

RTCA, Inc.
1828 L Street, NW, Suite 805
Washington, DC 20036-5133 USA

**Safety, Performance and Interoperability
Requirements Document for
ATSA-SURF Application**

RTCA DO-322
December 8, 2010

Prepared by: SC-186
© 2010 RTCA, Inc.

Copies of this document may be obtained from

RTCA, Inc.

Telephone: 202-833-0339

Facsimile: 202-833-9434

Internet: www.rtca.org

Please visit the RTCA Online Store for document pricing and ordering information.

FOREWORD

The document was prepared by RTCA Special Committee 186 (SC-186), in the framework of the Requirements Focus Group (RFG), and was approved by the RTCA Program Management Committee (PMC) on December 8, 2010.

RTCA, Incorporated, is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;
- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;
- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and
- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based.

The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders.

Since RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U.S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

This page intentionally left blank

Currently in preview, click buy full version

TABLE OF CONTENTS

| | | |
|-------|--|----|
| 1 | INTRODUCTION | 1 |
| 1.1 | Purpose of This Document..... | 1 |
| 1.1.1 | ATSA-SURF Overview | 2 |
| 1.1.2 | Use of Document for Approvals | 2 |
| 1.1.3 | Relationship to Other Applications | 3 |
| 1.2 | Scope of the Document | 3 |
| 1.2.1 | ATSA-SURF Context | 4 |
| 1.2.2 | Assumed Airborne & Ground Generic Functional Architecture..... | 5 |
| 1.3 | Structure of This Document | 7 |
| 1.3.1 | Document Organization | 7 |
| 1.4 | Relationship to ICAO Documents | 8 |
| 1.5 | References..... | 8 |
| 1.5.1 | ICAO..... | 9 |
| 1.5.2 | EUROCAE/RTCA | 9 |
| 1.5.3 | Other..... | 12 |
| 2 | APPROACH AND METHODOLOGY | 13 |
| 2.1 | Document Development Process | 13 |
| 2.2 | Methodology | 13 |
| 2.2.1 | Operational Services and Environment Definition (OSED) | 13 |
| 2.2.2 | Safety and Performance Requirements (S.P.R) | 14 |
| 2.2.3 | Interoperability Requirements (Interop)..... | 15 |
| 2.3 | Key Terms..... | 15 |
| 2.3.1 | Use of Requirements and Recommendations and Key Words..... | 15 |
| 2.3.2 | Assumptions..... | 16 |
| 2.3.3 | Mitigation Means | 16 |
| 2.3.4 | Requirements | 17 |
| 2.3.5 | Recommendations | 18 |
| 3 | SAFETY AND PERFORMANCE REQUIREMENTS (SPR)..... | 19 |
| 3.1 | Introduction | 19 |
| 3.1.1 | OPA Process | 19 |
| 3.1.2 | OSA Process | 20 |
| 3.1.3 | S&K Process | 22 |
| 3.2 | Assumptions..... | 23 |
| 3.2.1 | General Assumptions | 24 |
| 3.2.2 | Environmental Assumptions | 25 |
| 3.2.3 | Receive Aircraft Domain Assumptions | 27 |
| 3.2.4 | Transmit Aircraft/Vehicle Domain Assumptions | 28 |
| 3.2.5 | Ground Domain Assumptions..... | 29 |
| 3.3 | Operational Requirements..... | 29 |
| 3.4 | ATSA-SURF Equipment Requirements | 30 |
| 3.4.1 | Functional Requirements | 30 |
| 3.4.2 | Performance Requirements | 36 |
| 3.5 | Data Requirements..... | 38 |

