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

Safety, Performance and Interoperability Requirements Document for Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (SURF IA)

RTCA DO-323
December 8, 2010

Prepared by: SC-186
© 2010 RTCA, Inc.

Copies of this document may be obtained from

RTCA, Inc.

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

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

FOREWORD

This document was prepared by RTCA Special Committee 186 (SC-186). It 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 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 (MOPS) 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 (ICAO) and the International Telecommunication Union (ITU) and other appropriate international organizations can be based.

The recommendations of RTCA 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 (TSO).

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 United States Government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

This Page Intentionally Left Blank

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 Purpose of the Document 1

1.2 Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts 2

1.3 Airborne and Ground Generic Surveillance Functional Architecture 3

1.4 Structure of the Document 5

1.5 Definition of Terms 5

1.6 References 8

1.6.1 ICAO 8

1.6.2 EUROCONTROL 8

1.6.3 EUROCAE/RTCA 8

1.6.4 Other 9

2 APPROACH AND METHODOLOGY 11

2.1 Document Development Process 11

2.2 Methodology 11

2.2.1 Operational Services and Environment Definition (OSED) 12

2.2.2 OSA Process 12

2.2.3 OPA Process 14

2.2.4 Safety and Performance Requirements (SPR) 15

2.2.5 Interoperability Requirements 15

2.3 Key Terms 15

2.3.1 Uses of Requirements and Recommendations and Key Terms 15

2.3.2 Assumptions 16

2.3.3 Mitigation Means 16

2.3.4 Requirements 16

2.3.5 Recommendations 17

3 SAFETY AND PERFORMANCE REQUIREMENTS (SPR) 19

3.1 Background/Introduction 19

3.2 Conclusions of the SPR 19

3.2.1 Conclusions of the OSA 19

3.2.2 Conclusions of the OPA 20

3.3 Assumptions 20

3.3.1 General Assumptions 20

3.3.2 Environmental Assumptions 22

3.3.3 Receive Aircraft Domain Assumptions 22

3.3.4 Ground Domain Assumptions 22

3.3.5 Performance Assumptions 23

3.3.6 Safety Assumptions 23

3.4 Operational Requirements 25

3.5 Equipment Requirements and Recommendations 27

3.5.1 General 27
3.5.2 Indications and Alerts 32
3.6 Data Requirements 37
3.6.1 Airport Data 37
3.6.2 Ownship Data 39
3.6.3 Traffic Data 44
3.7 System Reliability 48
3.8 Safety Requirements 49
3.9 Design Considerations 50
3.9.1 Runway Geometry and Geometric Assumptions 51
3.9.2 TIS-B Considerations 51
3.9.3 ADS-B Link MOPS Version Considerations 52
4 INTEROPERABILITY REQUIREMENTS 53
4.1 Purpose of Interoperability Requirements 53
4.2 Scope of Interoperability Requirements 53
4.2.1 SURF IA Domains 53
4.3 SURF IA Interoperability Requirements 55
4.3.1 INTEROP Data 55
4.3.2 Identity 57
4.3.3 Horizontal Position 58
4.3.4 Vertical Position 59
4.3.5 Velocity 60
4.3.6 Type of Traffic 62
4.3.7 Surveillance Quality Indicators 62
4.3.8 Aircraft/Vehicle Size 64
APPENDIX A OPERATIONAL SERVICES AND ENVIRONMENT DESCRIPTION (OSED) A-1
A.1 Introduction A-1
A.1.1 Improving Runway Safety A-2
A.1.2 Operational Purpose A-4
A.1.3 Relation to other CDTI Applications on the Airport Surface A-4
A.1.4 Maturity and User Interest A-5
A.2 Operational Concept, Roles, and Procedures A-5
A.2.1 Concept Description A-5
A.2.2 Procedures and Responsibilities A-28
A.3 Sample Scenarios A-29
A.3.1 Ownship on Approach to Runway; Conflict Traffic on Runway A-30
A.3.2 Ownship Approaching a Runway With Intent to Cross A-30
A.3.3 Ownship is Taking Off; Another Aircraft is Entering Ahead A-31
A.3.4 Ownship Landing; Conflict Traffic Taxiing onto the Runway A-32
A.3.5 Ownship Taxiing on a Runway; an Aircraft on Approach from Behind A-32
A.4 Requirements A-33
A.4.1 Operational Service Requirements and Recommendations A-33

