Alternate Power Unit **Description** The alternate power or back up unit of the AGATE aircraft system, which increases the safety level of operations **Type** Physical **Media** Electronic and Electric	**Input To** 7 7 Provide EMERGENCY Mode **Output From** 7 7 1 Supply Alternate Power

7.7.2 Supply Aircraft Master Caution/Master Warning

Interface Characteristics	Source / Destination
Master Caution/Master Warning Unit **Description** The aircraft master caution/master warning unit of the AGATE aircraft system that provided for in case of emergency situations **Type** Physical **Media** Caution/Warning Unit	**Input To** 7 7 Provide EMERGENCY Mode **Output From** 7 7 2 Supply Aircraft Master Caution/Master Warning

7.7.3 Supply Alternate Memory

Interface Characteristics	Source / Destination
Alternate Memory Unit **Description** The alternate memory of the AGATE aircraft system, which increases the safety level of operations **Type** Physical **Media** Electronic and Electric	**Input To** 7 7 Provide EMERGENCY Mode **Output From** 7 7 3 Supply Alternate Memory

8.0 - The System Shall Provide Flight Path Control Modes

Interface Characteristics	Source / Destination
APPROACH Text/Graphical Data **Description** The text and graphical data of an instrument approach procedure that displayed on the MFD screen. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.0 The System Shall Provide Flight Path Control Modes **Output From** 8.1 Provide APPROACH Mode
Input Signal (8.0-8.1) **Description**: A pilot inputs the electronic signal by pushing a button through the APPROACH mode. **Type**: Analog **Media**: Electronic Signal	**Input To**: 8.1 Provide APPROACH Mode **Output From**: 8.0 The System Shall Provide Flight Path Control Modes
Flight Management Data **Description**: The flight management data, used in the PFD and MFD. **Type** Mixed **Media**: Computer Data Files	**Input To**: 8.0 The System Shall Provide Flight Path Control Modes **Output From**: 8.2 Provide FMS Mode
Input Signal (8.0-8.2) **Description**· A pilot inputs the electronic signal by pushing a button through the FMS mode. **Type**: Analog **Media**: Electronic Signal	**Input To**: 8.2 Provide FMS Mode **Output From**· 8.0 The System Shall Provide Flight Path Control Modes
Departure Text/Graphical Data **Description**. The text and graphical data of a standard instrument departure that displayed on the MFD screen. **Type** Digital **Media**: Computer Data Files	**Input To**: 8.0 The System Shall Provide Flight Path Control Modes **Output From**: 8.3 Provide SID Mode

Interface Characteristics	Source / Destination
Input Signal (8.0-8.3) **Description**· A pilot inputs the electronic signal by pushing a button through the SID mode **Type**: Analog **Media**: Electronic Signal	**Input To**: 8.3 Provide SID Mode **Output From**: 8.0 The System Shall Provide Flight Path Control Modes
Arrival Text/Graphical Data **Description**: The text and graphical data of a standard terminal arrival route procedure that displayed on the MFD screen. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.0 The System Shall Provide Flight Path Control Modes **Output From**: 8.4 Provide STAR Mode
Input Signal (8.0-8.4) **Description**: A pilot inputs the electronic signal by pushing a button through the STAR mode. **Type**: Analog **Media**. Electronic Signal	**Input To**: 8.4 Provide STAR Mode **Output From**: 8.0 The System Shall Provide Flight Path Control Modes
VFR Text Data **Description**: The text data of a visual flight rule procedure that displayed on the MFD screen **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.0 The System Shall Provide Flight Path Control Modes **Output From**: 8.5 Provide VFR Mode
Input Signal (8.0-8.5) **Description**: A pilot inputs the electronic signal by pushing a button through the VFR mode **Type**: Analog **Media**: Electronic Signal	**Input To**: 8.5 Provide VFR Mode **Output From**: 8.0 The System Shall Provide Flight Path Control Modes
VFR Text Data **Description**: The text data of a visual flight rule procedure that displayed on the MFD screen. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.0 The System Shall Provide Flight Path Control Modes **Output From**: 8.5 Provide VFR Mode

Interface Characteristics	Source / Destination
Input Signal (8.0-8.6) **Description**: A pilot inputs the electronic signal by pushing a button through the TAXI mode. **Type**: Analog **Media**: Electronic Signal	**Input To**: 8.6 Provide TAXI Mode **Output From**: 8.0 The System Shall Provide Flight Path Control Modes

8.1 Provide APPROACH Mode

Interface Characteristics	Source / Destination
APPROACH Text/Graphical Data **Description**: The text and graphical data of an instrument approach procedure that displayed on the MFD screen. **Type** Digital **Media**: Computer Data Files	**Input To**: 8.0 The System Shall Provide Flight Path Control Modes **Output From**: 8.1 Provide APPROACH Mode
Input Signal (8.0-8.1) **Description**: A pilot inputs the electronic signal by pushing a button through the APPROACH mode **Type**: Analog **Media**: Electronic Signal	**Input To**: 8.1 Provide APPROACH Mode **Output From**: 8.0 The System Shall Provide Flight Path Control Modes
Initial Approach Procedures **Description**: The procedures of initial approach that provided for the instrument approach. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.1 Provide APPROACH Mode **Output From**: 8.1.1 Demonstrate Initial Approach
Intermediate Approach Procedures **Description**: The procedures of intermediate approach that provided for the instrument approach. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.1 Provide APPROACH Mode **Output From**: 8.1.2 Demonstrate Intermediate Approach

Interface Characteristics	Source / Destination
Final Approach Procedures **Description** The procedures of final approach that provided for the instrument approach **Type** Digital **Media** Computer Data Files	**Input To** 8 1 Provide APPROACH Mode **Output From** 8 1 3 Demonstrate Final Approach
Missed Approach Procedures **Description** The procedures of missed approach that provided for the instrument approach **Type** Digital **Media** Computer Data Files	**Input To** 8 1 Provide APPROACH Mode **Output From** 8 1 4 Demonstrate Missed Approach