| | | |
|--------------|---|----|
| 3.6 | Recommendations and Design Considerations | 42 |
| 3.7 | Training Considerations | 42 |
| 4 | INTEROPERABILITY REQUIREMENTS | 44 |
| 4.1 | Purpose of Interoperability Requirements..... | 44 |
| 4.2 | Scope of Interoperability Requirements..... | 44 |
| 4.2.1 | ATSA-SURF Domains..... | 44 |
| 4.3 | ATSA-SURF Interoperability Requirements | 46 |
| 4.3.1 | Interop Data..... | 46 |
| 4.3.2 | Identity | 48 |
| 4.3.3 | Horizontal Position | 49 |
| 4.3.4 | Vertical Position..... | 50 |
| 4.3.5 | Velocity | 51 |
| 4.3.6 | Type of Traffic | 53 |
| 4.3.7 | Surveillance Quality Indicators..... | 53 |
| 4.3.8 | Aircraft/Vehicle Size..... | 56 |
| ANNEX A | OPERATIONAL SERVICES AND ENVIRONMENT DEFINITION | 1 |
| A.1 | Introduction | 1 |
| A.2 | Context | 2 |
| A.3 | Objective | 4 |
| A.4 | Procedure Description..... | 5 |
| A.4.1 | Current Procedures..... | 5 |
| A.4.2 | Operational Examples | 6 |
| A.4.3 | Proposed Procedures for ATSA-SURF | 10 |
| A.4.4 | Roles and Responsibilities | 17 |
| A.4.5 | Impact on Phraseology | 17 |
| A.5 | Airspace Characteristics | 18 |
| A.5.1 | Airspace Characteristics..... | 18 |
| A.5.2 | Partial and Mixed Airspace Considerations | 19 |
| A.6 | Phase Diagrams..... | 20 |
| A.6.1 | Definitions of the Phases..... | 20 |
| A.6.2 | Detailed Phase Diagrams | 23 |
| A.7 | Abnormal Modes..... | 28 |
| A.8 | ASSUMPTIONS And OPERATIONAL REQUIREMENTS | 29 |
| A.8.1 | Assumptions..... | 29 |
| A.8.2 | Operational Requirements..... | 34 |
| APPENDIX A-A | OPERATIONAL SCENARIOS..... | 1 |
| A-A.1 | Scenario #1: Traffic Crossing Runway | 2 |
| A-A.1.1 | Scenario 1.A – Traffic Holding or Approaching Hold Bar (Perceived Threat) | 2 |
| A-A.1.2 | Scenario 1.B – Traffic Is Crossing Runway (Real Threat depicted as Non-Threat)..... | 3 |
| A-A.2 | Scenario #2: Traffic in Air (Approaching)..... | 3 |
| A-A.2.1 | Scenario 2.A – Traffic Appears Closer Than Actual Position | 3 |
| A-A.2.2 | Scenario 2.B – Traffic Appears Farther Away Than Actual Position..... | 4 |
| A-A.3 | Scenario #3: Traffic in Air (Approaching Parallel Runways)..... | 4 |

| | | |
|---------|---|----|
| A-A.3.1 | Scenario 3.A – Traffic Appears As Threat Where None Exists..... | 4 |
| A-A.3.2 | Scenario 3.B – Traffic Appears as Non-Threat Where One Exists..... | 5 |
| A-A.4 | Scenario #4: Traffic Rolling Out – Exit Runway or Not | 5 |
| A-A.4.1 | Scenario 4.A – Traffic on Rapid Exit Taxiway But Shown as On Runway | 5 |
| A-A.4.2 | Scenario 4.B – Traffic on Runway But Shown on Nearby Rapid Exit Taxiway | 6 |
| A-A.5 | Scenario #5: Traffic with Taxiway Parallel to Runway | 6 |
| A-A.5.1 | Scenario 5.A – Traffic on Adjacent Taxiway | 6 |
| A-A.5.2 | Scenario 5.B – Traffic on Runway..... | 7 |
| A-A.6 | Scenario #6: Traffic on Crossing Runway | 7 |
| A-A.6.1 | Scenario 6.A – Displayed Traffic Nearer (and Faster) Than Actual Traffic | 8 |
| A-A.6.2 | Scenario 6.B – Actual Traffic Closer (and Faster) Than Displayed Traffic | 8 |
| A-A.7 | Scenario #7: Traffic on Runway That Ownship Is Crossing..... | 9 |
| A-A.7.1 | Scenario 7.A – Actual Traffic Has Passed Ownship’s Hold Position | 9 |
| A-A.7.2 | Scenario 7.B – Displayed Traffic Has Passed Ownship’s Hold Position, when Actual Traffic Has Not Yet Cleared | 9 |
| A-A.8 | Scenario #8: Traffic and Ownship Taxi Operations..... | 9 |
| A-A.8.1 | Scenario 8.A – Along Track Swap..... | 10 |
| A-A.8.2 | Scenario 8.B – Cross Track Swap..... | 10 |
| A-A.8.3 | Scenario 8.C – Directionality Swap..... | 11 |
| ANNEX B | OPERATIONAL PERFORMANCE ASSESSMENT | 1 |
| B.1 | Introduction..... | 1 |
| B.1.1 | Purpose..... | 1 |
| B.1.2 | The CNS/ATM system..... | 1 |
| B.1.3 | Definitions..... | 3 |
| B.2 | ATSA-SURF Operational Performance Assessment..... | 4 |
| B.2.1 | Scope of ATSA-SURF | 4 |
| B.2.2 | Analysis Approach..... | 5 |
| B.3 | Required Information for the ATSA-SURF Application..... | 6 |
| B.3.1 | Operationally Required ATSA-SURF Information | 6 |
| B.3.2 | Required Data Items at the Input of the ATSA-SURF Equipment | 6 |
| B.4 | Operational Objectives, Scenarios, And Aerodrome Physical Size Characteristics | 8 |
| B.4.1 | ATSA-SURF Operational Objectives | 8 |
| B.4.2 | Relevant Operational Scenarios | 9 |
| B.4.3 | Aerodrome Physical Characteristics Relevant for ATSA-SURF..... | 16 |
| B.4.4 | Scenarios with Limiting Physical Constraints Illustrated | 26 |
| B.4.5 | Minimum Aerodrome Assumptions for ATSA-SURF | 28 |
| B.5 | Definition And Specification Of Performance Parameters | 29 |
| B.5.1 | Operational Performance | 29 |
| B.5.2 | ATSA-SURF Qualified Traffic Requirements..... | 41 |
| B.5.3 | Ownship Requirements | 55 |
| B.5.4 | Aerodrome Surface Map Database Assumptions..... | 58 |
| B.6 | Design Considerations | 60 |
| B.6.1 | Availability..... | 60 |
| B.6.2 | Continuity..... | 60 |
| B.6.3 | Coverage Volume | 60 |