A.4.2 Operational Requirements A-38
A.4.3 Application Assumptions A-39
A.4.4 Display and Interface Requirements A-41
A.4.5 Infrastructure Requirements A-47
A.5 Application Phases A-49
A.5.1 Setup Phase A-49
A.5.2 Conduct Phase A-49
A.5.3 Termination Phase A-51
A.6 Other Considerations A-52
A.6.1 Relationship to Other Programs and Future Enhancements A-52
A.6.2 Advanced Development A-52
A.7 Issues that are Outside the Scope of this Version of the Application A-53
A.8 References A-53
APPENDIX B OPERATIONAL PERFORMANCE ASSESSMENT (OPA) B-1
B.1 Introduction B-4
B.1.1 Approach B-4
B.1.2 Scope B-4
B.1.3 Referenced Documents B-6
B.2 Input and Display Requirements B-7
B.2.1 Surveillance Equipage B-7
B.2.2 Data Requirements B-8
B.2.3 Variable Data Quality B-14
B.2.4 Information and Display Requirements B-14
B.2.5 Performance Requirements Established by Existing Standards B-14
B.2.6 Referenced Performance Metrics B-15
B.3 Analysis Approach B-22
B.3.1 Analysis Nomenclature B-23
B.3.2 Types of Detections B-23
B.3.3 Types of Analysis B-25
B.4 Nuisance Detection Analysis B-31
B.4.1 Overview of Nuisance Detection Analysis B-31
B.4.2 Error Model Assumptions B-33
B.4.3 Other Assumptions B-37
B.4.4 Algorithmic Models for Nuisance Detection Analysis B-46
B.4.5 Characterizing Aircraft on Approach B-51
B.4.6 Mathematical Shorthand Used in Analysis Documentation B-51
B.4.7 Nuisance Detections Per Ownship State B-52
B.4.8 Nuisance Detections Per Operation B-55
B.4.9 Position Accuracy Requirements for Nuisance Detections B-55
B.5 Analysis of Aircraft on Approach B-63
B.5.1 True Location Assumptions B-63
B.5.2 Nuisance and Missed Detections for Aircraft on Approach B-65
B.5.3 Approach Corridor Definition B-69
B.5.4 Analysis B-73

B.6 Data Integrity Analysis B-83
B.6.1 Horizontal Position Integrity B-83
B.6.2 Other Data Integrity B-86
B.7 Other Analysis B-86
B.7.1 Altitude Analysis B-86
B.7.2 Velocity Accuracy Analysis B-87
B.7.3 Latency Analysis B-93
B.7.4 Data Age Drop Considerations B-96
B.7.5 Surface Vehicle Analysis B-97
B.7.6 Directionality Analysis B-107
B.7.7 Electronic Airport Map Analysis B-109
B.8 Missed Detection Analysis B-111
B.8.1 Assumptions B-111
B.8.2 Algorithmic Models for Missed Detection Analysis B-116
B.8.3 Probability of Missed Detection for Each Aircraft State B-119
B.8.4 Results of Missed Detection Analysis for Example Scenarios B-125
B.9 Sensitivity Analysis B-130
B.9.1 Accuracy vs. Probability of Nuisance B-130
B.9.2 Acceptable Nuisance Rate (ANR) Sensitivity B-131
B.9.3 Aircraft Traffic Volume Sensitivity B-132
B.10 Design Considerations B-133
B.10.1 Runway Geometry and Geometric Assumptions B-133
B.10.2 TIS-B Considerations B-138
B.11 Mathematical Formulae for Probability Calculations B-138
B.11.1 Detections Past Geometric Bound in 1 Direction B-139
B.11.2 Detections Past Geometric Bound in 2 Directions B-139
B.11.3 Combining Multiple Probabilities that are Equal B-139
B.11.4 Combining Multiple Probabilities that are Not Equal B-140
APPENDIX C OPERATIONAL SAFETY ASSESSMENT (OSA) C-3
C.1 Introduction to Operational Safety Assessment (OSA) C-5
C.1.1 Safety Assessment Approach C-5
C.1.2 OHA Process C-11
C.1.3 ASOR Process C-15
C.2 OHA Interconnect Map C-19
C.2.1 Parameter Analysis C-19
C.2.2 Detailed Tree Mapping C-25
C.3 SURF IA Application Description C-31
C.3.1 Functional System Description C-32
C.4 SURF IA Main OSA Results C-35
C.4.1 Operational Hazard Identification C-36
C.4.2 Operational Hazards Effects Assessment C-38
C.4.3 Safety Objectives Determination C-53
C.4.4 Allocation of the Safety Objectives C-54
C.5 Inhibition of SURF IA Output C-57

C.5.1 Introduction to Risks Associated with Stop versus Go Decision C-60
C.6 Overview of Aircraft States C-62
C.6.1 State 1: Taxi on Taxiway in Proximity to Runway C-64
C.6.2 State 2: Holding Short of Runway C-64
C.6.3 State 3: Entering a Runway C-65
C.6.4 State 4: Crossing and Exiting Runway C-66
C.6.5 State 5: Position and Hold on Runway C-67
C.6.6 State 6: Taxiing on a Runway < 40 knots or Initial Takeoff Roll C-68
C.6.7 State 7: Takeoff > 40 and < 80 knots C-69
C.6.8 State 8: Takeoff > 80 knots and < 100 knots C-70
C.6.9 State 9: Takeoff > 100 knots and < V1 knots C-71
C.6.10 State 10: Takeoff > = V1 to Liftoff C-72
C.6.11 State 11: Cruise > 1,000 feet AGL C-72
C.6.12 State 12: On Approach before Reaching the Caution Alert Threshold C-73
C.6.13 State 13: On Approach after reaching Caution Alert Threshold but before Reaching the Warning Alert Threshold C-74
C.6.14 State 14: On Approach after reaching the Warning Alert Threshold and before Touchdown C-74
C.6.15 State 15: Touchdown and Landing Roll C-75
C.6.16 State 16: Full Length Aircraft Takeoff during LAHSO (Land and Hold Short Operation) C-77
C.7 Hazard and Effects Analysis C-79
C.8 Analysis Description C-83
C.8.1 Event Tree Description C-84
C.8.2 Fault Tree Description C-165
C.9 Bowtie Result Summary C-218
C.9.1 Introduction C-218
C.9.2 Dissecting the Catastrophic Level Medium Risks C-221
C.9.3 Mitigations C-222
C.9.4 Treatment of the Missed Case C-223
C.10 Allocation of Safety Objectives and Requirements (ASOR) C-224
APPENDIX D LIST OF ACRONYMS AND GLOSSARY D-1
D.1 Acronyms List D-1
D.2 Glossary D-5
APPENDIX E PARTICIPATING MEMBERS E-1