8.1.1 Demonstrate Initial Approach

Interface Characteristics	Source / Destination
Initial Approach Procedures **Description** The procedures of initial approach that provided for the instrument approach **Type** Digital **Media** Computer Data Files	**Input To** 8 1 Provide APPROACH Mode **Output From** 8 1 1 Demonstrate Initial Approach

8.1.2 Demonstrate Intermediate Approach

Interface Characteristics	Source / Destination
Intermediate Approach Procedures **Description** The procedures of intermediate approach that provided for the instrument approach **Type** Digital **Media** Computer Data Files	**Input To** 8 1 Provide APPROACH Mode **Output From** 8 1 2 Demonstrate Intermediate Approach

8.1.3 Demonstrate Final Approach

Interface Characteristics	Source / Destination
Final Approach Procedures **Description**: The procedures of final approach that provided for the instrument approach. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.1 Provide APPROACH Mode **Output From**: 8.1.3 Demonstrate Final Approach

8.1.4 Demonstrate Missed Approach

Interface Characteristics	Source / Destination
Missed Approach Procedures **Description**: The procedures of missed approach that provided for the instrument approach. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.1 Provide APPROACH Mode **Output From**: 8.1.4 Demonstrate Missed Approach

8.2 Provide FMS Mode

Interface Characteristics	Source / Destination
Flight Management Data **Description**: The flight management data that used in the PFD and MFD. **Type**: Mixed **Media**: Computer Data Files	**Input To**: 8.0 The System Shall Provide Flight Path Control Modes **Output From**: 8.2 Provide FMS Mode
Input Signal (8.0-8.2) **Description**: A pilot inputs the electronic signal by pushing a button through the FMS mode. **Type**: Analog **Media**: Electronic Signal	**Input To**: 8.2 Provide FMS Mode **Output From**: 8.0 The System Shall Provide Flight Path Control Modes

8.3 Provide SID Mode

Interface Characteristics	Source / Destination
Departure Text/Graphical Data **Description**. The text and graphical data of a standard instrument departure that displayed on the MFD screen. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8 0 The System Shall Provide Flight Path Control Modes **Output From**. 8.3 Provide SID Mode
Input Signal (8.0-8.3) **Description**· A pilot inputs the electronic signal by pushing a button through the SID mode. **Type**: Analog **Media**: Electronic Signal	**Input To**: 8.3 Provide SID Mode **Output From** 8.0 The System Shall Provide Flight Path Control Modes
Pilot Navigation SIDs Procedures **Description**: The procedure of pilot navigation SID that provided for the SID procedure **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.3 Provide SID Mode **Output From**: 8.3.1 Demonstrate Pilot Navigation SIDs
Vector SIDs Procedures **Description**· The procedure of vector SID that provided for the SID procedure **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.3 Provide SID Mode **Output From**· 8.3.2 Demonstrate Vector SIDs

8.3.1 Demonstrate Pilot Navigation SIDs

Interface Characteristics	Source / Destination
Pilot Navigation SIDs Procedures **Description**: The procedure of pilot navigation SID that provided for the SID procedure. **Type**: Digital **Media**: Computer Data Files	**Input To**: 8.3 Provide SID Mode **Output From**: 8.3.1 Demonstrate Pilot Navigation SIDs

8.3.2 Demonstrate Vector SIDs

Interface Characteristics	Source / Destination
Vector SIDs Procedures **Description** The procedure of vector SID that provided for the SID procedure **Type** Digital **Media** Computer Data Files	**Input To** 8 3 Provide SID Mode **Output From** 8 3 2 Demonstrate Vector SIDs

8.4 Provide STAR Mode

Interface Characteristics	Source / Destination
Arrival Text/Graphical Data **Description** The text and graphical data of a standard terminal arrival route procedure that displayed on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 8 0 The System Shall Provide Flight Path Control Modes **Output From** 8 4 Provide STAR Mode
Input Signal (8.0-8.4) **Description** A pilot inputs the electronic signal by pushing a button through the STAR mode **Type** Analog **Media** Electronic Signal	**Input To** 8 4 Provide STAR Mode **Output From** 8 0 The System Shall Provide Flight Path Control Modes
Lateral/Vertical Navigation **Description** The text and graphical data of a standard terminal arrival route procedure that displayed on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 8 4 Provide SID Mode **Output From** 8 4 1 Pilot Navigation SIDs
Vertical Navigation **Description** The text data of a visual flight rule procedure that displayed on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 8 4 Provide SID Mode **Output From** 8 4 2 Pilot Navigation SIDs

8.4.1 Demonstrate Descent Via (Lateral/Vertical Navigation)

Interface Characteristics	Source / Destination
Lateral/Vertical Navigation **Description** A normal descent clearance for lateral and vertical navigation **Type** Digital **Media** Computer Data Files	**Input To** 8 4 Provide SID Mode **Output From** 8 4 1 Demonstrate Descent Via (Lateral/Vertical Navigation)

8.4.2 Demonstrate Descent Via (Vertical Navigation)

Interface Characteristics	Source / Destination
Vertical Navigation **Description** A normal descent clearance for vertical navigation **Type** Digital **Media** Computer Data Files	**Input To** 8 4 Provide SID Mode **Output From** 8 4 2 Demonstrate Descent Via (Vertical Navigation)

8.5 Provide VFR Mode

Interface Characteristics	Source / Destination
VFR Text Data **Description** The text data of a visual flight rule procedure that displayed on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 8 0 The System Shall Provide Flight Path Control Modes **Output From** 8 5 Provide VFR Mode
Input Signal (8.0-8.5) **Description** A pilot inputs the electronic signal by pushing a button through the VFR mode **Type** Analog **Media** Electronic Signal	**Input To** 8 5 Provide VFR Mode **Output From** 8 0 The System Shall Provide Flight Path Control Modes

