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Authors of the document

Beneficiary	Date
EUROCONTROL	

Reviewers internal to the project

Beneficiary	Date
EUROCONTROL	

Reviewers external to the project

Beneficiary	Date
None	

Approved for submission to the S3JU By - Representatives of all beneficiaries involved in the project

Beneficiary	Date
EUROCONTROL	

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AART

AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

This Validation Report is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 874477 under European Union’s Horizon 2020 research and innovation programme.

Abstract

This Validation Report provides the results of the validation activities performed in the frame of PJ02 W2 project, for the solution PJ.02-W2-14.5 – “Increased Glide Slope to Second runway aiming point (IGS-to-SRAP)”.

The document provides the exercises outcome towards the validation objectives considered in the solution, for PJ02 W2.

Descriptions of tasks and measures performed to validate the impact of the concepts are developed along with the deviations from the planning.

Exercises results are analysed to present conclusions and raise recommendations for further steps.

Table of Contents

Abstract ... 3
1 Executive summary ... 17
2 Introduction ... 18
2.1 Purpose of the document ... 18
2.2 Intended readership ... 18
2.3 Background ... 18
2.4 Structure of the document ... 18
2.5 Acronyms and Terminology ... 19
3 Context of the Validation ... 21
3.1 SESAR Solution PJ.02-W2-14.5: a summary ... 21
3.2 Summary of the Validation Plan ... 23
3.2.1 Validation Plan Purpose ... 23
3.2.2 Summary of Validation Objectives and success criteria ... 23
3.2.3 Validation Assumptions ... 30
3.2.4 Validation Exercises List ... 30
3.2.4.1 EXE-14.5-V3-VALP-R01 ... 30
3.2.4.2 EXE-14.5-V3-VALP-R10 ... 31
3.2.4.3 EXE-14.5-V3-VALP-R15 ... 32
3.2.4.4 EXE-14.5-V3-VALP-R25 ... 34
3.3 Deviations ... 34
3.3.1 Deviations with respect to the SJU Project Handbook ... 34
3.3.2 Deviations with respect to the Validation Plan ... 35
4 SESAR Solution PJ.02-W2-14.5 Validation Results ... 36
4.1 Summary of SESAR Solution PJ.02-W2-14.5 Validation Results ... 36
4.2 Detailed analysis of SESAR Solution Validation Results per Validation objective . 40
4.2.1 OBJ-14.2-V3-VALP-0101 Results ... 40
4.2.2 OBJ-14.2-V3-VALP-0102a Results ... 40
4.2.3 OBJ-14.2-V3-VALP-0102b Results ... 40
4.2.4 OBJ-14.2-V3-VALP-0103 and OBJ-14.2-V3-VALP-0104 Results ... 41
4.2.5 OBJ-14.2-V3-VALP-0203 Results ... 42
4.2.6 OBJ-14.2-V3-VALP-0204 Results ... 42
4.2.7 OBJ-14.2-V3-VALP-0301 Results ... 43
4.3 Confidence in Validation Results ... 43
4.3.1 Limitations of Validation Results ... 43
4.3.1.1 Quality of Validation Results ... 43
4.3.1.1.1 From pilots' side ... 43
4.3.1.1.2 From ATC side ... 43
4.3.1.2 Significance of Validation Results ... 44
4.3.1.2.1 From pilots' side ... 44

4.3.1.2.2 From ATC side 44
5 Conclusions and recommendations 45
5.1 Conclusions 45
5.1.1 Conclusions on SESAR Solution maturity 45
5.1.1.1 Pilots' side 45
5.1.1.2 ATC side 45
5.1.2 Conclusions on concept clarification 46
5.1.3 Conclusions on technical feasibility 46
5.1.3.1.1 HMI 46
5.1.3.1.2 Separation Delivery Tool 46
5.1.3.1.3 Wrong Glideslope Alert 47
5.1.4 Conclusions on performance assessments 47
5.2 Recommendations 47
5.2.1 Recommendations for next phase 47
5.2.1.1 ATC side 47
5.2.1.2 Pilots' side 48
5.2.2 Recommendations for updating ATM Master Plan Level 2 49
5.2.3 Recommendations on regulation and standardisation initiatives 49
6 References 50
6.1 Applicable Documents 50
6.2 Reference Documents 51
7 Validation Exercise EXE-14.5-V3-VALP-R01 Report 52
7.1 Summary of the Validation Exercise EXE-14.5-V3-VALP-R01 Plan 52
7.1.1 Validation Exercise description, scope 52
7.1.1.1 Validation Technique and Platform 52
7.1.1.2 Simulation Operating Environment 52
7.1.1.3 Roles and Actors 54
7.1.1.4 Traffic Sample 54
7.1.2 Summary of Validation Exercise #01 Validation Objectives and success criteria 55
7.1.3 Summary of Validation Exercise EXE-14.5-V3-VALP-R01 Validation scenarios 58
7.1.3.1 Reference Scenarios 58
7.1.3.2 Solution Scenarios 58
7.1.3.2.1 Nominal Case 58
7.1.3.2.2 Non-Nominal Cases 64
7.1.3.2.2.1 Go-Around / Missed Approach Procedure 65
7.1.3.2.2.2 Wrong Glideslope Alert Procedure 65
7.1.3.2.2.3 ORD Failure Procedure 67
7.1.3.3 Experimental Design 67
7.1.4 Summary of Validation Exercise #01 Validation Assumptions 69
7.2 Deviation from the planned activities 71
7.3 Validation Exercise EXE-14.5-V3-VALP-R01 Results 72

