

RTCA, Incorporated
1140 Connecticut Avenue, NW, Suite 1020
Washington, DC 20036-4008

**APPLICATION OF AIRBORNE
CONFLICT MANAGEMENT
DETECTION, PREVENTION, & RESOLUTION**

RTCA/DO-263
December 14, 2000

Prepared by SC-186
© 2000 RTCA, Inc.

Copies of this document may be obtained from

RTCA, Incorporated
1140 Connecticut Avenue, NW, Suite 1020
Washington, DC 20036-4008 USA

Telephone: 202-833-9339
Facsimile: 202-833-9434
Internet: www.rtca.org

Please contact RTCA for price and ordering information.

TABLE OF CONTENTS

1	PURPOSE AND SCOPE.....	1
1.1	Introduction	1
1.2	Background	2
1.3	Operational Purpose and Justification	4
1.3.1	Safety	4
1.3.2	Capacity and Efficiency	6
1.3.3	Infrastructure.....	7
1.3.4	Environmental Impact.....	8
1.4	Intended Airspace Domains	8
1.5	Maturity and User Interest.....	9
1.5.1	Conflict Detection	9
1.5.2	Conflict Prevention	10
1.5.3	Conflict Resolution.....	11
1.5.4	Simulator and Flight Testing	14
2	ACM CONCEPT.....	19
2.1	ACM Overview	19
2.2	Conflict Zones	22
2.2.1	Protected Airspace Zone (PAZ).....	23
2.2.1.1	PAZ Purpose	23
2.2.1.2	PAZ Description.....	23
2.2.1.3	Suggested Initial PAZ Parameters	24
2.2.2	Collision Avoidance Zone (CAZ).....	24
2.2.2.1	CAZ Purpose	24
2.2.2.2	CAZ Description	25
2.3	Conflict Detection	25
2.3.1	Conflict Alert Thresholds	25
2.3.1.1	Low Level Conflict Alerts	26
2.3.1.2	PAZ Alert.....	26
2.3.1.3	PAZ Penetration Notification.....	27
2.3.1.4	CAZ Alert.....	27
2.3.1.5	Alert Sequencing	27
2.3.1.6	Example Conflict Alert Thresholds	27
2.3.1.6.1	PAZ Alert Threshold – Example Parameter.....	28
2.3.1.6.2	CAZ Alert Threshold – Example Initial Parameter	28
2.3.2	Notional, Graphical Depiction of Zones, Areas, and Thresholds.....	28
2.3.3	Example Effects of Encounter Geometry and Abnormal Conditions on Alert Thresholds	29
2.3.3.1	Alert Zones Vary According to Encounter Geometry.....	32
2.3.3.1.1	Effect of Closure Rate on Thresholds	32
2.3.3.1.2	Effect of Vertical Rates on Thresholds	34
2.3.3.2	Offset Intruders.....	36

2.3.3.3 Pop-up Intruders.....	37
2.3.3.4 Maneuvering	38
2.4 Conflict Prevention	40
2.4.1 Conflict Prevention Alerting.....	40
2.4.2 Conflict Prevention Guidance.....	41
2.4.3 A Conflict Prevention Example	41
2.5 Conflict Resolutions	41
2.5.1 General.....	41
2.5.2 Low Level Alert Resolutions	42
2.5.3 PAZ Conflict Resolutions.....	43
2.5.4 CAZ Conflict Resolutions	43
2.6 Airspace Operations	44
2.6.1 General Background	44
2.6.1.1 Graphical Depictions	45
2.6.2 Operation in Specific Airspace.....	47
2.6.2.1 Autonomous Airspace.....	47
2.6.2.2 Managed Airspace.....	48
2.6.2.3 Unmanaged Airspace.....	48
2.7 Pilot-Controller Roles and Responsibilities.....	48
2.7.1 Information Exchange.....	49
2.7.2 Pilot and Controller Separation Responsibilities.....	49
2.7.2.1 Unmanaged Airspace.....	49
2.7.2.2 Managed Airspace.....	49
2.7.2.3 Autonomous Airspace.....	50
2.8 Equipage and Operational Issues in a Mature Free Flight Environment.....	50
3 ACM/ACAS /ADS-B INTEROPERABILITY.....	51
3.1 ACAS and ACM Installed on the Same Aircraft.....	51
3.1.1 Conflict Alerts.....	52
3.1.2 Resolutions	52
3.2 ACM/ACAS Interoperability Amongst Aircraft	53
3.2.1 Configuration	53
3.2.2 Interactions	53
3.2.3 Problem Cases Where ACM is on One Aircraft and ACAS is on the Other.....	54
MEMBERSHIP.....	57