| | | |
|--------------|---|----|
| B.6.4 | Tracking of Aircraft/Vehicles | 61 |
| B.6.5 | Number of ATSA-SURF Traffic Targets Displayed | 61 |
| B.6.6 | Surveillance Position Reference Point (SPRP) and Aircraft/Vehicle Size Information | 62 |
| B.6.7 | Aerodrome Surface Map Database Recommendations | 62 |
| B.6.8 | Traffic Position and Velocity Accuracy Recommendations | 63 |
| B.6.9 | Ownship Performance and Ownship Symbol Placement Considerations | 63 |
| B.6.10 | Traffic Display Design Considerations | 64 |
| B.6.11 | Provision for Integration with Other Functions | 68 |
| B.7 | Summary Of Performance Requirements | 69 |
| APPENDIX B-A | ATSA-SURF ERROR ANALYSIS MODELING | 77 |
| B-A.1.1 | Details of Error Sources Modeled | 77 |
| B-A.2.1 | RSS Model Validation | 30 |
| B-A.3.1 | Position Source Error Model | 83 |
| B-A.3.2 | ADS-B/R and Surveillance Processing Position Errors | 84 |
| B-A.3.3 | Map Error Model | 89 |
| B-A.3.4 | Display Resolution Error Model | 90 |
| APPENDIX B-B | ERROR ANALYSIS MODELING RESULTS SUMMARY | 1 |
| B-B.3.1 | Modeling Coordinate Frame | 3 |
| B-B.3.2 | Monte-Carlo Simulation Total Position Error Results Overview | 4 |
| B-B.3.3 | RSS Total Position Error Results Overview | 8 |
| B-B.4.1 | Traffic On-Ground Simulation Results | 9 |
| B-B.4.2 | Traffic In-Air Simulation | 15 |
| B-B.5.1 | On Ground RSS Model Results | 20 |
| B-B.5.2 | Airborne RSS Model Results | 21 |
| B-B.7.1 | True Traffic Ground Speed 0 Kts with Receive-Side Latency Compensation Threshold | 24 |
| B-B.7.2 | True Traffic Ground Speed 5 Kts with Receive-Side Latency Compensation Threshold | 27 |
| B-B.7.3 | True Traffic Ground Speed 10 Kts with Receive-side Latency Compensation Threshold | 29 |
| B-B.7.4 | Conclusion of Traffic Position Latency Compensation Threshold Analysis | 31 |
| ANNEX C | OPERATIONAL SAFETY ASSESSMENT | 1 |
| C.1 | Introduction | 1 |
| C.1.1 | Objectives of This Assessment | 1 |
| C.1.2 | Purpose And Scope | 1 |
| C.1.3 | Strategy | 2 |
| C.1.4 | Structure | 4 |
| C.1.5 | Definition of Safety Terms | 4 |
| C.2 | Approach | 6 |
| C.2.1 | OHA Process | 8 |
| C.2.2 | ASOR Process | 14 |
| C.3 | Hazard Identification | 17 |
| C.3.1 | Event Tree Strategy | 18 |
| C.3.2 | Defining the Barriers in the Event Trees | 21 |
| C.4 | OH1 - Traffic Display Has Credible Erroneous Information | 27 |
| C.4.1 | Hazard Description | 27 |