TABLE OF FIGURES

Figure 1-1 Example of a SURF IA Indication on a CDTI 3
Figure 1-2 Surveillance Functional Architecture 4
Figure 2-1 Relationship Between Operational, Safety, Performance and Interoperability Requirements 12
Figure 3-1 Metrics DimA and DimB are Used to Describe Horizontal Position Accuracy Requirements 41
Figure A-1 Conceptual Diagram of Relation Between SURF IA Application and Cockpit Display of Traffic Information A-5
Figure A-2 Schematic Depiction of Relation Between Traffic Relevance and Indications and Alerts (Not Drawn to Scale) A-8
Figure A-3 Example Implementation of Runway Status and Traffic Indications A-10
Figure A-4 Examples for Runway Status Indication (Note: Shown traffic symbols are brown, not yellow) A-11
Figure A-5 Example for Traffic Indication (Note: Shown traffic symbols are brown, not yellow) A-12
Figure A-6 Example for Warning Alert A-15
Figure A-7 Two Cases for LAHSO Suppression: Either Ownship has Accepted LAHSO (Left) or Traffic has Accepted a LAHSO Clearance (Right) A-26
Figure A-8 Ownship has Received a Clearance to Cross a Runway on Which an Aircraft is on Approach A-27
Figure A-9 Illustration of LAHSO Suppression Cases A-27
Figure A-10 Ownship (Outline of Triangle) on Approach to a Runway Where an Aircraft is in Position and Holding (Dark Chevron) (Not Drawn to Scale) A-30
Figure A-11 Ownship is Approaching a Runway from a Taxiway While an Aircraft is Initially in Position and Holding and then Departs A-31
Figure A-12 Ownship is in Position and Holding and then taking off as an Aircraft is About to Enter the Runway A-31
Figure A-13 Ownship has Landed on a Runway and an Aircraft is Entering the Runway Ahead of Ownship A-32
Figure A-14 Ownship is Taxiing on Runways and an Aircraft is Approaching from Behind A-33
Figure A-15 ADS-B Surface Environment A-48
Figure B-1 Functional Architecture B-5
Figure B-2 Information Flow between SURF IA and CDTI B-6
Figure B-3 Definition of Surface Geometry Investigated in this Document B-18
Figure B-4 Minimum Hold Line and Runway Separation Distances for Aerodrome Code 4 (Adapted from RTCA DO-289, Figure F-7) B-22
Figure B-5 Venn Diagram of Detection Events B-24
Figure B-6 Missed Detection Occurs on Approach B-30
Figure B-7 Bivariate Gaussian Distribution Used for Position Error B-34
Figure B-8 Deriving the Number of Standard Deviations for a 95% Accuracy Bound B-35
Figure B-9 Illustration of “On Runway” when Lined up with Runway B-39
Figure B-10 Illustration of “On Runway” When Not Lined Up with Runway B-39
Figure B-11 Airport Surface Examples of Total Position Error, Geometric Error Bound (GEB), and Probability of Nuisance Detection B-40