7.3.1 Summary of Validation Exercise #01 Results ... 72
7.3.2 Analysis of Exercise R01 Results per Validation objective ... 78
7.3.2.1 R01-OBJ-14.5-V3-VALP-0101 Results ... 79
7.3.2.2 R01-OBJ-14.5-V3-VALP-0102a Results ... 79
7.3.2.3 R01-OBJ-14.5-V3-VALP-0102b Results ... 80
7.3.2.4 R01-OBJ-14.5-V3-VALP-013 and R01-OBJ-14.5-V3-VALP-0104 Results ... 81
7.3.2.4.1 Human Performance ... 81
7.3.2.4.1.1 Workload ... 81
7.3.2.4.1.1.1 Sector Performance ... 82
7.3.2.4.1.1.2 Subjective Feedback ... 84
7.3.2.4.1.2 Situational Awareness ... 86
7.3.2.4.1.3 Teamwork ... 89
7.3.2.4.1.4 Transition ... 90
7.3.2.4.2 Safety ... 91
7.3.2.4.3 Operational Feasibility ... 92
7.3.2.4.4 Non-nominal Procedures ... 92
7.3.2.4.4.1 Glide Alert Triggered by an Aircraft Intercepting the Wrong Glideslope 92
7.3.2.4.4.2 Go-Arounds/Missed Approaches by Leading Aircraft with Possible Follower Go-Around ... 94
7.3.2.4.4.3 Separation Delivery Tool Failure Analysis ... 98
7.3.2.5 Additional results outside R01 objectives ... 100
7.3.2.5.1 Additional comments linked to ORD tool ... 100
7.3.2.5.2 Additional comments about IGS-to-SRAP HMI ... 101
7.3.2.5.3 Additional comments about phraseology ... 101
7.3.3 Unexpected Behaviours/Results ... 102
7.3.4 Confidence in Results of Validation Exercise EXE-14.5-V3-VALP-R01 ... 102
7.3.4.1 Level of significance/limitations of Validation Exercise Results ... 102
7.3.4.2 Quality of Validation Exercises Results ... 103
7.3.4.3 Significance of Validation Exercises Results ... 103
7.3.5 Conclusions ... 104
7.3.5.1 Conclusions on concept clarification ... 104
7.3.5.1.1 Wrong Glideslope Alert Procedure ... 104
7.3.5.1.2 Go-Arounds/Missed Approaches ... 105
7.3.5.1.3 Separation Delivery Tool Failure ... 105
7.3.5.2 Conclusions on technical feasibility ... 105
7.3.5.2.1 HMI ... 105
7.3.5.2.2 Separation Delivery Tool ... 106
7.3.5.2.3 Wrong Glideslope Alert ... 106
7.3.5.3 3. Conclusions on performance assessments ... 106
7.3.5.3.1 Safety ... 106
7.3.5.3.2 Human Performance ... 106
7.3.6 Recommendations ... 107
8 Validation Exercise EXE-14.5-V3-VALP-R10 Report ... 108
8.1 Summary of the Validation Exercise EXE-14.5-V3-VALP-R10 Plan ... 108
8.1.1 Validation Exercise description, scope ... 108