| | | |
|---------|--|----|
| C.4.2 | Event Trees Per Phase of Flight for OH1 | 27 |
| C.4.3 | Safety Objective Assignment for OH1 | 53 |
| C.4.4 | Allocation of Safety Objectives and Requirements (ASOR) for OH1 | 54 |
| C.5 | OH2 – Traffic Display Has Missing Information | 72 |
| C.5.1 | Event Tree Strategy | 73 |
| C.5.2 | Safety Objective Assignment | 75 |
| C.5.3 | Fault Tree Strategy | 76 |
| C.5.4 | Allocation of Safety Objectives To OH2 Fault Tree | 77 |
| C.6 | OH3 – Traffic Display Has Erroneous Traffic Identification Information | 77 |
| C.6.1 | Event Tree Strategy | 78 |
| C.6.2 | Safety Objective Assignment | 81 |
| C.6.3 | OH3 Basic Causes | 82 |
| C.6.4 | Allocation of Safety Objectives | 83 |
| C.7 | Summary of Safety Assessment | 83 |
| C.7.1 | Hazard Identification | 84 |
| C.7.2 | Environmental Conditions | 84 |
| C.7.3 | External Mitigation Means | 85 |
| C.7.4 | Use of EC and EMM in Barriers for Event Trees | 85 |
| C.7.5 | Safety Assumptions | 88 |
| C.7.6 | Safety Requirements | 90 |
| C.7.7 | Safety Assessment Conclusions | 91 |
| C-A.2.1 | Safety Risk-Benefit Analysis Approach | 2 |
| C-A.2.2 | Assessment Summary of Hazard for Partial Equipped and Recommended Procedural and Training Safety Requirements | 2 |
| C-A.2.3 | Assessment Summary of Hazard for Full or Nearly Full Equipped and Recommended Safety Requirements | 3 |
| C-A.2.4 | Detailed Safety Risk-Benefit Assessment of Hazard Using Logic Trees | 3 |
| C-A.2.5 | Summary of Results | 15 |
| ANNEX D | EXTENDED AVAILABILITY RISK MITIGATION PLAN | 1 |
| D.1 | Introduction | 1 |
| D.2 | Background | 1 |
| D.3 | Risk Management Plan (RMP) Summary | 2 |
| D.4 | Risk Management Plan Rationale | 2 |
| D.5 | Risk Management Plan Summary | 12 |
| ANNEX E | VALIDATING VELOCITY FROM POSITION REPORTS | 1 |
| E.1 | Background | 1 |
| E.2 | Analysis Summary | 1 |
| E.2.1 | Simulation Overview | 1 |
| E.2.2 | Modeling Approach | 2 |
| E.2.3 | Validation Algorithms | 2 |
| E.2.4 | Simulation Results | 3 |
| E.2.5 | Conclusions | 5 |
| ANNEX F | COMPARISON OF MINIMUM REQUIREMENTS FOR ATSA-SURF (RFG) AND DO-317 SURFACE OPERATIONS APPLICATIONS | 1 |
| F.1 | Overview of Issue | 1 |

| | | |
|---------|---|---|
| F.2 | The Objective Of ATSA-SURF..... | 1 |
| F.3 | The Operational Input | 1 |
| F.4 | The Presentation Of Information To The Flight Crew..... | 2 |
| F.5 | How Accurate Does The System Need To Be? | 3 |
| F.6 | How Safe Does The System Need To Be?..... | 3 |
| F.7 | Where Is FAROA In ATSA-SURF?..... | 4 |
| F.8 | The Impact On Performance Values | 4 |
| ANNEX G | ACRONYMS..... | 1 |
| ANNEX H | GLOSSARY..... | 4 |
| ANNEX I | LIST OF PARTICIPANTS..... | 1 |

TABLE OF TABLES

| | |
|---|----|
| Table 3.1: Operational Requirements | 30 |
| Table 3.2: Ownship Functional Requirements | 32 |
| Table 3.3: Traffic Functional Requirements..... | 35 |
| Table 3.4: General Functional Requirements | 35 |
| Table 3.5: Integrity and general performance requirements..... | 36 |
| Table 3.6: Timing requirements | 38 |
| Table 3.7: Data requirements | 42 |
| | |
| Table A.1 Flight crew actions during regular scan at a controlled airport | 13 |
| Table A.2 Flight crew actions during conditional clearances at a controlled airport | 14 |
| Table A.3 Flight crew actions during regular scan at an uncontrolled airport | 16 |
| Table A.4 Summary of ATSA-SURF operational phases | 21 |
| Table A.5 Abnormal Modes | 29 |
| | |
| Table B.1 Assumed Range of Speeds and Acceleration for ATSA-SURF Aircraft and Ground Vehicles..... | 15 |
| Table B.2 Aerodrome Reference Code | 17 |
| Table B.3 Aerodrome Reference Codes for Example Aircraft..... | 18 |
| Table B.4 Minimum Width Runway and Taxiway Design Standards by Aerodrome Code Number and Letter..... | 19 |
| Table B.5 Minimum Distance between Parallel Runways | 20 |
| Table B.6 Taxiway Minimum Separation Distances..... | 21 |
| Table B.7 Minimum Distance from Runway Centreline to Holding Bay, Taxi-Holding Position, or Road-Holding Position..... | 22 |
| Table B.8 Minimum Separation Distances as a Function of Aerodrome Code Number..... | 24 |
| Table B.9 Minimum Separation Distances as a Function of Aerodrome Code Letter | 25 |
| Table B.12 Aerodrome Surface Map Database Feature Summary..... | 59 |
| Table B.13 ATSA-SURF Performance Requirements Summary..... | 69 |
| Table B.14 Inputs to Total Position Error Analysis Models | 1 |
| | |
| Table C.1 OSA – Definition of Safety Terms | 5 |
| Table C.2 Safety Targets from US SMS Approach..... | 11 |
| Table C.3 ATM Safety Targets from European Approach | 12 |
| Table C.4 Number of Atm Hazards Per Severity Class in the Application’s Environment | 12 |
| Table C.5 ATSA-SURF Safety Targets (Per Flight Hour), European Approach..... | 13 |

