



AEROSPACE RECOMMENDED PRACTICE

ARP5365™

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Superseding ARP5365

Human Interface Criteria for Cockpit Display of Traffic Information

RATIONALE

The G-10 committee has agreed to stabilize this document as the content has been determined to be basic and stable information not dynamic in nature.

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Documents

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) sets forth design and operational recommendations concerning the human factors issues and criteria for cockpit display of traffic information systems. The visual and aural characteristics are covered for both the alerting components and traffic depiction/situation components. The display system may contain any one or a combination of these components. Although the system functionality assumed for this document exemplifies fixed-wing aircraft implementation, the recommendations do not preclude other aircraft types. The recommendations contained in this document address both near and far term technology directed toward providing in flight traffic awareness, although the present version remains primarily focused on near term applications. Since this document provides recommendations, the guidance is provided in the form of “should” statements as opposed to the “shall” statements that appear in standards and requirements.

The assumptions about the system that guided and bounded the recommendations contained in this document include: the system is an airborne (flight deck based) system displaying traffic surveillance information to the flight crew; multiple sources of surveillance data will be used, when available, to provide the flight crew with the best available information; the system will have a human centered design based on the “lessons learned” from past systems; the system is not intended to replace the current Traffic Alert and Collision Avoidance (TCAS) function, but there will be a close relationship between the CDTI and the alerting system since both use the same sensors, and the display of the generated alerts and command information is generally considered a CDTI function; there will be pilot in the loop/manual involvement in any flight path changes; information will be accessible by appropriate flight crew members; the system will be based on the English language, but other languages may have to be considered; the system will address all fixed wing airplane types; the system will be operational full time in all airborne flight phases; the display function may be stand alone or part of a multi-function display; initial design will provide for upgradability and expansion; it will be properly integrated with other display functions and will not interfere with critical functions; the system may be capable of presenting additional traffic outside the range and capability of TCAS; and this document will not deal with the presentation of man made obstructions (e.g., towers or buildings) even though they may be equipped with an ADS-B transmitter.

2. REFERENCES:

The documents listed in 2.1 are referenced for guidance in this document. The documents listed in 2.2 are provided for information purposes only and do not form a part of the recommendations of this document. A bibliography of literature relevant to this document is presented in Section 10.

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS264	Instrument and Cockpit lighting for Commercial Transport Aircraft
ARP268	Location and Actuation of Flight Deck Controls for Transport Aircraft
AS425C	Nomenclature and Abbreviations for Use on the Flight Deck
ARP571	Flight Deck Controls and Displays for Communication and Navigation Equipment for Transport Aircraft
ARP1068	Flight Deck Instrumentation, Display Criteria and Associated Controls for Transport Aircraft
ARP1093	Numerical, Letter, and Symbol Dimensions for Aircraft Instrument Displays
ARP1161	Crew Station Lighting - Commercial Aircraft
ARP1782	Photometric and Colorimetric Measurement Procedures for Direct View CRT Displays
ARP1874	Design Objectives for CRT Displays for Part 25 (Transport) Aircraft
ARP4032	Human Engineering Considerations in the Application of Color to Electronic Aircraft Displays
ARP4033	Pilot-System Integration
ARP4101	Core Document, Flight Deck Layout and Facilities
ARP4101/2	Pilot Visibility from the Flight Deck
ARP4102	Core Document, Flight Deck Panels, Controls and Displays
ARP4102/4	Flight Deck Alerting Systems
ARP4102/7	Electronic Displays
ARP4102/7	Appendix A – Electronic Display Symbolology for EADI/PFD
ARP4102/7	Appendix B – Electronic Display Symbolology for EHSI/ND
ARP4102/7	Appendix C – Electronic Display Symbolology for Engine Displays
ARP4105	Abbreviations and Acronyms for Use on the Flight Deck
ARP4107	Aerospace Glossary for Human Factors Engineers
ARP4153	Human Interface Criteria for Collision Avoidance Systems in Transport Aircraft

2.1.1 (Continued):

ARP4256	Design Objectives for Liquid Crystal Displays for Part 25 (Transport) Aircraft
ARP4260	Photometric and Colorimetric Measurement Procedures for Airborne Direct View Flat Panel Displays (when approved)
AS8034	Minimum Performance Standards for Airborne Multipurpose Electronic Displays