8.1.1.1 Lighting options 110
8.1.1.2 Charts 113
8.1.1.3 Phraseology 113
8.1.1.4 Scenarios 113
8.1.1.5 Scope of EXE-14.5-V3-VALP-R10 114
8.1.2 Summary of Validation Exercise EXE-14.5-V3-VALP-R10 Validation Objectives and success criteria 115
8.1.3 Summary of Validation Exercise EXE-14.5-V3-VALP-R10 Validation scenarios 115
8.1.4 Summary of Validation Exercise EXE-14.5-V3-VALP-R10 Validation Assumptions 117
8.2 Deviation from the planned activities 117
8.3 Validation Exercise EXE-14.5-V3-VALP-R10 Results 118
8.3.1 Summary of Validation Exercise EXE-14.5-V3-VALP-R10 Results 118
8.3.2 Analysis of Exercise EXE-14.5-V3-VALP-R10 Results per Validation objective 121
8.3.2.1 OBJ-14.5-V3-VALP-0203 Results 121
8.3.2.2 OBJ-14.5-V3-VALP-0204 Results 123
8.3.2.2.1 PAPI 124
8.3.2.2.2 Threshold identification 125
8.3.2.2.3 Aiming Point 127
8.3.2.3 OBJ-14.5-V3-VALP-0301 Results 130
8.3.3 Unexpected Behaviours/Results 130
8.3.4 Confidence in Results of Validation Exercise EXE-14.5-V3-VALP-R10 130
8.3.4.1 Level of significance/limitations of Validation Exercise Results 131
8.3.4.2 Quality of Validation Exercises Results 131
8.3.4.3 Significance of Validation Exercises Results 131
8.3.5 Conclusions 131
8.3.6 Recommendations 131
9 Validation Exercise EXE-14.5-V3-VALP-R15 Report 133
9.1 Summary of the Validation Exercise EXE-14.5-V3-VALP-R15 Plan 133
9.1.1 Validation Exercise description, scope 133
9.1.1.1 Marking options 136
9.1.1.2 Charts 137
9.1.1.3 Phraseology 138
9.1.1.4 Scope of EXE-14.5-V3-VALP-R15 138
9.1.2 Summary of Validation Exercise EXE-14.5-V3-VALP-R15 Validation Objectives and success criteria 139
9.1.3 Summary of Validation Exercise EXE-14.5-V3-VALP-R15 Validation scenarios 139
9.1.4 Summary of Validation Exercise EXE-14.5-V3-VALP-R15 Validation Assumptions 142
9.2 Deviation from the planned activities 143
9.3 Validation Exercise EXE-14.5-V3-VALP-R15 Results 143
9.3.1 Summary of Validation Exercise EXE-14.5-V3-VALP-R15 Results 143

9.3.2 Analysis of Exercise EXE-14.5-V3-VALP-R15 Results per Validation objective 146
9.3.2.1 OBJ-14.5-V3-VALP-SRAP.0203 Results 146
9.3.2.2 OBJ-14.5-V3-VALP-SRAP.0204 Results 149
9.3.2.2.1 PAPI 149
9.3.2.2.2 Threshold 152
9.3.2.2.3 Aiming Point 155
9.3.2.2.4 Touchdown Zone Marking 158
9.3.2.3 OBJ-14.5-V3-VALP-00301 Results 163
9.3.2.4 Additional results on workload 163
9.3.3 Unexpected Behaviours/Results 166
9.3.4 Confidence in Results of Validation Exercise EXE-14.5-V3-VALP-R15 166
9.3.4.1 Level of significance/limitations of Validation Exercise Results 166
9.3.4.2 Quality of Validation Exercises Results 166
9.3.4.3 Significance of Validation Exercises Results 166
9.3.5 Conclusions 166
9.3.6 Recommendations 167
10 Validation Exercise EXE-14.5-V3-VALP-R25 Report 168
10.1 Summary of the Validation Exercise EXE-14.5-V3-VALP-R25 Plan 168
10.1.1 Validation Exercise description, scope 168
10.1.1.1 Charts 171
10.1.1.2 Phraseology 171
10.1.1.3 Scope of EXE-14.5-V3-VALP-R25 172
10.1.2 Summary of Validation Exercise EXE-14.5-V3-VALP-R25 Validation Objectives and success criteria 173
10.1.3 Summary of Validation Exercise EXE-14.5-V3-VALP-R25 Validation scenarios 173
10.1.4 Summary of Validation Exercise EXE-14.5-V3-VALP-R25 Validation Assumptions 174
10.2 Deviation from the planned activities 174
10.3 Validation Exercise EXE-14.5-V3-VALP-R25 Results 174
10.3.1 Summary of Validation Exercise EXE-14.5-V3-VALP-R25 Results 174
10.3.2 Analysis of Exercise EXE-14.5-V3-VALP-R25 Results per Validation objective 178
10.3.2.1 OBJ-14.5-V3-VALP-0203 Results 178
10.3.2.2 OBJ-14.5-V3-VALP-0204 Results 179
10.3.2.2.1 PAPI 180
10.3.2.2.2 Threshold identification 182
10.3.2.2.3 Approach Light Configuration 183
10.3.2.3 OBJ-14.5-V3-VALP-0301 Results 186
10.3.3 Unexpected Behaviours/Results 186
10.3.4 Confidence in Results of Validation Exercise EXE-14.5-V3-VALP-R25 186
10.3.4.1 Level of significance/limitations of Validation Exercise Results 187
10.3.4.2 Quality of Validation Exercises Results 187
10.3.4.3 Significance of Validation Exercises Results 187
10.3.5 Conclusions 187