APPENDICES

Appendix A – SAMPLE OPERATIONAL SCENARIOS

A.1	Free Flight Scenario	A-1
A.2	Low Cost ACM Scenario	A-4
A.2.1	Introduction	A-4
A.2.2	Equipment	A-4
A.2.3	Operation	A-4
A.2.4	Example Flight Interaction	A-5
A.2.5	Additional Example Annunciation	A-6

Appendix B – REFERENCES

Appendix C – ABBREVIATIONS

Appendix D – DEFINITIONS

Appendix E – AIRBORNE EQUIPAGE IN A FREE FLIGHT ENVIRONMENT

Aircraft Equipage Categories	E-2
Unequipped Aircraft	E-2
Basic Equipped Aircraft	E-2
Dependent Aircraft	E-2
3-D-Dependent Aircraft	E-2
4-D-Dependent Aircraft	E-2
Independent Equipped Aircraft	E-2
3-D-Independent Aircraft	E-2
4-D-Independent Aircraft	E-3
Equipage and Capability Summary	E-3

Appendix F – PARALLEL WORK THAT MAY IMPACT FUTURE AIRSPACE OPERATIONS

Scope of DAG-TM Concept	F-1
ACM Related DAG-TM Concept Elements	F-1
Example: Concept Element 5 in Managed Airspace	F-2

Appendix G – ADS-B MESSAGE FORMAT

Appendix H – LIST OF UNRESOLVED ISSUES AND RESEARCH AREAS

TABLE OF FIGURES

<u>Figure 1-1</u>	Conflict Probability Maps from Analytic Deterministic Analysis and Stochastic (Monte Carlo) Analysis.....	9
<u>Figure 1-2</u>	Example EUROCONTROL Simulator Navigation Display with a Conflict detected.....	10
<u>Figure 1-3</u>	NLR PASAS Example Display.	11
<u>Figure 1-4</u>	Example NLR Conflict Resolution Display.	12
<u>Figure 1-5</u>	Example EUROCONTROL Simulator Conflict Resolution.	13
<u>Figure 1-6</u>	Separation Achieved in 8-Aircraft Conflicts a) Without and b) With Application of the Resolution Technique.	14
<u>Figure 1-7</u>	Screenshot of Conflict Detection (moving map)	15
<u>Figure 2-1</u>	ASSAP Functional View	22
<u>Figure 2-2</u>	Example Cylindrical Zone Shapes for the Inner Collision Avoidance Zone (CAZ) and the Outer Protected Airspace Zone (PAZ).....	23
<u>Figure 2-3</u>	Graphical Relationship Among Conflict Zones, Areas, and Thresholds, Viewed From Above	29
<u>Figure 2-4</u>	Example PAZ and CAZ Zone Sizes, Depicted to Scale With a Large Aircraft.....	30
<u>Figure 2-5</u>	Example PAZ and CAZ Zone Sizes, Different Scales.....	31
<u>Figure 2-6</u>	Effect of Slow Horizontal Closure Rate on Alert Thresholds	32
<u>Figure 2-7</u>	Effect of Fast Horizontal Closure Rate on Alert Thresholds	33
<u>Figure 2-8</u>	Effect of Slow Horizontal, Fast Vertical Closure Rates on Alert Thresholds	34
<u>Figure 2-9</u>	Effect of Fast Horizontal, Fast Vertical Closing Rates on Alert Thresholds	35
<u>Figure 2-10</u>	Vertically Offset Intruder Aircraft.....	36
<u>Figure 2-11</u>	Horizontally Offset Intruder Aircraft.....	37
<u>Figure 2-12</u>	Intruder Outside of Alerting Parameters.....	38
<u>Figure 2-13</u>	Maneuver by Intruder Shifts Alerting Parameters.....	39
<u>Figure 2-14</u>	More Severe Maneuver Further Shifts Alerting Parameters.....	40
<u>Figure 2-15</u>	Low Level Alert, PAZ Alert Coming Soon.....	45
<u>Figure 2-16</u>	PAZ Alert.....	46
<u>Figure 2-17</u>	Conflict Resolved by Speed Change.....	47
<u>Figure F-1</u>	Flight Crew and Controller Temporal Zones	F-3