Figure B-12 Geometric Assumptions for Nuisance Detection Analysis B-42
Figure B-13 DFW Aircraft Traffic Volume Model for Analysis B-43
Figure B-14 Comparison of Algorithms dealing with Aircraft Length & POR B-50
Figure B-15 Accuracy Performance Requirement Analysis Process B-57
Figure B-16 Ownship Accuracy Performance Requirements B-58
Figure B-17 Traffic Aircraft Accuracy Performance Requirements B-59
Figure B-18 Philadelphia Airport ASDE-X Approach Corridors B-64
Figure B-19 SURF IA Truth Corridor and Sliding Gaussian Distribution for FTE B-64
Figure B-20 Notional Single Runway Approach Corridor B-66
Figure B-21 Probability of Nuisance Detection for Aircraft on Approach B-67
Figure B-22 Diagram of Closely Spaced Parallel Runways B-68
Figure B-23 Notional Examples for Closely Spaced Parallel Runways B-69
Figure B-24 Single Runway Approach Corridor B-71
Figure B-25 Approach Corridor Shape Near Runway Threshold B-72
Figure B-26 NACp8 and NACp7 Runway Approach Corridors & P(missed) B-75
Figure B-27 Single Runway Corridor P(missed) vs. Accuracy B-76
Figure B-28 Single Runway Corridor P(missed) vs. Accuracy-Closer Look B-76
Figure B-29 Parallel Runway Performance vs. Distance From Runway B-78
Figure B-30 Parallel Runway Performance vs. Runway Separation B-79
Figure B-31 Parallel Runway Performance vs. Accuracy B-80
Figure B-32 Runway Separation vs. TI Mitigation for Closely Spaced Parallel Runways B-82
Figure B-33 Velocity-based Convergence B-89
Figure B-34 Minimum Convergence Rates for Velocity-based Convergence B-90
Figure B-35 Time to Alert vs. Time to Alert Error for Approach Aircraft B-92
Figure B-36 Position Errors for Vehicle on Shoulder Edge B-98
Figure B-37 Aircraft & Surface Vehicle “On-Runway” Crossing Definition B-98
Figure B-38 Traffic Accuracy Performance Requirements B-99
Figure B-39 Surface Vehicle & Aircraft Missed Detection Analysis Results – On-Runway and Line Up B-102
Figure B-40 Surface Vehicle & Aircraft Static Missed Detection Analysis Results – Crossing Runway B-104
Figure B-41 Surface Vehicle & Aircraft Dynamic Missed Detection Analysis Results – Crossing Runway B-106
Figure B-42 Map Database Horizontal Accuracy Sensitivity B-109
Figure B-43 Position Error Distributions, Geometric Error Bound (GEB), and Probability of Missed Detection for Several Runway Scenarios B-114
Figure B-44 Airport Geometry Assumptions for Missed Detections B-115
Figure B-45 Probability of Missed Detection for Aircraft on Holdline B-120
Figure B-46 Probability of Missed Detection for Aircraft on Runway and Lined Up B-121
Figure B-47 Probability of Missed Detection of Aircraft Crossing a Runway – Static Analysis B-122
Figure B-48 Probability of Missed Detection of Aircraft Crossing a Runway – Dynamic Analysis B-123
Figure B-49 Probability of Missed Detection of Aircraft Crossing & Stopped on Runway Centerline B-124

Figure B-50 Probability of Missed Detection of Aircraft Crossing & Stopped on Runway Centerline Zoomed In B-125
Figure B-51 Missed Detection Example Scenario, Aircraft 1 Behind Hold Line – Aircraft 2 Approach and Land B-126
Figure B-52 Missed Detection Example Scenario, Aircraft 1 Crossing Small Runway & Stopped on Centerline – Aircraft 2 Approach and Land B-127
Figure B-53 Missed Detection Example Scenario, Aircraft 1 Crossing Large Runway & Stopped on Centerline – Aircraft 2 Approach and Land B-128
Figure B-54 Missed Detection Example Scenario, Aircraft 1 Approach and Land – Aircraft 2 Takeoff B-129
Figure B-55 Accuracy vs. P(nuisance warning alerts) Sensitivity B-131
Figure B-56 Acceptable Nuisance Rate Sensitivity Plot B-132
Figure B-57 Aircraft Traffic Volume Sensitivity Plot B-133
Figure B-58 Example 1 *Excerpt from Table B-9, Table B-11, and Table B-25* B-135
Figure B-59 Example 2 *Excerpt from Table B-9, Table B-11, and Table B-25* B-136
Figure B-60 Example 3 *Excerpt from Table B-9, Table B-11, and Table B-25* B-137
Figure B-61 Excerpt from *Table B-26* B-137
Figure C-1 Bowtie Model C-6
Figure C-2 Extended Bowtie Model C-7
Figure C-3 Individual State Analysis Process C-9
Figure C-4 Likelihood Combination across All States C-10
Figure C-5 OHA Steps C-12
Figure C-6 Probability “Pe” per Hazard-Effect Pair Scheme C-14
Figure C-7 ASOR Steps C-16
Figure C-8 Example of Fault Tree Structure C-17
Figure C-9 Boundary of SURF IA System (OSED) C-33
Figure C-10 SMS Manual v2.1 - Risk Matrix C-45
Figure C-11 Untrue Rate Model C-56
Figure C-12 False and Nuisance Rate Components C-57
Figure C-13 Inhibiting Alerts – Stop versus Go C-61
Figure C-14 Inhibiting Indications – Stop versus Go C-62
Figure C-15 State 1: Taxi on Taxiway in Proximity to the Runway C-64
Figure C-16 State 2: Holding Short of Runway C-65
Figure C-17 State 3: Entering a Runway C-66
Figure C-18 State 4: Crossing a Runway C-67
Figure C-19 State 4: Exiting a Runway C-67
Figure C-20 State 5: Position and Hold on Runway C-68
Figure C-21 State 6: Taxiing on a Runway < 40 knots or Initial Takeoff Roll C-69
Figure C-22 State 7: Takeoff > 40 and < 80 knots C-70
Figure C-23 State 8: Takeoff > 80 knots and < V1 (Warning and Caution Not Suppressed) C-71
Figure C-24 State 9: Takeoff > 100 knots and < V1 (Warning and Caution Not Suppressed) C-72
Figure C-25 State 11: Climb C-73
Figure C-26 State 12: On Approach before Reaching the Caution Alert Threshold C-73
Figure C-27 State 13: On Approach after reaching Caution Alert Threshold but before reaching the Warning Alert Threshold C-74