| | |
|--|----|
| Table C.6 Results of Hazard Identification | 18 |
| Table C.7 Durations for Phases of Operations | 19 |
| Table C.8 Scenarios Used in Each Phase of Operations | 20 |
| Table C.9 Barriers | 24 |
| Table C.10 Safety Objectives Per Flight Hour for ATSA-SURF OH1 | 54 |
| Table C.11 Critical Information Driving Threat Interpretation Per Scenario..... | 59 |
| Table C.12 Probability of Erroneous Display | 61 |
| Table C.13 Adjusted Probabilities of Inaccurate Position or Direction Per Sample | 62 |
| Table C.14 Probability of Direction Acting as Mitigation for Inaccurate Position Appearing Credible, Applied to Perceived Threats and Real Threats..... | 64 |
| Table C.15 Probability of Credible Rare Normal Inaccuracies Per Flight Hour Per Phase | 65 |
| Table C.16 Allocation Per Phase For Basic Causes (All Figures Per Flight Hour) | 72 |
| Table C.17 Values for Barriers Used in OH2..... | 73 |
| Table C.18 Safety Objectives Per Flight Hour for ATSA-SURF OH2 | 75 |
| Table C.19 New Barriers Used for OH3 | 79 |
| Table C.20 Safety Objectives for ATSA-SURF (OH3) | 81 |
| Table C.21 Hazard Summary | 84 |
| Table C.22 Summary of Barriers Used in Event Trees | 85 |
| Table C.23 Safety Assumptions Summary | 88 |
| Table C.24 Safety Requirements Summary | 90 |
| Table C.25 Summary of Safety Assessment Conclusions..... | 91 |
| Table C.26 Probability of Induced Error | 13 |
| Table C.27 Comparison of ATSA-SURF Effect Between Near-Term (Low-Equipage) Operations and Far-Term (100% Equipage) Operations | 14 |
| Table C.28 Sources of ATSA-SURF Error | 14 |
| Table C.29 ATSA-SURF performance for a real threat undetectable by other means drawn from Case 2B. | 15 |
| Table C.30 SURF Benefit Improvements Based on 100% Equipage Rate | 15 |
| | |
| Table D.1 Relationship of HDOP to the Resulting 95% Horizontal Position Accuracy (HFOM) and NACp..... | 3 |
| Table D.2 Δ HDOP for All-in-View Receiver (5 deg) versus Removal of Lowest Elevation Satellite..... | 6 |
| Table D.3 Δ HDOP for All-in-View Receiver (5 deg) versus Removal of Two Lowest Elevation Satellites | 8 |
| Table D.4 RMP Probability Calculation Summary | 10 |

| | |
|--|----|
| Table D.5 Criteria for Identifying GPS as the Traffic Position Source for a 1090 MHz ADS-B Link | 11 |
| Table E.1 Field Data Results | 3 |
| Table E.2 Simulation Results | 3 |
| Table F.1 Summary of High-Level Differences Between ATSA-SURF and DO-317 Surface Operations Applications | 5 |