Interface Characteristics	Source / Destination
MVFR Data **Description** The data of MVFR that provided for the VFR procedure **Type** Digital **Media** Computer Data Files	**Input To** 8 5 Provide VFR Mode **Output From** 8 5 1 MVFR
VFR Data **Description** The data of VFR that provided for the VFR procedure **Type** Digital **Media** Computer Data Files	**Input To** 8 5 Provide VFR Mode **Output From** 8 5 2 VFR

8.5.1 MVFR

Interface Characteristics	Source / Destination
MVFR Data **Description** The data of MVFR that provided for the VFR procedure **Type** Digital **Media** Computer Data Files	**Input To** 8 5 Provide VFR Mode **Output From** 8 5 1 MVFR

8.5.2 VFR

Interface Characteristics	Source / Destination
VFR Data **Description** The data of VFR that provided for the VFR procedure **Type** Digital **Media** Computer Data Files	**Input To** 8 5 Provide VFR Mode **Output From** 8 5 2 VFR

8.6 Provide TAXI Mode

Interface Characteristics	Source / Destination
TAXI Graphical Data **Description** The graphical data of a taxi procedure that displayed on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 8 0 The System Shall Provide Flight Path Control Modes **Output From** 8 6 Provide TAXI Mode
Input Signal (8.0-8.6) **Description** A pilot inputs the electronic signal by pushing a button through the TAXI mode **Type** Analog **Media** Electronic Signal	**Input To** 8 6 Provide TAXI Mode **Output From** 8 0 The System Shall Provide Flight Path Control Modes
Taxi prior to Departure Procedures **Description** The display of taxi movement prior to departure **Type** Digital **Media** Computer Data Files	**Input To** 8 6 Provide TAXI Mode **Output From** 8 6 1 Demonstrate Taxi prior to Departure
Taxi after Landing Procedures **Description** The display of taxi movement after landing **Type** Digital **Media** Computer Data Files	**Input To** 8 6 Provide TAXI Mode **Output From** 8 6 2 Demonstrate Taxi after Landing

8.6.1 Demonstrate Taxi prior to Departure

Interface Characteristics	Source / Destination
Taxi prior to Departure Procedures **Description** The display of taxi movement prior to departure **Type** Digital **Media** Computer Data Files	**Input To** 8 6 Provide TAXI Mode **Output From** 8 6 1 Demonstrate Taxi prior to Departure

8.6.2 Demonstrate Taxi after Landing

Interface Characteristics	Source / Destination
Taxi after Landing Procedures **Description** The dısplay of taxı movement after landıng **Type** Dıgıtal **Media** Computer Data Fıles	**Input To** 8 6 Provıde TAXI Mode **Output From** 8 6 2 Demonstrate Taxı after Landıng

9.0 - The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction

Interface Characteristics	Source / Destination
Terrain Graphical Data **Description**: The graphical data of terrain that provided for the terrain/obstruction display **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.1 Display Terrain
Mountainous Obscuration Graphical Data **Description**: The graphical data of mountainous obscuration that provided for the terrain/obstruction display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.2 Display Mountainous Obscuration
Hidden Obstacles Graphical Data **Description**: The graphical data of hidden obstacles that provided for the terrain/obstruction display **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9 3 Display Hidden Obstacles
Hazard Materials Graphical Data **Description**: The graphical data of hazard materials that provided for the terrain/obstruction display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.4 Display Hazard Materials
Obstruction Graphical Data **Description**: The graphical data of obstruction that provided for the terrain/obstruction display **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.5 Display Obstruction

9.1 Display Terrain

Interface Characteristics	Source / Destination
Terrain Graphical Data **Description**. The graphical data of terrain that provided for the terrain/obstruction display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.1 Display Terrain

9.2 Display Mountainous Obscuration

Interface Characteristics	Source / Destination
Mountainous Obscuration Graphical Data **Description**: The graphical data of mountainous obscuration that provided for the terrain/obstruction display **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.2 Display Mountainous Obscuration

9.3 Display Hidden Obstacles

Interface Characteristics	Source / Destination
Hidden Obstacles Graphical Data **Description**: The graphical data of hidden obstacles that provided for the terrain/obstruction display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.3 Display Hidden Obstacles

9.4 Display Hazard Materials

Interface Characteristics	Source / Destination
Hazard Materials Graphical Data **Description**. The graphical data of hazard materials that provided for the terrain/obstruction display. **Type**: Digital **Media**. Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.4 Display Hazard Materials

9.5 Display Obstruction

Interface Characteristics	Source / Destination
Obstruction Graphical Data **Description**: The graphical data of obstruction that provided for the terrain/obstruction display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 9.0 The System Shall Display a 4D Synthetic Vision of Terrain/Obstruction **Output From**: 9.5 Display Obstruction

10.0 - The System Shall Display a 4D Synthetic Vision of Weather

Interface Characteristics	Source / Destination
Precipitation Graphical Data **Description** The graphical data of precipitation that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 1 Display Precipitation
Thunderstorm Graphical Data **Description** The graphical data of thunderstorm that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 2 Display Thunderstorm
Lightning Graphical Data **Description** The graphical data of lightning that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 3 Display Lightning
Ceilings Graphical Data **Description** The graphical data of ceilings that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 4 Display Ceiling
Visibility Graphical Data **Description** The graphical data of visibility that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 5 Display Visibility
Wind Speed and Direction Text/Graphical Data **Description** The text and graphical data of wind speed and direction that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 6 Display Wind Speed and Direction

Surface and Upper Air Graphical Data **Description** The graphical data of surface and upper air that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 7 Display Surface and Upper Air
Icing Potential Graphical Data **Description** The graphical data of icing potential that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 - The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 8 Display Icing Potential
Convection Graphical Data **Description** The graphical data of convection that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 9 Display Convection
Turbulence Graphical Data **Description** The graphical data of turbulence that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 10 Display Turbulence
Volcanic Ash Graphical Data **Description** The graphical data of volcanic ash that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 11 Display Volcanic Ash