2.1.2 FAA Publications: Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

FAA-RD-81-38II	Aircraft Alerting System Standardization Study: Volume II Aircraft Alerting System Design Guidelines (Berson, et al.,1981)
DOT/FAA/PS-89/1	Flight Status Monitor Design Guidelines (Anderson, et al. 1989)

2.2 Regulatory Publications:

FAA AC-23.1309-1A	Equipment, Systems, and Installations in Part 23 Airplane
FAA AC-23.1311-1	Installation of Electronic Display Instrument Systems In Part 23 Airplanes
FAA AC 25-11	Transport Category Airplane Electronic Display Systems
FAA Ac-25.1309-1A	System Design Analysis
FAR Part 23	Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes
FAR Part 25/ JAR Part 25	Airworthiness Standards: Transport Category Airplanes
FAR Part 27	Airworthiness Standards: Transport Category Rotorcraft
TSO-C113	Airborne Multipurpose Electronic Displays

3. GLOSSARY:

3.1 Acronyms and Abbreviations:

AC	Advisory Circular
ACAS	Airborne Collision Avoidance System
ADI	Attitude Direction Indicator
ADS-B	Automatic Dependent Surveillance-Broadcast
AGL	Above Ground Level
ARP	Aerospace Recommended Practice (SAE)
ATC	Air Traffic Control
ATM	Air Traffic Management
A/V	Aircraft/Vehicle
CDTI	Cockpit Display of Traffic Information
CNS	Communications, Navigation and Surveillance
CPA	Closest Point of Approach
EADI	Electronic Attitude Direction Indicator
EHSI	Electronic Horizontal Situation Indicator
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FMS	Flight Management System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HUD	Head Up Display
Hz	Hertz
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
ITC	In-Trail Climb
ITD	In-Trail Descent
JAA	Joint Aviation Authority
JAR	Joint Aviation Requirements
MASPS	Minimum Aviation System Performance Standards
MFD	Multi-Functional Display
MHz	Megahertz
MOPS	Minimum Operational Performance Standards
MSL	Mean Sea Level
NAS	National Airspace System
PFD	Primary Flight Display
RA	Resolution Advisory
Rnav	Area Navigation
RTCA	Radio Technical Commission for Aeronautics
RVSM	Reduced Vertical Separation Minimum

3.1 (Continued):

SAE	Society of Automotive Engineers, Inc
TA	Traffic Advisory
TCAS	Traffic Alert and Collision Avoidance System
TIS	Traffic Information Service
UAT	Universal Access Terminal
VDL	VHF Data Link
VHF	Very High Frequency
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

3.2 Definition of Terms:

ABSOLUTE ALTITUDE: Aircraft altitude referenced to mean sea level (QNH). Typically referred to as barometric corrected altitude.

ACCURACY: A measure of the difference between the reported A/V position as compared to the true position. Accuracy is usually defined in statistical terms of either: (1) a mean (bias) and a variation about the mean as defined by the standard deviation (sigma) or (2) root mean square (rms) value from the mean. The values given in this document are in terms of the two sigma variation from an assumed zero mean error.

AIRBORNE COLLISION: This occurs when two aircraft that are in flight come into contact. The word “collision” is not an antonym of the word “separation”, as separation criteria are typically defined to create a significant zone around each aircraft which must not be entered for “separation” to be guaranteed. As such, airborne collisions are subsets of airborne conflicts.

AIRBORNE CONFLICT: This occurs when two aircraft that are in flight come closer together than specified separation criteria. An airborne conflict does not necessarily result in an airborne collision; however, it does represent a situation considered hazardous, from which a collision may be possible without sufficient warning for a suitable pilot reaction.

AIRCRAFT/VEHICLE (A/V): Either (1) a machine or service capable of atmospheric flight, or (2) a vehicle on the airport surface movement area.

AIRPLANE STATE: The variables required to fully describe the dynamic behavior of an airplane and to predict this behavior into the future. These variables include, speed, flight path vector, attitude (pitch and roll), and horizontal track. Aircraft state is often represented as a state vector, which comprises the minimum number of values required to fully specify the state; from the state vector, related values such as angle of attack, flight path angle and sideslip can be derived.

AIR MASS DATA: Air mass data includes all aircraft sensor information which measures or is derived from the aircraft-local properties of the atmosphere. Direct measurements include air temperature, pressure, humidity and density; derived measurements include barometric corrected altitude (QNH), vertical speed and computed airspeed.