Figure C-28 State 14: On Approach after Reaching the Warning Alert and Before Touchdown C-75
Figure C-29 State 15: Touchdown and Landing Roll Conflict Ahead (Warning and Caution Not Suppressed) C-76
Figure C-30 State 15: Touchdown and Landing Roll Conflict Behind (Warning and Caution Not Suppressed) C-76
Figure C-31 State 16: Ownship is Hold Short Aircraft C-78
Figure C-32 State 16: Ownship is Full Length Aircraft C-79
Figure C-33 ET1: True Indication or Alert / Controlled Environment C-93
Figure C-34 ET2: True Indication or Alert / Uncontrolled Environment C-94
Figure C-35 ET3: Untrue Indication or Alert / Controlled Environment C-96
Figure C-36 ET4: Untrue Indication or Alert / Uncontrolled Environment C-97
Figure C-37 ET5: Low Speed (< 40 knots), Lateral Excursion C-99
Figure C-38 ET6: Lateral Runway Excursion C-100
Figure C-39 ET7: Non-Reversible Maneuver Rejected Takeoff – True / below 100 knots C-101
Figure C-40 ET8: Non-Reversible Maneuver Rejected Takeoff – True / Collision or Overrun / above 100 knots and below or Equal to V1 ..... C-102
Figure C-41 ET10: Non-Reversible Maneuver Rejected Takeoff – Untrue / below 100 knots C-103
Figure C-42 ET11: Non-Reversible Maneuver Rejected Takeoff – Untrue / Overrun / above 100 knots and below or Equal to V1 ..... C-104
Figure C-43 ET13: Non-Reversible Maneuver Early Rotation / True / Incursion or Collision C-105
Figure C-44 ET14: Non-Reversible Maneuver Early Rotation – Untrue / Tail Strike C-106
Figure C-45 ET15: Non-Reversible Maneuver Maximum Braking During Landing – True / Collision / High Speed C-107
Figure C-46 ET16: Non-Reversible Maneuver Maximum Braking During Landing – Untrue / High Speed C-108
Figure C-47 Entering Runway Case C-109
Figure C-48 Exiting Runway Case C-110
Figure C-49 True Indication or Alert / Controlled Environment / Entering or Exiting Runway C-111
Figure C-50 True Indication or Alert/ Uncontrolled Environment / Entering or Exiting Runway C-112
Figure C-51 Symbol Examples C-165
Figure C-52 True Case C-181
Figure C-53 Untrue Case C-182
Figure C-54 True Indication Case C-183
Figure C-55 Untrue Indication Case C-184
Figure C-56 Flight Crew Observes Untrue Indication Taxi Branch C-185
Figure C-57 Flight Crew Observes Untrue Alert Taxi Case C-186
Figure C-58 Flight Crew Observes Unsuppressed LAHSO Alert C-188
Figure C-59 Controlled Mitigation G1 Branch C-189
Figure C-60 Uncontrolled Mitigation G2 Branch C-191
Figure C-61 G1 Mitigation Failure Controlled + Suppressed Branch C-192
Figure C-62 Mitigation Failure G2 Uncontrolled + Suppressed Branch C-193
Figure C-63 Controlled Mitigation Failure G3 Branch C-194
Figure C-64 FT1: Indication + True + Controlled (G1) Case C-197
Figure C-65 FT2: Indication + True + Uncontrolled (G2) Case C-198
Figure C-66 FT3: Indication + Untrue + Controlled (G1) Case C-199