10.1 Display Precipitation

Interface Characteristics	Source / Destination
Precipitation Graphical Data **Description** The graphical data of precipitation that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 1 Display Precipitation

10.2 Display Thunderstorm

Interface Characteristics	Source / Destination
Thunderstorm Graphical Data **Description** The graphical data of thunderstorm that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 2 Display Thunderstorm

10.3 Display Lightning

Interface Characteristics	Source / Destination
Lightning Graphical Data **Description** The graphical data of lightning that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 3 Display Lightning

10.4 Display Ceiling

Interface Characteristics	Source / Destination
Ceilings Graphical Data **Description** The graphical data of ceilings that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 4 Display Ceiling

10.5 Display Visibility

Interface Characteristics	Source / Destination
Visibility Graphical Data **Description** The graphical data of visibility that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 5 Display Visibility
Flight Visibility Data **Description** The data of flight visibility that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 5 Display Visibility **Output From** 10 5 1 Display Flight Visibility
Ground Visibility Data **Description** The data of ground visibility that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 5 Display Visibility **Output From** 10 5 2 Display Ground Visibility
RVR Data **Description** The data of RVR that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 5 Display Visibility **Output From** 10 5 3 Display RVR

10.5.1 Display Flight Visibility

Interface Characteristics	Source / Destination
Flight Visibility Data **Description**: The data of flight visibility that provided for the weather display. **Type**: Digital **Media**· Computer Data Files	**Input To**: 10.5 Display Visibility **Output From**: 10 5.1 Display Flight Visibility

10.5.2 Display Ground Visibility

Interface Characteristics	Source / Destination
Ground Visibility Data **Description** The data of ground visibility that provided for the weather display. **Type** Digital **Media**· Computer Data Files	**Input To**: 10.5 Display Visibility **Output From**: 10.5.2 Display Ground Visibility

10.5.3 Display RVR

Interface Characteristics	Source / Destination
RVR Data **Description**. The data of RVR that provided for the weather display **Type** Digital **Media**. Computer Data Files	**Input To**: 10.5 Display Visibility **Output From**: 10.5.3 Display RVR

10.6 Display Wind Speed and Direction

Interface Characteristics	Source / Destination
Wind Speed and Direction Text/Graphical Data **Description**: The text and graphical data of wind speed and direction that provided for the weather display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 10.0 The System Shall Display a 4D Synthetic Vision of Weather **Output From**: 10.6 Display Wind Speed and Direction

10.7 Display Surface and Upper Air

Interface Characteristics	Source / Destination
Surface and Upper Air Graphical Data **Description**: The graphical data of surface and upper air that provided for the weather display **Type**: Digital **Media**: Computer Data Files	**Input To**: 10.0 The System Shall Display a 4D Synthetic Vision of Weather **Output From**: 10.7 Display Surface and Upper Air

10.8 Display Icing Potential

Interface Characteristics	Source / Destination
Icing Potential Graphical Data **Description**: The graphical data of icing potential that provided for the weather display **Type**. Digital **Media**: Computer Data Files	**Input To**: 10.0 The System Shall Display a 4D Synthetic Vision of Weather **Output From**: 10.8 Display Icing Potential
Structure Icing Data **Description**: The data of structure icing that provided for the icing potential display **Type**: Digital **Media**: Computer Data Files	**Input To**: 10.8 Display Icing Potential **Output From**: 10.8.1 Display Structure Icing

Interface Characteristics	Source / Destination
Induction Icing Data **Description** The data of induction icing that provided for the icing potential display **Type** Digital **Media** Computer Data Files	**Input To** 10 8 Display Icing Potential **Output From** 10 8 2 Display Induction Icing

10.8.1 Display Structure Icing

Interface Characteristics	Source / Destination
Structure Icing Data **Description** The data of structure icing that provided for the icing potential display **Type** Digital **Media** Computer Data Files	**Input To** 10 8 Display Icing Potential **Output From** 10 8 1 Display Structure Icing

10.8.2 Display Induction Icing

Interface Characteristics	Source / Destination
Induction Icing Data **Description** The data of induction icing that provided for the icing potential display **Type** Digital **Media** Computer Data Files	**Input To** 10 8 Display Icing Potential **Output From** 10 8 2 Display Induction Icing

10.9 Display Convection

Interface Characteristics	Source / Destination
Convection Graphical Data **Description** The graphical data of convection that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 9 Display Convection

10.10 Display Turbulence

Interface Characteristics	Source / Destination
Turbulence Graphical Data **Description** The graphical data of turbulence that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 10 Display Turbulence

10.11 Display Volcanic Ash

Interface Characteristics	Source / Destination
Volcanic Ash Graphical Data **Description** The graphical data of volcanic ash that provided for the weather display **Type** Digital **Media** Computer Data Files	**Input To** 10 0 The System Shall Display a 4D Synthetic Vision of Weather **Output From** 10 11 Display Volcanic Ash

11.0 - The System Shall Display a 4D Synthetic Vision of Traffic

Interface Characteristics	Source / Destination
Ground Traffic Flow Graphical Data **Description** The graphical data of traffic flow during ground movement **Type** Digital **Media** Computer Data Files	**Input To** 11 0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From** 11 1 Display Ground Traffic Flow
Air Traffic Flow Graphical Data **Description** The graphical data of traffic flow during flying **Type** Digital **Media** Computer Data Files	**Input To** 11 0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From** 11 2 Display Air Traffic Flow
Traffic Flow during Approach Graphical Data **Description** The graphical data of traffic flow during approach **Type** Digital **Media** Computer Data Files	**Input To** 11 0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From** 11 3 Display Traffic Flow during Approach
Traffic Conflict Area Graphical Data **Description** The graphical data of the traffic during congestion **Type** Digital **Media** Computer Data Files	**Input To** 11 0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From** 11 4 Display Traffic Conflict Area
Collision Zones Graphical Data **Description** The graphical data of potentially dangerous collision zones **Type** Digital **Media** Computer Data Files	**Input To** 11 0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From** 11 5 Display Collision Zones