3.2 (Continued):

AIRSPACE: In the most general sense, airspace refers to the atmosphere in which aircraft operate, extending upwards from the surface of the earth. However, the term airspace also commonly denotes the spatial boundaries used to define areas restricted to civilian flight and to subdivide the airspace into areas controllable by individual air traffic controllers. These airspace boundaries add a constraint to aircraft operations by limiting acceptable aircraft flight paths.

ALERT: A visual, auditory or tactile stimulus presented to attract the flight crew's attention and convey some information concerning an event/situation.

AURAL ALERT: Discrete tone/sound used for attention getting.

AVAILABILITY: Is the probability that a function is up and able to perform were it called on.

BAROMETRIC ALTITUDE: Geopotential altitude in the earth's atmosphere above mean standard sea level pressure datum plane, measured by a pressure (barometric) altimeter.

BAROMETRIC ALTITUDE ERROR: For a given true barometric pressure, P_0 , the error is the difference between the transmitted pressure altitude and the altitude determined using a standard temperature and pressure model with P_0 .

CAUTION: Non-normal operational or aircraft system conditions that require immediate flight crew awareness and subsequent corrective or compensatory flight crew action.

CLOSEST POINT OF APPROACH (CPA): The minimum horizontal distance between two aircraft during a close proximity encounter, also known as miss distance.

CLUTTER: Clutter refers to the negative impact of poorly organized and crowded displays. It generally results in reduced display legibility, and/or in increases in the time needed to locate information on the display.

COCKPIT DISPLAY OF TRAFFIC INFORMATION (CDTI): A Cockpit Display of Traffic Information (CDTI) is a generic display that provides the flight crew with surveillance information about other aircraft, including their position. Traffic information for a CDTI may be obtained from one or multiple sources (including ADS-B, TCAS, and TIS) and it may be used for a variety of purposes. Any means of communicating the information is acceptable (aural, graphical, head-up, etc.) as long as the information is conveyed effectively. Requirements for CDTI information will vary based on intended use of the data (i.e., application).

COLLISION AVOIDANCE: A maneuver taken to avoid a collision.

COLOR VALUE: The attribute of a color that allows it to be classed on a scale from very dark to very light (brightness is a perception that results from surface luminance and is a property of the object itself and of the light illuminating it).

3.2 (Continued):

CONFLICT: Any situation involving two or more aircraft, or an aircraft and an airspace, or an aircraft and ground terrain, in which the applicable separation minima may be violated.

CONFLICT AVOIDANCE: A maneuver taken to resolve a conflict.

CONFLICT DETECTION: The process of projecting an aircraft's trajectory to determine whether it is probable that the applicable separation minimum will not be maintained between the aircraft and another aircraft or vehicle. The level of uncertainty in the projection is reduced with increased knowledge about the situation, including aircraft capabilities, flight plan, short term intent information, etc.

CONFLICT MANAGEMENT: Process of detecting and resolving conflicts.

CONFLICT PROBE: An airborne or ground based system that performs the process of conflict detection.

CONFLICT RESOLUTION: The process of identifying and or performing a maneuver or a set of maneuvers that are intended to resolve a conflict or potential conflict between the own ship and either (1) another aircraft or vehicle, (2) a given airspace, or (3) terrain.

COOPERATIVE SURVEILLANCE: (1) Surveillance in which the target assists by cooperatively providing data using on-board equipment. (2) A concept which envisions a transfer of responsibility for aircraft separation from ground based systems to the air-crew of appropriately equipped aircraft, for a specific separation function such as In-trail merging or separation management of close proximity encounters. It is cooperative in the sense that ground-based ATC is involved in the handover process, and in the sense that all involved aircraft must be appropriately equipped, e.g., with RNAV and ADS-B capability, to perform such functions.

CRITICALITY: Indication of the hazard safety level associated with a function, hardware, software, etc., considering abnormal behavior (of this function, hardware, software, etc.) alone, in combination or in combination with external events.

CROSS-LINK: A cross-link is a special purpose data transmission mechanism for exchanging data between two aircraft—a two-way addressed data link. For example, the TCAS II system uses a cross-link with another TCAS II to coordinate resolution advisories that are generated. A cross-link may also be used to exchange other information that is not of a general broadcast nature, such as intent information.

DEDICATED DISPLAY: A display that has only a single intended function in the flight deck.

ERROR: (1) An occurrence arising as a result of an incorrect action or decision by personnel operating or maintaining a system. (2) A mistake in specification, design, or implementation.