10.3.6 Recommendations 187
Appendix A Analysis for EXE-14.5-V3-VALP-R01: ISA vs Event Per Run 188
Appendix B Analysis for EXE-14.5-V3-VALP-R01: Teamwork 189
Appendix C EXE-14.5-V3-VALP-R10 - Recorded data for each scenario (vertical path) 190
Appendix D EXE-14.5-V3-VALP-R15- Recorded data for each scenario (vertical path) .198
Appendix E Charts used in EXE-14.5-V3-VALP-R10 215
Appendix F Charts used in EXE-14.5-V3-VALP-R15 219
Appendix G Charts used in EXE-14.5-V3-VALP-R25 221

List of Tables

Table 1: Acronyms and terminology 20
Table 2: SESAR Solution(s) addressed in the Validation Report.. 22
Table 3: R01 Validation Exercise layout 31
Table 4: R10 Validation Exercise layout 32
Table 5: R15 Validation Exercise Layout 33
Table 6: Summary of Validation Exercises Results 39
Table 7: Percentage of Aircraft per RECAT-EU Category for Traffic Sample 54
Table 8: Validation Objectives addressed in Validation Exercise R01 58
Table 9: RTS Experimental Design 68
Table 10: R01 Validation Assumptions overview 71
Table 11: Validation Results for Exercise R01 78
Table 12: Time to React to the Wrong Glideslope Alert 93
Table 13: Number of Go-arounds/Missed Approaches and related loss of separation 95
Table 14: Number of Go-arounds/Missed Approaches and related loss of separation for the ILS-IGS-to-SRAP pairs that resulted in a double go-around 95
Table 15: Time to React to a Go-Around from a Heavy Aircraft on ILS approach with IGS-to-SRAP approach following where separation is less than RECAT-EU.. 96
Table 16: Number of Go-Arounds following the ORD Tool Failure 98
Table 17: Sequence of flown scenarios in exercise R10 114
Table 18: stakeholders' expectations of EXE-14.5-V3-VALP-R10 115
Table 19: Scenario List (in blue, IGS-to-SRAP runs) 117

Table 20: R10 Validation Assumptions overview ... 117
Table 21: Validation Results for Exercise R10 ... 120
Table 22: stakeholders' expectations of EXE-14.5-V3-VALP-R15 ... 139
Table 23: Scenario List Session 1-6 ... 141
Table 24: Scenario List Session 7-12 ... 142
Table 25: R15 Validation Assumptions overview ... 143
Table 26: Validation Objectives for Exercise 15 (IGS-to-SRAP) ... 145
Table 27: stakeholders' expectations of EXE-14.5-V3-VALP-R15 ... 173
Table 28: Scenario List of R25 (in blue, IGS-to-SRAP runs) ... 174
Table 29: R25 Validation Assumptions overview ... 174
Table 30: Validation Objectives for Exercise R25 (IGS-to-SRAP) ... 177

List of Figures

Figure 1: Northern section of Paris CDG including RWY27L ... 53
Figure 2: IGS-to-SRAP procedure (red slope) ... 59
Figure 3: runway 27L markings for IGS-to-SRAP ... 60
Figure 4: Runway 27L and 28L as shown on TWR CWP for R01 ... 61
Figure 5: illustration of approach menu displayed in the case the aircraft selected is GBAS capable . 62
Figure 6: Illustration of red chevron displayed in case of infringement as displayed on the CWP HMI63
Figure 7: FTD and ITD shape and colours as displayed on the CWP HMI ... 63
Figure 8: Automatic FTD Pop-up, Catch-Up and Speed Alert displayed on the CWP HMI ... 64
Figure 9: ILS and IGS-to-SRAP interception point display design for R01 ... 64
Figure 10: Aiming points on the runway as displayed on CWP HMI ... 64
Figure 11: Non-Nominal Cases to be validated ... 65
Figure 12: CWP HMI for Wrong Glideslope Alert ... 66
Figure 13: IGS-to-SRAP Wrong Glideslope Alert Cone Activation ... 67
Figure 14: Timetable and Controller Rotation for Simulation R01 ... 69
Figure 15: Subjective Feedback from Post-Simulation Questionnaire on HMI usability ... 79
Figure 16: Subjective Feedback from Post-Exercise Questionnaires on ORD tool usability ... 80