11.1 Display Ground Traffic Flow

Interface Characteristics	Source / Destination
Ground Traffic Flow Graphical Data **Description** The graphical data of traffic flow during ground movement **Type** Digital **Media** Computer Data Files	**Input To** 11 0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From** 11 1 Display Ground Traffic Flow
Traffic on Ramp Graphical Data **Description** The graphical data of traffic on ramp that provided for the ground traffic flow display **Type** Digital **Media** Computer Data Files	**Input To** 11 1 Display Ground Traffic Flow **Output From** 11 1 1 Display Traffic on Ramp
Traffic during Taxi Graphical Data **Description** The graphical data of traffic during taxi that provided for the ground traffic flow display **Type** Digital **Media** Computer Data Files	**Input To** 11 1 Display Ground Traffic Flow **Output From** 11 1 2 Display Traffic during Taxi
Traffic during Holding Graphical Data **Description** The graphical data of traffic during holding that provided for the ground traffic flow display **Type** Digital **Media** Computer Data Files	**Input To** 11 1 Display Ground Traffic Flow **Output From** 11 1 3 Display Traffic during Holding
Traffic during Takeoff Graphical Data **Description** The graphical data of traffic during takeoff that provided for the ground traffic flow display **Type** Digital **Media** Computer Data Files	**Input To** 11 1 Display Ground Traffic Flow **Output From** 11 1 4 Display Traffic during Takeoff

11.1.1 Display Traffic on Ramp

Interface Characteristics	Source / Destination
Traffic on Ramp Graphical Data **Description** The graphical data of traffic on ramp that provided for the ground traffic flow display. **Type**: Digital **Media**. Computer Data Files	**Input To**: 11.1 Display Ground Traffic Flow **Output From**: 11.1.1 Display Traffic on Ramp

11.1.2 Display Traffic during Taxi

Interface Characteristics	Source / Destination
Traffic during Taxi Graphical Data **Description**. The graphical data of traffic during taxi that provided for the ground traffic flow display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 11.1 Display Ground Traffic Flow **Output From**: 11.1.2 Display Traffic during Taxi

11.1.3 Display Traffic during Holding

Interface Characteristics	Source / Destination
Traffic during Holding Graphical Data **Description**: The graphical data of traffic during holding that provided for the ground traffic flow display **Type**. Digital **Media**: Computer Data Files	**Input To**. 11.1 Display Ground Traffic Flow **Output From**: 11.1.3 Display Traffic during Holding

11.1.4 Display Traffic during Takeoff

Interface Characteristics	Source / Destination
Traffic during Takeoff Graphical Data **Description**: The graphical data of traffic during takeoff that provided for the ground traffic flow display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 11.1 Display Ground Traffic Flow **Output From**. 11.1.4 Display Traffic during Takeoff

11.2 Display Air Traffic Flow

Interface Characteristics	Source / Destination
Air Traffic Flow Graphical Data **Description**: The graphical data of traffic flow during flying **Type**: Digital **Media**: Computer Data Files	**Input To**: 11.0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From**: 11.2 Display Air Traffic Flow
Traffic during Climb Graphical Data **Description** The graphical data of traffic during climbing that provided for the air traffic flow display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 11.2 Display Air Traffic Flow **Output From**: 11.2.1 Display Traffic during Climb
Traffic during Cruise Graphical Data **Description** The graphical data of traffic during cruising that provided for the air traffic flow display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 11.2 Display Air Traffic Flow **Output From**: 11.2.2 Display Traffic during Cruise

Interface Characteristics	Source / Destination
Traffic during Descend Graphical Data **Description**: The graphical data of traffic during descending that provided for the air traffic flow display. **Type**: Digital **Media** Computer Data Files	**Input To**: 11.2 Display Air Traffic Flow **Output From**: 11.2.3 Display Traffic during Descend

11.2.1 Display Traffic during Climb

Interface Characteristics	Source / Destination
Traffic during Climb Graphical Data **Description**: The graphical data of traffic during climbing that provided for the air traffic flow display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 11.2 Display Air Traffic Flow **Output From**: 11.2.1 Display Traffic during Climb

11.2.2 Display Traffic during Cruise

Interface Characteristics	Source / Destination
Traffic during Cruise Graphical Data **Description**: The graphical data of traffic during cruising that provided for the air traffic flow display. **Type**: Digital **Media**: Computer Data Files	**Input To**: 11.2 Display Air Traffic Flow **Output From**: 11.2.2 Display Traffic during Cruise

11.2.3 Display Traffic during Descend

Interface Characteristics	Source / Destination
Traffic during Descend Graphical Data **Description**: The graphical data of traffic during descending that provided for the air traffic flow display. **Type**. Digital **Media**: Computer Data Files	**Input To**: 11.2 Display Air Traffic Flow **Output From**: 11.2.3 Display Traffic during Descend

11.3 Display Traffic Flow during Approach

Interface Characteristics	Source / Destination
Traffic Flow during Approach Graphical Data **Description**: The graphical data of traffic flow during approach. **Type**. Digital **Media**· Computer Data Files	**Input To**: 11.0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From**: 11.3 Display Traffic Flow during Approach
Upwind Leg Approach Graphical Data **Description**: The graphical data of traffic flow during the upwind leg approach pattern **Type**. Digital **Media**: Computer Data Files	**Input To**· 11.3 Display Traffic Flow during Approach **Output From**: 11.3.1 Upwind Leg
Crosswind Leg Approach Graphical Data **Description**: The graphical data of traffic flow during the crosswind leg approach pattern. **Type**: Digital **Media**: Computer Data Files	**Input To**: 11.3 Display Traffic Flow during Approach **Output From**: 11.3.2 Crosswind Leg