TABLE OF FIGURES

| | |
|---|----|
| Figure 1.1 Surveillance Functional Architecture..... | 5 |
| Figure 2.1 Traceability Scheme..... | 17 |
| Figure 3.1 Surveillance Functional Architecture Scope for ATSA-SURF..... | 23 |
| | |
| Figure A.1 Milan-Linate Aerodrome and sequence of events on 8 October 2001 | 8 |
| Figure A.2 Map of Quincy Airport showing the paths of the 3 aircraft involved in the November 1996 accident (after NTSB report) | 9 |
| Figure A.3 Sample scenario for proposed new procedures for ATSA-SURF..... | 11 |
| Figure A.5 High level phase diagram for ATSA-SURF | 22 |
| Figure A.6 ATSA-SURF Phase 1 – Initiation (controlled and uncontrolled airports) | 23 |
| Figure A.7 ATSA-SURF Phase 2 – Execution – High Level | 23 |
| Figure A.8 ATSA-SURF Phase 2 – Execution – Taxi operations at controlled airports | 24 |
| Figure A.9 ATSA-SURF Phase 2 – Execution – Runway operations at controlled airports | 25 |
| Figure A.10 ATSA-SURF Phase 2 – Execution – Taxi operations at uncontrolled airports | 26 |
| Figure A.11 ATSA-SURF Phase 2 – Execution – Runway operations at uncontrolled airports .. | 27 |
| Figure A.12 ATSA-SURF Phase 4 – Exception..... | 28 |
| Figure A.13 Notional ATSA-SURF Traffic Display showing chevrons displaced from airport movement surfaces due to unusually large system errors. | 1 |
| | |
| Figure B.1 ADS-B Functional Architecture Scope for ATSA-SURF..... | 2 |
| Figure B.2 Scenario #1: Traffic Crossing Runway | 10 |
| Figure B.3 Scenario #2: Traffic In-Air (Approaching) | 11 |
| Figure B.4 Scenario #3: Traffic In-Air (Approaching with Parallel Runways) | 11 |
| Figure B.5 Scenario #4: Traffic Rolling Out (Exit Runway or Not)..... | 12 |
| Figure B.6 Scenario #5: Traffic with Taxiway Parallel to Runway | 12 |
| Figure B.7 Scenario #6: Traffic on Crossing Runway | 13 |
| Figure B.8 Scenario #7: Traffic on Runway that Ownship is Crossing | 13 |
| Figure B.9 Scenario #8: Traffic and Ownship on Taxiways | 14 |
| Figure B.10 Non-stressing Scenario – Parallel Runway with Aircraft on the Ground..... | 14 |
| Figure B.11 Traffic on Intersecting Runway..... | 15 |
| Figure B.12 Example Hold Bar to Runway Edge Separation Distances for Aerodrome Code 1.. | 23 |
| Figure B.13 Example Hold Bar to Runway Edge Separation Distances for Aerodrome Code 2.. | 23 |
| Figure B.14 Example Hold Bar to Runway Edge Separation Distances for Aerodrome Code 4.. | 24 |
| Figure B.15 Rapid Exit Taxiway..... | 25 |

| | |
|--|----|
| Figure B.16 Approximate Scale of a Boeing 747 Overlaid with 10-meter Square Grids | 26 |
| Figure B.17 Limiting Physical Characteristics of Scenario #1 | 26 |
| Figure B.18 Limiting Physical Characteristics of Scenario #3 | 27 |
| Figure B.19 Limiting Physical Characteristics of Scenario #4 | 27 |
| Figure B.20 Limiting Physical Characteristics of Scenario #5 | 27 |
| Figure B.21 Limiting Physical Characteristics of Scenario #8B | 28 |
| Figure B.22 Limiting Physical Characteristics of Scenario #8C | 28 |
| Figure B.23 Airport Diagram for Memphis International Airport (KMEM) | 34 |
| Figure B.24 95% Horizontal Position Uncertainty Boundary Overlaid on KMEM Airport | 34 |
| Figure B.25 99% Horizontal Position Uncertainty Boundary Overlaid on KMEM Airport | 35 |
| Figure B.26 99.9% Horizontal Position Uncertainty Boundary Overlaid on KMEM Airport | 35 |
| Figure B.27 95% Horizontal Position Uncertainty Boundary Overlaid on KMEM Airport | 36 |
| Figure B.28 99% Horizontal Position Uncertainty Boundary Overlaid on KMEM Airport | 36 |
| Figure B.29 99.9% Horizontal Position Uncertainty Boundary Overlaid on KMEM Airport | 37 |
| Figure B.30 Different Traffic Symbol Reference Points | 65 |
| Figure B.31 Symbol Size | 66 |
| Figure B.32 Primary Contributors to the ATSA-SURF Total Traffic Position Error Model | 78 |
| Figure B.33 Details of Sources Contributing to Total Traffic Position Error | 79 |
| Figure B.34 The Root-Sum-Squared Position Uncertainty Model for ATSA-SURF | 80 |
| Figure B.35 Monte-Carlo Total Position Error Analysis Model | 83 |
| Figure B.36 Position Source Error Model | 84 |
| Figure B.37 ADS-B/R and Surveillance Processing Error Model | 84 |
| Figure B.38 Additional information for Blocks 2.6 and 2.7 depicted in Figure B.37 | 85 |
| Figure B.39 Map Error Model | 90 |
| Figure B.41 Display Resolution Error Model | 90 |
| Figure B.42 Reference Coordinate Frame Depicted on Scenario #1A | 4 |
| Figure B.43 Reference Coordinate Frame Depicted on Scenario #5A | 4 |
| Figure B.44 Asymmetric Along-Track 99.9% Total Position Error (X-Axis) – ADS-B | 5 |
| Figure B.45 Composite Along-Track 99.9% Total Position Error (X-Axis) – ADS-B | 7 |
| Figure B.46 Symmetric Cross-Track 99.9% Total Position Error (Y-Axis) – ADS-B | 7 |
| Figure B.47 Composite Cross-Track 99.9% Total Position Error (Y-Axis) – ADS-B | 8 |
| Figure B.48 ADS-B Traffic On-Ground – Along-Track (X-Axis) Total Position Error Uncertainty for Speeds of 0, 30, and 50 knots (Sensor Accuracy 0 to 50 m) | 10 |
| Figure B.49 ADS-B Traffic On-Ground – Along-Track (X-Axis) Total Position Error Uncertainty for Speeds of 0, 30, and 50 knots (Sensor Accuracy 0 – 100 m) | 11 |