Figure 17: Subjective Feedback from Post-Simulation Questionnaires on ORD tool usability 80

Figure 18: Subjective Feedback from Post-Exercise Questionnaires on Wrong Glideslope Alert usability 80

Figure 19: Subjective Feedback from Post-Simulation Questionnaire on Wrong Glideslope Alert usability 81

Figure 20: Sector Performance (ISA ratings, Sector Load, R/T Load and Instructions given to Pilots) . 82

Figure 21: Overall Trend for the average number of aircraft on frequency and average ISA ratings per each two-minute interval during the five IGS-to-SRAP exercises 84

Figure 22: Subjective Feedback from Post-Exercise Questionnaire on Workload 85

Figure 23: Bedford Workload Rating Feedback from Post-Exercise Questionnaire 85

Figure 24: Subjective Feedback from Post-Exercise Questionnaire on Situational Awareness 87

Figure 25: Subjective Feedback from Post-Simulation Questionnaire on Situational Awareness 88

Figure 26: Overall Situational Awareness 89

Figure 27: Subjective Feedback from Post-Simulation Questionnaires on Transition 90

Figure 28: Subjective Feedback from Post-Exercise Questionnaire on the Safety Performance 91

Figure 29: Subjective Feedback from Post-Simulation Questionnaires on the Safety Performance 92

Figure 30: Subjective Feedback from Post-Simulation Questionnaires on the Operational Feasibility 92

Figure 31: Subjective Feedback from Post-Exercise Questionnaires on the Safety performance, Human Performance and User acceptance of the Wrong Glideslope Alert Procedures................................. 94

Figure 32: Detailed separations after double go-around for the ILS-IGS2SRAP case with loss of wake separation.. 96

Figure 33: Subjective feedback from Post-Exercise Questionnaires on the Safety performance, Human Performance and User Acceptance of the Go-Around/Missed Approach Procedures........................ 97

Figure 34: Subjective Feedback from Post-Exercise Questionnaires on the Safety Performance, Human Performance and User Acceptance of the Separation Delivery Tool Failure Procedures 99

Figure 35: Subjective Feedback from Post-Simulation Questionnaires on Phraseology 101

Figure 36: A319-100 Full Flight Simulator 108

Figure 37: Flight Deck Airbus A319 FFS 109

Figure 38: Position of the second threshold 110

Figure 39: Position of the second threshold in detail 110

Figure 40: Steady lighting configuration Rwy 08R/09R activated 111

Figure 41: Switching lights with primary threshold Rwy 08R activated 112

Figure 42: Switching lights with secondary threshold Rwy 09R (SRAP) activated 112

Figure 43: Landing sequence in switching configuration 117
Figure 44: Perceived level of safety after all runs Pilot flying 121
Figure 45: Perceived level of safety after all runs Pilot flying 122
Figure 46: Perceived Level of Safety comparing Wind Conditions........ 122
Figure 47: Perceived Level of Safety comparing Type of Approach 123
Figure 48: Acceptability of different PAPI settings for the pilot flying........ 124
Figure 49: Acceptability of different PAPI settings for the pilot-non-flying........ 124
Figure 50: Acceptability of different PAPI settings comparing different approach-types 125
Figure 51: Acceptability of the threshold identification for the pilot flying........ 126
Figure 52: Acceptability of the threshold identification for the pilot-non-flying........ 126
Figure 53: Acceptability of the threshold identification with respect of the type of approach 127
Figure 54: Acceptability of the threshold identification with respect of the wind condition........ 127
Figure 55: Acceptability of different aiming identification for the pilot flying 128
Figure 56: Acceptability of different aiming identification for the pilot non-flying........ 128
Figure 57: Acceptability of different aiming identification for different wind conditions 129
Figure 58: Overall acceptability of Lighting Concept........ 129
Figure 59: Pilots preference regarding different Approach Light Configurations........ 130
Figure 60: A319-100 Full Flight Simulator 133
Figure 61: Flight Deck Airbus A319 FFS 134
Figure 62: Position of the second threshold 135
Figure 63: Position of the second threshold in detail 135
Figure 64: Marking options 136
Figure 65: Instructor Operation Station Full Flight Simulator 137
Figure 66: Perceived Level of Safety Session 1-6 Pilot Flying........ 146
Figure 67: Perceived Level of Safety Session 1-6 Pilot Non-Flying........ 147
Figure 68: Perceived Level of Safety Session 7-12 Pilot Flying........ 148
Figure 69: Perceived Level of Safety Session 7-12 Pilot Non-Flying........ 148
Figure 70: Acceptability of different PAPI settings for the pilot flying (session 1-6) 149
Figure 71: Acceptability of different PAPI settings for the pilot non-flying (session 1-6)........ 150
Figure 72: Acceptability of different PAPI settings for the pilot flying (session 7-12) 151