Interface Characteristics	Source / Destination
Base Leg Approach Graphical Data **Description** The graphical data of traffic flow during the base leg approach pattern **Type** Digital **Media** Computer Data Files	**Input To** 11 3 Display Traffic Flow during Approach **Output From** 11 3 3 Base Leg
Final Approach Graphical Data **Description** The graphical data of final approach that provided on the MFD screen **Type** Digital **Media** Computer Data Files	**Input To** 11 3 Display Traffic Flow during Approach **Output From** 11 3 4 Final Approach

11.3.1 Upwind Leg

Interface Characteristics	Source / Destination
Upwind Leg Approach Graphical Data **Description** The graphical data of traffic flow during the upwind leg approach pattern **Type** Digital **Media** Computer Data Files	**Input To** 11 3 Display Traffic Flow during Approach **Output From** 11 3 1 Upwind Leg

11.3.2 Crosswind Leg

Interface Characteristics	Source / Destination
Crosswind Leg Approach Graphical Data **Description** The graphical data of traffic flow during the crosswind leg approach pattern **Type** Digital **Media** Computer Data Files	**Input To** 11 3 Display Traffic Flow during Approach **Output From** 11 3 2 Crosswind Leg

11.3.3 Base Leg

Interface Characteristics	Source / Destination
Base Leg Approach Graphical Data **Description** The graphıcal data of traffic flow durıng the base leg approach pattern **Type** Dıgıtal **Media** Computer Data Fıles	**Input To** 11 3 Dısplay Traffic Flow durıng Approach **Output From** 11 3 3 Base Leg

11.3.4 Final Approach

Interface Characteristics	Source / Destination
Final Approach Graphical Data **Description** The graphıcal data of final approach that provıded on the MFD screen **Type** Dıgıtal **Media** Computer Data Fıles	**Input To** 11 3 Dısplay Traffic Flow durıng Approach **Output From** 11 3 4 Fınal Approach

11.4 Display Traffic Conflict Area

Interface Characteristics	Source / Destination
Traffic Conflict Area Graphical Data **Description** The graphıcal data of the traffic durıng congestıon **Type** Dıgıtal **Media** Computer Data Fıles	**Input To** 11 0 The System Shall Dısplay a 4D Synthetıc Vısıon of Traffic **Output From** 11 4 Dısplay Traffic Conflıct Area

11.5 Display Collision Zones

Interface Characteristics	Source / Destination
Collision Zones Graphical Data **Description** The graphical data of potentially dangerous collision zones **Type** Digital **Media** Computer Data Files	**Input To** 11 0 The System Shall Display a 4D Synthetic Vision of Traffic **Output From** 11 5 Display Collision Zones

12.0 - The System Shall Offer Real-Time System

Interface Characteristics	Source / Destination
Real-Time Hardware Components **Description** The hardware system programs of a real-time system **Type**: Physical **Media**: Hardware Unit	**Input To** 12.0 The System Shall Offer Real-Time System **Output From**: 12.1 Provide Real-Time Hardware
Real-Time Operating System Programs **Description**: The operating system programs of a real-time system. **Type**· Digital **Media**. Computer Data Files	**Input To**: 12.0 The System Shall Offer Real-Time System **Output From**: 12.2 Provide Real-Time Operating Systems
Real-Time Software Programs **Description**· The software programs of a real-time system. **Type**· Digital **Media**. Computer Data Files	**Input To**: 12.0 The System Shall Offer Real-Time System **Output From**: 12.3 Provide Real-Time Software
Real-Time Databases **Description**· The databases program of a real-time system. **Type**. Digital **Media** Computer Data Files	**Input To**: 12.0 The System Shall Offer Real-Time System **Output From**: 12.4 Provide Real-Time Database

12.1 Provide Real-Time Hardware

Interface Characteristics	Source / Destination
Real-Time Hardware Components **Description** The hardware system programs of a real-time system **Type**: Physical **Media**. Hardware Unit	**Input To**: 12.0 The System Shall Offer Real-Time System **Output From** 12.1 Provide Real-Time Hardware

12.2 Provide Real-Time Operating Systems

Interface Characteristics	Source / Destination
Real-Time Operating System Programs **Description** The operating system programs of a real-time system **Type** Digital **Media** Computer Data Files	**Input To** 12 0 The System Shall Offer Real-Time System **Output From** 12 2 Provide Real-Time Operating Systems

12.3 Provide Real-Time Software

Interface Characteristics	Source / Destination
Real-Time Software Programs **Description** The software programs of a real-time system **Type** Digital **Media** Computer Data Files	**Input To** 12 0 The System Shall Offer Real-Time System **Output From** 12 3 Provide Real-Time Software

12.4 Provide Real-Time Database

Interface Characteristics	Source / Destination
Real-Time Databases **Description** The databases program of a real-time system **Type** Digital **Media** Computer Data Files	**Input To** 12 0 The System Shall Offer Real-Time System **Output From** 12 4 Provide Real-Time Database
Terrain/Obstruction Databases **Description** The databases of terrain/obstruction that provided for the real-time databases program **Type** Digital **Media** Computer Data Files	**Input To** 12 4 Provide Real-Time Database **Output From** 12 4 1 Provide Terrain/Obstruction Database

Interface Characteristics	Source / Destination
Weather Databases **Description** The databases of weather that provided for the real-time databases program **Type** Digital **Media** Computer Data Files	**Input To** 12 4 Provide Real-Time Database **Output From** 12 4 2 Provide Weather Database
Traffic Databases **Description** The databases of traffic that provided for the real-time databases program **Type** Digital **Media** Computer Data Files	**Input To** 12 4 Provide Real-Time Database **Output From** 12 4 3 Provide Traffic Database