Figure C-67 FT4: Indication + Untrue + Uncontrolled (G2) Case C-200
Figure C-68 FT9: Indication + True + Controlled + Suppression (G1 + S) Case C-201
Figure C-69 FT10: Indication + True + Uncontrolled + Suppression (G2 + S) Case C-202
Figure C-70 FT11: Indication + Untrue + Controlled + Suppression (G1 + S) Case C-203
Figure C-71 FT12: Indication + Untrue + Uncontrolled + Suppression (G2 + S) Case C-204
Figure C-72 FT18: Indication + Untrue Taxiway + Controlled (G1) Case C-205
Figure C-73 FT19: Indication + Untrue Taxiway + Uncontrolled (G2) Case C-206
Figure C-74 FT5: Alert + True + Controlled (G1) Case C-207
Figure C-75 FT6: Alert + True + Uncontrolled (G2) Case C-208
Figure C-76 FT7: Alert + Untrue + Controlled (G1) Case C-209
Figure C-77 FT8: Alert + Untrue + Uncontrolled (G2) Case C-210
Figure C-78 FT13: Alert + True + Controlled + Suppression (G1 + S) Case C-211
Figure C-79 FT14: Alert + True + Uncontrolled + Suppression (G2 + S) Case C-212
Figure C-80 FT15: Alert + Untrue + Controlled + Suppression (G1 + S) Case C-213
Figure C-81 FT16: Alert + Untrue + Uncontrolled + Suppression (G2 + S) Case C-214
Figure C-82 FT17: Alert + Unsuppressed + LAHSO + Controlled (G3) Case C-215
Figure C-83 FT20: Alert + Untrue + Taxiway + Controlled (G1) Case C-216
Figure C-84 FT21: Alert + Untrue + Taxiway + Uncontrolled (G2) Case C-217
Appendix C, Annex B, Figure B-1 Categories of Runway Incursion Severity (FY 2004-2007) C-245
Appendix C, Annex B, Figure B-2 Runway Incursion Severity Distribution (FY 2004-2007) C-246
Appendix C, Annex B, Figure B-3 A and B Runway Incursions C-247
Appendix C, Annex B, Figure B-4 Worldwide C-249
Appendix C, Annex B, Figure B-5 EASA States C-249
Appendix C, Annex B, Figure B-6 Excursions (2004-2008) C-250
Appendix C, Annex B, Figure B-7 Early Rotation / 747 Tail Strike C-251
Appendix C, Annex B, Figure B-8 Commercial Overruns C-253
Appendix C, Annex B, Figure B-9 Distribution of Rejected Takeoff Initiation Speeds C-254
Appendix C, Annex B, Figure B-10 Rejected Takeoff Availability Statistics C-254
Appendix C, Annex B, Figure B-11 Example of Major / Hazardous Runway Excursion (Landing Case) C-255
Appendix C, Annex B, Figure B-12 Example of Catastrophic Runway Excursion (Landing Case) C-256
Appendix C, Annex B, Figure B-13 Causes of Reported RTO Events (Source: Runway Safety Aid) C-256
Appendix C, Annex B, Figure B-14 Estimates of Human Performance Error Rates (Source: SSDC course handouts. Data points were compiled from various government studies) C-257

TABLE OF TABLES

Table 3-1 Required Data Items for the Electronic Airport Map 37
Table 3-2 Recommended Data Items for the Electronic Airport Map 38
Table 3-3 Required Data Items for Ownship 39
Table 3-4 Recommended Data Items for Ownship 40
Table 3-5 Ownship and Traffic Aircraft Horizontal Position Accuracy Requirements on the Surface 42
Table 3-6 Required Data Items for Traffic 44
Table 3-7 Recommended Data Items for Traffic 45
Table 3-8 Integrity Level Requirements for Traffic and Ownship 48
Table 3-9 Alternatives for Providing Directionality for Stopped or Slowly Moving Targets and Ownship 51
Table A-1 List of Aircraft States Used in OSED (SPR Appendix A) and Comparison to States Used in OSA (SPR Appendix C) A-16
Table A-2 SURF IA Outputs for all Possible Two-Aircraft State Combinations A-19
Table A-3 SURF IA Outputs for Intersecting Runways A-24
Table A-4 SURF IA Information Elements for the Flight Crew A-41
Table A-5 Rationale for Display Requirements A-43
Table A-6 Example SURF IA Indication and Alerting Messages; Auditory Alerts are the Same as the Textual Message A-45
Table A-7 Comparison of TCAS and SURF IA Behavior A-46
Table A-8 SURF IA Setup Phase A-49
Table A-9 SURF IA Conduct Phase A-50
Table A-10 SURF IA Termination Phase A-52
Table B-1 Referenced Documents B-6
Table B-2 Ownship Data Items B-9
Table B-3 Electronic Airport Map Data Items B-10
Table B-4 Traffic Element Data Requirements B-12
Table B-5 Data Quality Requirements for Display of Traffic for FAROA and ASSA (from RTCA DO-317) B-15
Table B-6 Navigation Accuracy Categories for Position (NACp) B-16
Table B-7 Navigation Integrity Categories (NIC) B-16
Table B-8 Surveillance Integrity Level (SIL) B-17
Table B-9 Navigation Accuracy Categories for Velocity (NACv) B-17
Table B-10 ICAO Minimum Airport Surface Geometry (ICAO Annex 14) B-19
Table B-11 US Minimum Airport Surface Geometry (AC 150/5300-13) B-19
Table B-12 DimA and DimB derived from ICAO Standards (ICAO Annex 14) B-20
Table B-13 DimA and DimB Derived from US Standards (AC 150/5300-13) B-21
Table B-14 Ownship States in One Operation B-23
Table B-15 Operationally Acceptable Nuisance Detection Rates per State B-32
Table B-16 Acceptable Nuisance Detection Rates from Operational Safety Assessment B-32
Table B-17 Operationally Acceptable Nuisance Rates per Operation B-33
Table B-18 Ownship True States and Associated Nuisance States B-38
Table B-19 Traffic Aircraft True States and Associated Nuisance States B-38