3.2 (Continued):

ESCAPE MANEUVER: Aircraft maneuver performed to resolve a time critical conflict with the traffic.

EVENT: An occurrence which has its origin distinct from the aircraft, such as atmospheric conditions (e.g., wind gusts, icing, lightning strikes), runway conditions, cabin and cargo fires.

EXPOSURE TIME: The period of time between when an item was last known to be operating properly and when it will be known to be operating properly again.

FAILURE: A loss of function or a malfunction of a system or part thereof.

FALSE ALERT: An alert that occurs in a situation for which the system design should not have presented an alert.

FAULT: An undesired anomaly in a function or system

GUIDELINES: Recommended procedures for complying with regulations

HUE: The dominant wavelength category which is described by a color term such as red or green (white, gray, and black are considered achromatic colors, being differentiable but without perceptible hue).

INDEPENDENCE: (1) A design concept which ensures that a failure of one item does not cause a failure of another item. (2) Separation of responsibilities that assures the accomplishment of objective evaluation.

INTEGRATION: (1) The act of causing elements of an item to function together. (2) The act of gathering a number of separate functions within a single implementation.

ISOMETRIC VIEW: A method of drawing so that three dimensions are shown not in perspective but in their actual measurements.

IN-TRAIL CLIMB: In-trail climb (ITC) procedures enable trailing aircraft to climb to more fuel-efficient or less turbulent altitude.

IN-TRAIL DESCENT: In-trail descent (ITD) procedures enable trailing aircraft to descend to more fuel-efficient or less turbulent altitude.

LATE ALERT: an alert that does not provide the flight crew with sufficient time to respond successfully.

LATENCY: The total system time from the time of applicability of the aircraft/vehicle position report until the information is presented to the flight crew.

3.2 (Continued):

LATENCY COMPENSATION: High accuracy applications may correct for system latency introduced position errors using time synchronized position and velocity information.

LUMINANCE: An objective measure of the effective intensity of light emitted from (or reflected by) a surface. Perceived luminance can also be affected by contrast from adjacent or surrounding colors.

MASTER VISUAL ALERT: Discrete annunciator used for attention getting and providing indication of situation urgency.

MISSED ALERT: The absence of an alert in a situation for which the system was designed to provide an alert.

MODE: The current selected state of a system that determines which of many possible functions the system will perform at that specific time. For example, CDTI may present different information or use different display formats depending on the particular application (mode).

NUISANCE ALERT: An alert that, while occurring as intended in the system design, was not appropriate in the specific situation for which it occurred.

ORTHOGRAPHIC VIEW: Drawing in which the depicted lines are perpendicular to the plane of projection; a 2-D View.

OWN SHIP: The aircraft in which the CDTI is installed and about which the traffic situation mental model is being built.

PASSING MANEUVERS: Procedures whereby flight crew use: (1) onboard display of traffic to identify an aircraft they wish to pass; (2) traffic display and weather radar to establish a clear path for the maneuver; and (3) communication with controllers to positively identify traffic to be passed, state intentions and report maneuver initiation and completion.

PERSPECTIVE VIEW: A method of drawing used to show the effect of relative distance and position. A perspective view may be either an "inside-out view" (also known as the pilot's-eye or camera view) or an "outside-in view" (also known as a "God's-eye view"). Both types of perspective drawings assume a given viewing angle, viewing distance, display field of view and point of convergence. In an outside-in view two additional parameters must be assumed: the elevation-viewing angle and the azimuth viewing angle. Manipulation of any of these parameters changes the viewers perception of the display.

PICTORIAL INFORMATION: Presentation of information in a form other than alpha-numerically.

PLAN VIEW: A drawing which shows a horizontal section; drawing plane is shown perpendicular to the line of sight between the eye and the object.

3.2 (Continued):

POP-UP MODE: The mode of a shared display that automatically changes the information that is being displayed in response to a specified set of conditions (e.g., automatically switching a shared display to traffic information when there is a caution level traffic conflict alert).

PRIMARY FLIGHT DISPLAY (PFD): An electronic display which provides the basic “T” including information (attitude, airspeed, altitude, and heading) and other information pertinent to navigation and fundamental control of flight.

PROFILE VIEW: A sideways-looking display which depicts elevation or altitude versus range or speed.

REFLECTANCE: The proportion of incident light reflected by a surface.

RELIABILITY: A number associated with (the probability) that a function will perform as required under specified conditions, without failure, for a specified period of time.