12.4.1 Provide Terrain/Obstruction Database

Interface Characteristics	Source / Destination
Terrain/Obstruction Databases **Description** The databases of terrain/obstruction that provided for the real-time databases program **Type** Digital **Media** Computer Data Files	**Input To** 12 4 Provide Real-Time Database **Output From** 12 4 1 Provide Terrain/Obstruction Database

12.4.2 Provide Weather Database

Interface Characteristics	Source / Destination
Weather Databases **Description** The databases of weather that provided for the real-time databases program **Type** Digital **Media** Computer Data Files	**Input To** 12 4 Provide Real-Time Database **Output From** 12 4 2 Provide Weather Database

12.4.3 Provide Traffic Database

Interface Characteristics	Source / Destination
Traffic Databases **Description**: The databases of traffic that provided for the real-time databases program. **Type**. Digital **Media**: Computer Data Files	**Input To** 12 4 Provide Real-Time Database **Output From**. 12 4 3 Provide Traffic Database

13.0 - The System Shall Provide Liquid Crystal Display (LCD)

Interface Characteristics	Source / Destination
Resolution **Description** The electronic signal of resolution, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 1 Provide High Solution
Contrast **Description** The electronic signal of contrast, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 2 Provide Contrast in High Ambient Light
Brightness **Description** The electronic signal of brightness, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 3 Provide High Brightness
Gray Scale **Description** The electronic signal of gray scale, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 4 Provide High Gray Scale
Modulation **Description** The electronic signal of modulation, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 5 Provide High Modulation
Uniformity **Description** The electronic signal of uniformity, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 6 Provide High Uniformity

Interface Characteristics	Source / Destination
Viewing Angle **Description** The electronic signal of viewing angle, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 7 Provide Wide Viewing Angle
Photo-Realistic **Description** The electronic signal of photo-realistic, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 8 Reproduce Photo-Realistic on Display Screen
Symbol/String **Description** The electronic signal of symbol/string, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 9 Provide Automatic Blink Symbol/String
Shading **Description** The electronic signal of shading, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 10 Provide Discriminatory Shading on Graphics
Stable Display Screen **Description** The stable display screen in a wide range of temperature **Type** Physical **Media** Display	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 11 Provide Stable Display in Wide Range of Temperature

13.1 Provide High Solution

Interface Characteristics	Source / Destination
Resolution **Description** The electronic signal of resolution, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 1 Provide High Solution

13.2 Provide Contrast in High Ambient Light

Interface Characteristics	Source / Destination
Contrast **Description** The electronic signal of contrast, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 2 Provide Contrast in High Ambient Light

13.3 Provide High Brightness

Interface Characteristics	Source / Destination
Brightness **Description** The electronic signal of brightness, inputted into a display screen **Type** Analog **Media** Electronic Signal	**Input To** 13 0 The System Shall Provide Liquid Crystal Display (LCD) **Output From** 13 3 Provide High Brightness

13.4 Provide High Gray Scale

Interface Characteristics	Source / Destination
Gray Scale **Description**: The electronic signal of gray scale, inputted into a display screen **Type**: Analog **Media**: Electronic Signal	**Input To** 13.0 The System Shall Provide Liquid Crystal Display (LCD) **Output From**. 13.4 Provide High Gray Scale

13.5 Provide High Modulation

Interface Characteristics	Source / Destination
Modulation **Description**: The electronic signal of modulation, inputted into a display screen. **Type**: Analog **Media**: Electronic Signal	**Input To**: 13.0 The System Shall Provide Liquid Crystal Display (LCD) **Output From**: 13.5 Provide High Modulation

13.6 Provide High Uniformity

Interface Characteristics	Source / Destination
Uniformity **Description**: The electronic signal of uniformity, inputted into a display screen **Type**. Analog **Media** Electronic Signal	**Input To**: 13.0 The System Shall Provide Liquid Crystal Display (LCD) **Output From**: 13.6 Provide High Uniformity

13.7 Provide Wide Viewing Angle

Interface Characteristics	Source / Destination
Viewing Angle **Description**: The electronic signal of viewing angle, inputted into a display screen **Type**: Analog **Media**: Electronic Signal	**Input To**: 13.0 The System Shall Provide Liquid Crystal Display (LCD) **Output From**: 13.7 Provide Wide Viewing Angle

13.8 Reproduce Photo-Realistic on Display Screen

Interface Characteristics	Source / Destination
Photo-Realistic **Description**: The electronic signal of photo-realistic, inputted into a display screen **Type**: Analog **Media**: Electronic Signal	**Input To**: 13.0 The System Shall Provide Liquid Crystal Display (LCD) **Output From**: 13.8 Reproduce Photo-Realistic on Display Screen

13.9 Provide Automatic Blink Symbol/String

Interface Characteristics	Source / Destination
Symbol/String **Description**. The electronic signal of symbol/string, inputted into a display screen **Type**: Analog **Media**: Electronic Signal	**Input To**: 13.0 The System Shall Provide Liquid Crystal Display (LCD) **Output From**: 13.9 Provide Automatic Blink Symbol/String

13.10 Provide Discriminatory Shading on Graphics

Interface Characteristics	Source / Destination
Shading **Description** The electronic signal of shading, inputted into a display screen **Type**: Analog **Media**. Electronic Signal	**Input To**: 13.0 The System Shall Provide Liquid Crystal Display (LCD) **Output From**: 13.10 Provide Discriminatory Shading on Graphics

13.11 Provide Stable Display in Wide Range of Temperature

Interface Characteristics	Source / Destination
Stable Display Screen **Description**: The stable display screen in a wide range of temperature **Type**: Physical **Media**: Display	**Input To**: 13.0 The System Shall Provide Liquid Crystal Display (LCD) **Output From**: 13.11 Provide Stable Display in Wide Range of Temperature