Table B-20 Aircraft Traffic Volume for Nuisance Detection Analysis B-43
Table B-21 Aircraft Traffic Volume Category Assumptions based on Airport Geometry B-44
Table B-22 Possible Nuisance Detection Output Matrix (Derived from Table A-2) B-45
Table B-23 Aircraft Length Ranges for Monte Carlo Analysis B-46
Table B-24 Acceptable Nuisance Budget for Aircraft on Approach B-51
Table B-25 Functions Used in Requirements Analysis B-52
Table B-26 Horizontal Position Accuracy Requirements for Aircraft on the Surface B-60
Table B-27 NACp Reference for Traffic Aircraft B-63
Table B-28 ICAO Standard for Parallel Runway Spacing (ICAO Annex 14) B-66
Table B-29 US Standard for Parallel Runway Spacing (AC 150 / 5300-13) B-66
Table B-30 Straight Line Approach Corridor Single and Parallel Runway Analysis B-71
Table B-31 Acceptable Nuisance Rates for Indications, Cautions, and Warnings B-77
Table B-32 Exposure Times and Operationally Acceptable Nuisance Rates B-84
Table B-33 Integrity Level Requirements B-85
Table B-34 Integrity level requirements for traffic and ownship B-86
Table B-35 Alternatives for Providing Directionality for Stopped or Slowly Moving Targets and Ownship B-107
Table B-36 Ownship True States and Associated Missed States B-112
Table B-37 Traffic True States and Associated Missed States B-112
Table B-38 Aircraft Length Ranges for Monte Carlo Analysis B-116
Table C-1 Process ID and Document Traceability C-11
Table C-2 Safety Targets from FAA SMS Approach C-14
Table C-3 Parameters C-20
Table C-4 Overall Tree Mapping, State 1 ..... C-25
Table C-5 Overall Tree Mapping, State 2 ..... C-26
Table C-6 Overall Tree Mapping, State 3 ..... C-26
Table C-7 Overall Tree Mapping, State 4 ..... C-27
Table C-8 Overall Tree Mapping, State 5 ..... C-27
Table C-9 Overall Tree Mapping, State 6 ..... C-28
Table C-10 Overall Tree Mapping, State 7 ..... C-28
Table C-11 Overall Tree Mapping, State 8 ..... C-29
Table C-12 Overall Tree Mapping, State 9 ..... C-29
Table C-13 Overall Tree Mapping, State 12 ..... C-30
Table C-14 Overall Tree Mapping, State 13 ..... C-30
Table C-15 Overall Tree Mapping, State 14 ..... C-30
Table C-16 Overall Tree Mapping, State 15 ..... C-31
Table C-17 Overall Tree Mapping, State 16 ..... C-31
Table C-18 SURF IA Functions List C-34
Table C-19 SURF IA Operational Hazards C-37
Table C-20 Environmental Conditions C-38
Table C-21 SMS Manual v2.1 Severity Definitions C-40
Table C-22 SMS Manual v2.1 Likelihood Definitions C-43
Table C-23 SMS Manual v2.1 Safety Order of Precedence C-46
Table C-24 Worst Credible Hazard Effect for All States C-48
Table C-25 Operational Hazards Worst Credible Effect, Pe, and Severity Class C-50

Table C-26 Safety Targets from SMS Approach C-53
Table C-27 Safety Objectives per SURF IA Hazard C-54
Table C-28 SURF IA Safety Objective Achievement C-55
Table C-29 False Rate Basic Cause Description Table C-56
Table C-30 Inhibition of All Components of Alerts C-59
Table C-31 Inhibition of the Indications C-59
Table C-32 Available Responses, Based on Indications or Alerts C-80
Table C-33 Desired Actions C-81
Table C-34 Event Tree Mitigation Means Description, Assumptions, and Requirements C-85
Table C-35 Departure State Exposure Time C-114
Table C-36 Approach and Landing State Exposure Time C-115
Table C-37 Total Operational Exposure Time C-115
Table C-38 Action Likelihood Table C-118
Table C-39 Worst Case Assumption Table C-154
Table C-40 Observability Likelihood Table C-155
Table C-41 Annual Runway Incursions per Operations C-165
Table C-42 Indication Related Likelihood and Requirements C-166
Table C-43 Alert Related Likelihood and Requirements C-167
Table C-44 Ownship State and Action-Based State Transition Likelihood and Requirements C-168
Table C-45 Flight Crew Failures and Mitigation Failures Likelihood and Requirements C-169
Table C-46 OTW Mitigation Failure Likelihood and Requirements C-171
Table C-47 ATC Mitigation Failure Likelihood and Requirements C-173
Table C-48 Machine Equipage Error Likelihood and Requirements C-174
Table C-49 Environmental States Likelihood and Requirements C-174
Table C-50 LAHSO Likelihood and Requirements C-175
Table C-51 Hazard Branch Likelihoods for Indications C-179
Table C-52 Hazard Branch Likelihoods for Alerts C-179
Table C-53 Fault Tree Identifications and Top-level Event Likelihood C-195
Table C-54 Overall Indication Severity/Likelihood Results C-219
Table C-55 Overall Alert Severity/Likelihood Results C-220
Table C-56 Pre-existing High Risks C-223
Table C-57 Safety Assumptions C-225
Table C-58 Safety Requirements C-237
Appendix C, Annex B, Table B-1 FAA Severity Definitions C-243
Appendix C, Annex B, Table B-2 Comparison of Previous and Current FAA Descriptions for Runway Incursion Severity Classification C-244
Appendix C, Annex B, Table B-3 ICAO to SMS Accident to Incident Severity Mapping C-247
Appendix C, Annex B, Table B-4 SMS Accident to Incident Severity Mapping C-248
Appendix C, Annex B, Table B-5 Runway Incursion Severity Mapping C-248
Appendix C, Annex B, Table B-6 Runway Excursion Severity Mapping C-248
Appendix C, Annex B, Table B-7 Early Rotation Severity Mapping C-251
Appendix C, Annex B, Table B-8 Rejected Takeoff Severity Mapping C-252
Appendix C, Annex B, Table B-9 Rejected Takeoff Statistics C-253
Appendix C, Annex C, Table C-1 State Header and Legend C-258
Appendix C, Annex C, Table C-2 Fault Tree and Hazard Likelihood C-259