REQUIREMENT: An identifiable element of a specification that can be validated and against which an implementation can be verified.

RISK: The frequency (probability) of occurrence and the associated level of hazard.

SATURATION: The perception associated with the purity of a color in terms of the wavelengths represented in that color. Saturated colors consist of a narrow band of wavelengths and appear vivid; desaturated colors contain many other wavelengths as well as the dominant wavelength and appear muted.

SEAMLESS: A “chock-to-chock” continuous and common view of the surveillance situation from the perspective of all users.

SEPARATION: (1) Separation exists between two or more aircraft when their positions and velocities are in accordance with standards and procedures that have been determined to be appropriate for the operations in which the aircraft are engaged. (2) The maintenance of independence by means of a physical barrier between two hardware components.

SHARED DISPLAY: A shared display is multi-function and integrates multiple video/sensor inputs onto a single display.

STATION-KEEPING: Station-keeping provides the capability for a flight crew to maintain an aircraft's position relative to the designated aircraft. For example, an aircraft taxiing behind another aircraft can be cleared to follow and maintain separation on a lead aircraft. Station-keeping can be used to maintain a given (or variable) separation.

3.2 (Continued):

TIME-CRITICAL WARNING: Non-normal operational or aircraft system conditions that require unconditionally immediate corrective or compensatory flight crew action usually involving the flight path of the airplane.

TRAFFIC SITUATION DISPLAY (TSD): A flight deck display that provides graphical information that permits the identification of potential conflicts.

VALIDATION: The determination that the requirements for a function or system are sufficiently correct and complete.

VERIFICATION: The evaluation of an implementation to determine that all applicable requirements are met.

VISUAL ALERT: Discrete alphanumeric display or light used to get the attention of the flight crew and transfer some information about situation urgency.

VOICE ALERT: Auditory property of voice messages that gets the attention of the flight crew and transfers some information about situation urgency.

VOICE MESSAGE: The information content of a voice presentation in traffic conflict situation.

WARNING: Non-normal operational or aircraft system condition that requires immediate corrective or compensatory flight crew action conditional upon maintaining overall airplane safety.

4. SYSTEM FUNCTIONALITY - POTENTIAL FUNCTIONS:

The system will provide the functionality necessary and sufficient to support the following potential near-term applications. A description of these applications can be found in 7.2. Unnecessary restrictions or constraints should be avoided in order to maintain design flexibility needed for additional functionality that may be implemented to support future applications.

- a. Enhanced Visual Acquisition
- b. Enhanced Oceanic In-trail Climb/Descent Procedures
- c. Facilitate Station Keeping in Oceanic, En Route, and Remote Non-Radar Airspace
- d. Enhanced Visual Approach
- e. Facilitate Closely Spaced Parallel Approaches in IMC
- f. Enhanced Departure Spacing
- g. Increased Conflict Awareness

In order to support these operational applications, the system operations can be segmented into six functional areas: Sensing and Estimation, Conflict Detection and Assessment, Crew Alerting, Transmission/Presentation of Traffic Information, Self-Monitoring, and Recordkeeping. These functional characteristics will enhance the flight crew's ability to visually acquire the traffic, to build a mental model of the traffic situation (both spatial and temporal), to perform flight operations that are coordinated with the traffic situation, and to resolve traffic conflicts.

4.1 Sensing and Estimation:

In order to provide information about the traffic situation and to determine if and when a traffic alert is necessary, the system should have access to information related to the state of the own aircraft and its relationship to traffic. Generally, as more information is available, the system can be designed to operate in more complex situations. The following sub-sections describe the types of information that could be used.