| | |
|---|----|
| Figure B.50 ADS-R Traffic On-Ground – Along-Track (X-Axis) Total Position Error Uncertainty for Speeds of 0, 30, and 50 knots | 11 |
| Figure B.51 ADS-B Traffic On-Ground – Cross-Track (Y-Axis) Total Position Error Uncertainty for Speeds of 0, 30, and 50 knots (Sensor Accuracy 0 to 50 m) | 12 |
| Figure B.53 ADS-R Traffic On-Ground – Cross-Track (Y-Axis) Total Position Error Uncertainty for Speeds of 0, 30, and 50 knots (Sensor Accuracy 0 to 100 m) | 13 |
| Figure B.54 Traffic On-Ground – Comparison of Along-Track (X-Axis) ADS-B and ADS-R Total Position Error Uncertainty [0 knots]..... | 14 |
| Figure B.55 Traffic On-Ground – Comparison of Cross-Track (Y-Axis) ADS-B and ADS-R Total Position Error Uncertainty [0 knots] | 14 |
| Figure B.56 ADS-B Traffic In-Air – Along-Track (X-Axis) Total Position Error Uncertainty for Speeds of 80, 150, and 178 knots | 15 |
| Figure B.57 ADS-R Traffic In-Air – Along-Track (X-Axis) Total Position Error Uncertainty for Speeds of 80, 150, and 178 knots (Sensor Accuracy 0 to 100 m)..... | 16 |
| Figure B.59 ADS-B Traffic In-Air – Cross-Track (Y-Axis) Total Position Error Uncertainty for Speeds of 80, 150, and 178 knots | 17 |
| Figure B.61 ADS-R Traffic In-Air – Cross-Track (Y-Axis) Total Position Error Uncertainty for Speeds of 80, 150, and 178 knots (Sensor Accuracy 0 to 200 m)..... | 18 |
| Figure B.62 Traffic In-Air – Comparison of Along-Track (X-Axis) ADS-B and ADS-R Total Position Error Uncertainty [100 knots] | 19 |
| Figure B.63 Traffic In-Air – Comparison of Cross-Track (Y-Axis) ADS-B and ADS-R Total Position Error Uncertainty [100 knots] | 19 |
| Figure B.64 RMS-Model: ADS-B Traffic On-Ground – Along-Track (X-Axis) Total Position Error Uncertainty for Speeds of 0, 30, and 50 Knots | 20 |
| Figure B.65 RMS-Model: ADS-B Traffic On-Ground – Cross-Track (Y-Axis) Total Position Error Uncertainty for Speeds of 0, 30, and 50 Knots | 21 |
| Figure B.72 ADS-B Traffic On-Ground – Along-Track (X-Axis) Total Position Error Uncertainty (95%) as a Function of Latency Compensation Threshold [True Traffic Speed of 5 knots]..... | 27 |
| Figure B.75 ADS-B Traffic On-Ground – Cross-Track (Y-Axis) Total Position Error Uncertainty (99.9%) as a Function of Latency Compensation Threshold [True Traffic Speed of 5 knots]..... | 28 |
| Figure B.76 ADS-B Traffic On-Ground – Along-Track (X-Axis) Total Position Error Uncertainty (95%) as a Function of Latency Compensation Threshold [True Traffic Speed of 10 knots]..... | 29 |
| Figure B.79 ADS-B Traffic On-Ground – Cross-Track (Y-Axis) Total Position Error Uncertainty (99.9%) as a Function of Latency Compensation Threshold [True Traffic Speed of 10 knots]..... | 30 |
| Figure C.1 Safety Strategy for ATSA-SURF | 2 |
| Figure C.2 OSA Process Overview | 7 |