Appendix C, Annex C, Table C-3 ..... C-260
Appendix C, Annex C, Table C-4 Summation across Severity Levels for a Single Action within a given State C-261

1 INTRODUCTION

This document provides the minimum Operational, Safety, and Performance Interoperability Requirements (SPR) for the implementation of Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (SURF IA). The SURF IA application is fully defined in the Operational Services and Environment Definition (OSED) found in SPR Appendix A. A short description of the application can be found in Section 1.2.

All material in this document was developed by Working Group 1 as part of RTCA Special Committee 186.

This document was developed based on the criteria for SPR and interoperability 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." [7]. It provides the minimum SURF IA requirements—and allocations thereof—based on the results of a coordinated requirements determination process.

The requirements contained in this document are necessary to provide adequate assurance that the system operates as defined in the OSED and will perform its intended function in an acceptably safe manner.

1.1 Purpose of the 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 SURF IA application. This document can be used as a component for approval processes including aircraft type design approval, and aircraft operator operational approval. The SPR can be used as a starting point for the development of Minimum Operational Performance Standards (MOPS), Technical Standard Orders (TSOs) or other material to support SURF IA system development or certification. States or regions implementing an application different to that specified in the OSED must take into account those difference in the operations or environment that affect the supporting analysis used to derive the safety, performance or interoperability requirements. The assessments and specifications in this document are not intended to be the sole basis for operational and airworthiness approval. Aircraft and avionics system designers should consider any additional specifications that may enhance the system supporting the SURF IA application in view of other future Airborne Surveillance Applications (ASA) so that systems designed for SURF IA will easily accommodate more demanding ADS-B enabled operations in the future.

The SURF IA SPR is also envisaged to be used along with those from other surveillance applications based on Automatic Dependent Surveillance-Broadcast (ADS-B) to develop minimum standards for avionic systems to assure that all subsystems perform their intended functions adequately for these applications.

© 2010, RTCA, Inc.

Notes:

1. *Requirements that provide protection against intentional behavior causing harm or sabotage are beyond the scope of this document.*
2. *Requirements related to the recording of ADS-B data for accident or incident investigation purposes are beyond the scope of this document. Nevertheless, it is expected that the SURF IA equipment allows the recording of SURF IA output behavior (i.e., indications and alerts) along with internal system state characteristics that can be used to monitor and improve system performance and safety.*

1.2 Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts

Runway incursions have been a major area of concern for the worldwide aviation community for decades. The SURF IA application intends to help decrease the likelihood and severity of runway incursions and collisions on or near the airport surface by (1) increasing pilot awareness of runway safety-related traffic information, (2) increasing the likelihood that this information is correctly processed by the flight crew in a timely manner, and (3) facilitating an appropriate compensatory response once an error has occurred.

SURF IA enhances the display of runway-related taxi, takeoff, and approach/landing traffic on a Cockpit Display of Traffic Information (CDTI) to help pilots process the sometimes complex CDTI information. SURF IA builds on two existing application descriptions for CDTI's: the Airport Surface Situational Awareness (ASSA), and Final Approach and Runway Occupancy Awareness (FAROA) applications (RTCA DO-317 and DO-289). ASSA uses an airport database to display airport elements (buildings, ramps, taxiways, runways, etc.) necessary for maintaining situation awareness while operating on the airport surface. FAROA is a subset of ASSA which provides crew awareness about traffic that is approaching the runway of intended use and during takeoff and crossing. In parallel with SC-186 development of SURF IA, SC-186/EUROCAE 51 developed a Safety, Performance and Interoperability requirements document for an application known as ATSA SURF (DO-322). ATSA SURF is in many ways similar to FAROA and ASSA, so that SURF IA requirements should be able to be built harmoniously on most ATSA SURF requirements. However, no specific analysis has been conducted to ascertain that SURF IA requirements match the underlying ATSA SURF requirements. Such analyses were not possible since, as already mentioned, the applications were developed in parallel.

SURF IA adds two distinct components to the ASSA, ATSA SURF, and FAROA CDTI applications: SURF IA indications and SURF IA alerts. SURF IA indications are provided for normal operational situations where collision hazard exists. SURF IA alerts are provided for non-normal operational situations where collision hazard exists or a collision appears imminent. Both SURF IA indications and alerts enhance the CDTI by highlighting traffic and/or runways, providing alphanumeric information and symbology, as well as providing offscale display information. The SURF IA application displays indications and alerts on a CDTI that display airport surface information (ASSA, FAROA, or ATSA SURF).

© 2010, RTCA, Inc.