- 4.1.1 3-D/4-D Position of Own Ship Relative to Traffic: An estimate of the spatial and temporal proximity of the own ship to the traffic is necessary. This estimate may be obtained from an onboard sensor directly providing relative range, bearing and track of the traffic. The accuracy and integrity of this information should be high enough to enable the performance of the applications that have been implemented and not result in an unacceptable rate of missed, false, nuisance and late alerts by the alerting function of the system.
- 4.1.2 Aircraft State: In addition to proximity information, additional state information is required to determine whether the projected flight path of the own ship and that of the traffic are in conflict. This state information includes aircraft speed, attitude, horizontal track, and vertical flight path. The uncertainty of these state estimates should be controlled to prevent an unacceptable rate of nuisance alerts or late alerts.
- 4.1.3 Aircraft Capability/Performance: Information about aircraft performance should be available to the system in order to determine when maneuvers could be issued based on the airplane performance capability and current state data.
- 4.1.4 Flight Parameters: The phase of flight (e.g., takeoff, cruise, approach, landing), relationship to the intended landing runway and permitted separation criteria will affect the protection thresholds with which the alerting system operates. The definitions of the phases of flight and the separation criteria should be specified.
- 4.1.5 Intended Flight Path: The ability to have access to a Flight Management System (FMS) flight plan or other intended flight path information may be very useful. In one mode, the system could be used for flight planning/re-planning to examine the crew's inputs for accuracy and reasonableness by checking the intended flight path for traffic conflicts as the plan is being executed. In a second mode, knowledge that the aircraft will be turning, climbing or descending at a given waypoint can be used to reduce the probability of nuisance alerts that would have been produced without the intent information. Over reliance on intent information may result in nuisance alerts or late alerts if the aircraft deviates from the intended flight path.

4.2 Loss of Separation Detection and Assessment:

The system should be able to detect a potential loss of required separation with traffic. This detection is based on the information obtained through the Sensing and Estimation Function: proximity and closure with traffic, aircraft performance, and estimates of the aircraft's intentions. The decision that a situation is a conflict should consider the application and carefully balance safety against nuisance alerts. The system should not issue an alert when published procedures are being followed. This can be accomplished by examining a wide variety of traffic encounters, especially when the own ship, the traffic or both are maneuvering. Although the recommendations contained in this document are based on providing information about traffic/moving obstacles, there may be some benefit defined to provide the capability to present stationary obstructions (e.g., towers, cranes, new construction, etc.) that have been equipped with a position broadcast device.

4.3 Flight Crew Alerting:

Once a loss of separation has been detected, the system should alert the flight crew. Alerting should include aural and visual components. The system should be able to determine the urgency of a traffic situation and alerts should be presented to the flight crew in an unambiguous manner. Alerts should be integrated and consistent with the flight deck alerting system and philosophy. Appropriate response to any level of alert should prevent the conflict from transitioning to a situation of higher urgency.

4.4 Information Transmission:

In addition to an alerting function, the system will have a function that allows the flight crew to obtain more detailed information about the traffic situation. This information can be separated into Traffic Awareness and Traffic Avoidance categories.

4.4.1 Traffic Awareness: The system could enhance the flight crew's traffic awareness by allowing them to view relevant airspace/traffic geometry information. In order to accomplish this, the aircraft's location (in all dimensions) relative to traffic and its velocity vectors should be displayed. The flight crew should be provided sufficient information to accurately anticipate conflict situations.

4.4.2 Traffic Avoidance: When a conflict is detected and an alert is issued, additional resolution information may be needed. This may be in the form of a caution (e.g., "Traffic"), an open-loop command (e.g., "Climb"), or closed-loop command guidance (e.g., "Flight Director Bars"). The flight crew should have a clear idea of what action to perform to resolve the conflict. The system should indicate when the potential loss of separation alerting situation no longer exists.

4.5 Self-Diagnostics:

The system should detect and communicate failures in its operation. The system can be designed without redundant components or to be fail-operational. In either case, any failure should be detected and communicated to the flight crew. Means should be provided to detect/determine information quality in order to permit the assessment of the appropriateness of the information for specific system applications.

4.6 Recordkeeping:

The system should provide a means for post flight analysis of traffic situations and conflicts to support the development of a safer more effective use of the airspace.

5. DESIGN OBJECTIVES:

The control and display equipment for the cockpit display of traffic information system should apply the basic design objectives called out in ARP571, taking into consideration the functions, their frequency of use and all aircraft operational and environmental conditions so as to:

- a. Simplify operations
- b. Facilitate error-free operation
- c. Maximize flight crew traffic awareness
- d. Minimize head down time
- e. Provide consistency of operation for common functions
- f. Promote timely and accurate operation
- g. Ensure legibility of legends and displays throughout the wide range of flight deck ambient lighting conditions
- h. Ensure that system failures do not degrade the operational capability of other systems with which they interact
- i. Ensure intelligibility of voice messages throughout the wide range of flight deck ambient noise conditions, concurrent speech messages and other aural signals
- j. Provide for information redundancy to assist the flight crew in verification and error detection
- k. Minimize nuisance alerts
- l. Permit conflict analysis

The goal of these objectives, though not necessarily presented in order of importance, is to keep associated flight crew workload at a level compatible with efficient flight crew operation.