| | |
|--|----|
| Figure C.3 OSA Steps | 8 |
| Figure C.4 Probability “Pe” per Hazard-Effect Pair Scheme | 10 |
| Figure C.5 ASOR Steps..... | 15 |
| Figure C.6 Example Fault Tree | 16 |
| Figure C.7 “Taxi” Phase Event Tree | 29 |
| Figure C.8 “Taxi” Phase Secondary Event Tree (Real Threat Case) | 30 |
| Figure C.9 “Prior to Brake Release” Phase Event Tree | 33 |
| Figure C.10 “Prior to Brake Release” Phase Secondary Event Tree (Real Threat Case)..... | 34 |
| Figure C.11 “Rolling Less Than or Equal to 80 kts” Phase Event Tree..... | 37 |
| Figure C.12 “Rolling Less Than or Equal to 80 kts” Phase Secondary Event Tree (Real Threat Case)..... | 38 |
| Figure C.13 “Rolling Greater Than 80 kts” Phase Event Tree..... | 41 |
| Figure C.14 “Rolling Greater Than 80 kts” Phase Secondary Event Tree (Real Threat Case).... | 42 |
| Figure C.15 “Approach” Phase Event Tree..... | 46 |
| Figure C.16 “Approach” Phase Secondary Event Tree (Real Threat Case)..... | 47 |
| Figure C.17 “Landing” Phase Event Tree | 50 |
| Figure C.18 “Landing” Phase Secondary Event Tree (Real Threat Case) | 51 |
| Figure C.19 Fault Tree for OH1 | 55 |
| Figure C.20 Process for Calculating Credible Rare Normal Position Inaccuracy..... | 56 |
| Figure C.21 Illustration of Scenario Bounds for Perceived Threat | 58 |
| Figure C.22 Summary of Achievable Safety Levels, Assuming Varying Input Position Sensor Accuracy (95%)..... | 66 |
| Figure C.23 Summary of Along Track Errors, Assuming Varying Input Position Sensor Accuracy (95%)..... | 67 |
| Figure C.24 Summary of Cross Track Errors, Assuming Varying Input Position Sensor Accuracy (95%)..... | 67 |
| Figure C.25 OH2 Representative Event Tree..... | 74 |
| Figure C.26 OH2 Fault Tree..... | 76 |
| Figure C.27 OH3 Event Tree..... | 80 |
| Figure C.28 OH3 Fault Tree..... | 82 |
| Figure C.29 Example Scenario..... | 5 |
| Figure C.30 Relationship of Three Significant Cases in Analyzing ATSA-SURF Behaviour in a Conflict Situation | 6 |
| Figure C.31 Logic Tree for the Case Where Ownship Does Not Have ATSA-SURF Capability . | 6 |
| Figure C.32 Logic Tree for Case 2A—Ownship Equipped with ATSA-SURF, Traffic Has a Functioning ADS-B, and Traffic Is Detectable by Non-ADS-B Methods..... | 8 |
| Figure C.33 Logic Tree for Case 2B—Ownship Equipped with ATSA-SURF..... | 11 |

1 INTRODUCTION

This document provides the minimum operational, safety, and performance requirements (SPR) and interoperability requirements (INTEROP) for the implementation of enhanced Airborne Traffic Situational Awareness (ATSA) for Surface (SURF) Operations. The ATSA-SURF application is fully defined in the Operational Services and Environment Definition (OSED) found in Annex A.

All material in this document was developed jointly by EUROCAE Working Group 51 and RTCA Special Committee 186, within the group commonly referred to as the “ADS-B Requirements Focus Group” (RFG).

This document was developed based on the criteria for SPR and INTEROP documents set forth in RTCA DO-264/EUROCAE ED-78A, “Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications.[25]. It provides the minimum ATSA-SURF requirements - and allocations thereof - based on the results of a coordinated requirements determination process.

The requirements specified in this document are necessary to provide adequate assurance that the appropriate aspects of the relevant Communication Navigation Surveillance and Air Traffic Management (CNS/ATM) system, when operating together, will perform their intended function in an acceptably safe manner for the operations defined in the OSED. The system here includes airborne and, optionally, ground elements.

Whilst all detailed SPR related assessments are found in Annexes to this document, Chapter 3 presents the outcome of the reconciliation process of all of these results into a single set of underlying safety and performance requirements. This process retains the most stringent requirement for those attributes or parameters commonly treated by both the safety and performance assessments. Traceability of those requirements is provided back to the corresponding assessment(s).

1.1 Purpose of This Document

This document defines and allocates the set of minimum requirements for the end-to-end operational, safety, performance, and interoperability aspects for implementations of the ATSA-SURF application. Allocation of these requirements is done by this SPR/INTEROP to the necessary domains of the CNS/ATM system, i.e., at aircraft and Ground Domain level.

These requirements can be used for approval processes including aircraft type design approval, aircraft operator operational approval, and (should they be provided) Air Traffic Services (ATS) provider operational approval. Section 1.1.2 below provides more information on the use of this document for approvals.

In addition, this document also provides guidance to determine the levels of design assurance and performance that are needed for each element (aircraft, opera-