14.0 - The System Shall Provide Touch-Screen Display

Interface Characteristics	Source / Destination
Forward-Backward Function **Description**: The forward and backward actions during touching a display screen. **Type**: Analog **Media**: Electronic Signal	**Input To**: 14 0 The System Shall Provide Touch-Screen Display **Output From**: 14 1 Provide Forward-Backward Capability
Critical Markers **Description**: The markers that are used frequently and vital to the operation **Type** Analog **Media**: Electronic Signal	**Input To**: 14 0 The System Shall Provide Touch-Screen Display **Output From**: 14 2 Separate Critical Markers
Finger Oils' Protection **Description**: The display screen provides an oil protection from the pilot's fingerprint. **Type** Analog **Media**: Electronic Signal	**Input To**: 14.0 The System Shall Provide Touch-Screen Display **Output From**: 14.3 Provide Protection of Finger Oils
Spacing **Description**: The physical spacing between markers. **Type**: Analog **Media**: Electronic Signal	**Input To**: 14.0 The System Shall Provide Touch-Screen Display **Output From**: 14.4 Provide Adequate Spacing between Markers
Touch Screen Response **Description**: A fast response time from a touch of the system. **Type**: Analog **Media**: Electronic Signal	**Input To**: 14.0 The System Shall Provide Touch-Screen Display **Output From**: 14.5 Provide Rapid Response to Specific Pressure
Touch Sensitive Panel **Description**: A touch-screen panel is sensitive with a specific pressure. **Type**: Analog **Media**: Electronic Signal	**Input To**: 14.0 The System Shall Provide Touch-Screen Display **Output From**: 14 6 Provide Touch Sensitive Panel

14.1 Provide Forward-Backward Capability

Interface Characteristics	Source / Destination
Forward-Backward Function **Description** The forward and backward actions during touching a display screen **Type** Analog **Media** Electronic Signal	**Input To** 14 0 The System Shall Provide Touch-Screen Display **Output From** 14 1 Provide Forward-Backward Capability

14.2 Separate Critical Markers

Interface Characteristics	Source / Destination
Critical Markers **Description** The markers that are used frequently and vital to the operation **Type** Analog **Media** Electronic Signal	**Input To** 14 0 The System Shall Provide Touch-Screen Display **Output From** 14 2 Separate Critical Markers

14.3 Provide Protection of Finger Oils

Interface Characteristics	Source / Destination
Finger Oils' Protection **Description** The display screen provides an oil protection from the pilot's fingerprint **Type** Analog **Media** Electronic Signal	**Input To** 14 0 The System Shall Provide Touch-Screen Display **Output From** 14 3 Provide Protection of Finger Oils

14.4 Provide Adequate Spacing between Markers

Interface Characteristics	Source / Destination
Spacing **Description** The physical spacing between markers **Type** Analog **Media** Electronic Signal	**Input To** 14 0 The System Shall Provide Touch-Screen Display **Output From** 14 4 Provide Adequate Spacing between Markers

14.5 Provide Rapid Response to Specific Pressure

Interface Characteristics	Source / Destination
Touch Screen Response **Description** A fast response tıme from a touch of the system **Type** Analog **Media** Electronıc Sıgnal	**Input To** 14 0 The System Shall Provıde Touch-Screen Dısplay **Output From** 14 5 Provıde Rapıd Response to Specıfic Pressure

14.6 Provide Touch Sensitive Panel

Interface Characteristics	Source / Destination
Touch Sensitive Panel **Description** A touch-screen panel ıs sensıtıve wıth a specıfic pressure **Type** Analog **Media** Electronıc Sıgnal	**Input To** 14 0 The System Shall Provıde Touch-Screen Dısplay **Output From** 14 6 Provıde Touch Sensıtıve Panel

ACRONYMS AND ABBREVIATIONS

AGN	Aviator's Guide to Navigation, TAB Books, McGraw-Hill Publisher
AGATE C	AGATE Reference C Aircraft System Conceptual Design, Secondary Control/Preflight Activities, Embry-Riddle Laboratories
AGATE TRD	Technical Requirements Document for the AGATE System, NASA Langley Research Center
AGATE Homepage	AGATE Cockpit Images *"http://agate.larc.nasa.gov/images/AGATE_Cockpit.jpg"*
AGATE Proposal	Aquilas II Frame Overlay, Embry-Riddle Aeronautical University *"http://pinky.ent.db.erau.edu/agate/proposal/p_frame.htm"*
AIAA	Aircraft Instrument and Avionics, IAP, Inc
AIM/FAR 1998	Aeronautical Information Manual/Federal Aviation Regulating 1998, McGraw-Hill Publisher
AIM/FAR 1999	Aeronautical Information Manual/Federal Aviation Regulating 1999, McGraw-Hill Publisher
AIS	Aircraft Instrument System, IAP, Inc
AK	The Pilot's Handbook of Aeronautical Knowledge, TAB Books, McGraw-Hill Publisher
Allstar Network Web Page	*"http://www.allstar.fiu.edu/aerojava/FltDirS.htm"*
AW	Aviation Weather, Jeppesen Sanderson Training Products
Boeing 777 Web Page	*"http://www.mcs.net/~jerome/777/mid/pfd/pfd.htm"*
CD II	Cockpit Display II, the International Society for Optical Engineering

CD III	Cockpit Display III, the International Society for Optical Engineering
Geocities Web page	Gyroscopic Instruments *"http://www.geocities.com/capecanaveral/3819/GYRO.HTM"*
HUD	Head-Up Display: Designing the Way Ahead, AVEBURY Aviation
PFD ER Labs	The Synthetic Vision Conceptual Design Originated by ER Labs Staff
Oxford Dictionary	The Concise Oxford Dictionary of Current English, Clarendon Press, Oxford
RTS	Readings in Real-Time Systems, the Institute of Electrical and Electronics Engineers, Inc., Computer Society Press
SDSCA	Screen Design Strategies for Computer-Assisted Instruction, Digital Press
UL	Author Ideas (Ungul Laptaned, Graduate Student, Embry-Riddle Aeronautical University