TABLE OF TABLES

<u>Table 1-1</u>	U. S. Runway Incursion Data [25].....	5
<u>Table 3-1</u>	Conflict Resolution System Priority Matrix	54
<u>Table E-1</u>	Functional Category Summary.....	E-1
<u>Table E-2</u>	Aircraft Equipage Summary.....	E-4
<u>Table F-1</u>	Overview of ACM Concept Elements.....	F-2
<u>Table G-1</u>	Information Requirements (R) or no Requirement (n/R) for ADS-B [4].....	G-1

1 PURPOSE AND SCOPE

Note: Aspects of this concept are still under development and have not yet been validated. The document is not intended to set requirements, but is intended to serve as a foundation for follow-on requirements development.

1.1 Introduction

This document presents an operational concept for the Application of Airborne Conflict Management (ACM) using Automatic Dependent Surveillance-Broadcast (ADS-B). The ACM concept includes detecting conflicts, monitoring for potential conflicts, and suggesting resolutions to prevent a violation of airspace separation criteria against all other properly equipped aircraft/vehicles. (This concept was formerly known as Conflict Detection and Resolution [CD&R].)(See Appendix D for definitions.)

ACM is a core enabling function for the global implementation of the *Free Flight* concept, as it will aid pilots to fly user-preferred trajectories while avoiding conflicts with other aircraft. The long surveillance range afforded by ADS-B will enable alerts to be issued in time to solve the conflicts with minimum disruption to flight path. It is expected that the time provided by this long range will allow for a variety of solutions, or optimized solutions, thus enabling the choice of user-preferred trajectories while avoiding conflicts with other aircraft.

ACM includes three different functions: Conflict Detection (CD), Conflict Prevention (CP), and Conflict Resolution (CR). These functions need not all be present in an ACM system.

The CD part of this application will provide automated alerting and relevant traffic information, if displayed, to help the pilot detect existing conflicts with other aircraft based on current flight states and intents. The actions in response to these alerts may have to be coordinated with the air traffic service provider or may be solely managed by the pilot, depending on the operating environment and flight rules in effect at the time of the encounter.

The CP part of this application will predict conflicts that may occur if current flight state or own ship intent is changed. As such, it will offer guidance cues to prevent changes that will lead to conflicts.

The CR part of this application will provide recommended conflict resolutions or guidance cues. The CR function is designed to be completely interoperable with and functionally independent of existing Airborne Collision Avoidance Systems (ACAS).

Under normal circumstances, conflicts are expected to be resolved at long range by minor changes to the flight path. However, ACM is also designed with two shorter-range alert thresholds in which increasingly urgent alerts and updated resolutions are provided as necessary for required avoidance maneuvers.

In the future, it will be desirable for an ACM system to also take into account known, non-aircraft “threats” (e.g., terrain, weather, and restricted airspace); however, such capabilities are not described in this document.

This concept is being developed by a subgroup of Working Group 1 (WG-1) of RTCA Special Committee 186 (SC-186) on ADS-B. The group includes representatives from