Figure 73: Acceptability of different PAPI settings for the pilot non-flying (session 7-12) 151

Figure 74: Acceptability of different threshold identification for the pilot flying (session 1-6).......... 152

Figure 75: Acceptability of different threshold identification for the pilot non-flying (session 1-6) .. 153

Figure 76: Acceptability of different threshold identification for the pilot flying (session 7-12) 154

Figure 77: Acceptability of different threshold identification for the pilot non-flying (session 7-12) 154

Figure 78: Acceptability of different aiming identification for the pilot flying (session 1-6) 155

Figure 79: Acceptability of different aiming identification for the pilot non-flying (session 1-6)....... 156

Figure 80: Acceptability of different aiming identification for the pilot flying (session 7-12) 157

Figure 81: Acceptability of different aiming identification for the pilot non-flying (session 7-12)..... 157

Figure 82: Acceptability of different touchdown zone markings identification for the pilot flying (session 1-6) 158

Figure 83: Acceptability of different touchdown zone markings identification for the pilot non-flying (session 1-6) 159

Figure 84: Acceptability of different touchdown zone markings identification for the pilot flying (session 7-12) 160

Figure 85: Acceptability of different touchdown zone markings identification for the pilot non-flying (session 7-12) 160

Figure 86: Overall acceptability of marking concepts Session 1-6 161

Figure 87: Overall acceptability of marking concepts Session 7-12 161

Figure 88: Pilots preference regarding Option 1-4 for session 1-6 162

Figure 89: Pilots preference regarding Option 1-4 for session 7-12 162

Figure 90: Workload Session 1-6 Pilot Flying 163

Figure 91: Workload Session 1-6 Pilot Non-Flying 164

Figure 92: Workload Session 7-12 Pilot Flying 165

Figure 93: Workload Session 7-12 Pilot Non-Flying 165

Figure 94: A319-100 Full Flight Simulator 168

Figure 95: Flight Deck Airbus A319 FFS 169

Figure 96: Position of the second threshold 170

Figure 97: Position of the second threshold in detail 170

Figure 98: Steady lighting configuration Rwy 08R/09R activated 171

Figure 99: Perceived level of safety after all runs Pilot flying 178

Figure 100: Perceived level of safety after all runs Pilot non-flying... 179

Figure 101: Pilot`s acceptance using SRAP/IGS-SRAP in daily operations.. 180
Figure 102: Acceptability of different PAPI settings for the pilot flying... 181
Figure 103: Acceptability of different PAPI settings for the pilot-non-flying.................................. 181
Figure 104: Acceptability of the threshold identification for the pilot flying.................................. 182
Figure 105: Acceptability of the threshold identification for the pilot-non-flying........................... 183
Figure 106: Acceptability of the approach light configuration for the pilot flying............................ 184
Figure 107: Acceptability of the approach light configuration for the pilot non-flying 184
Figure 108: Overall acceptability of Lighting Concept.. 185
Figure 109 Acceptability of the consistent use of the second threshold 185
Figure 110: Preferred Options for IGS-to-SRAP Runway Designator 186
Figure 111: ISA rating scores per two minutes for each IGS-to-SRAP exercises with the number of events that occurred within those two minutes.. 188
Figure 112: Subjective feedback from the PEQ about coordination and teamwork 189
Figure 113: Subjective feedback from the PSQ about coordination and teamwork 189
Figure 114: Vertical Path Run 1 190
Figure 115: Vertical Path Run 2 190
Figure 116: Vertical Path Run 3 191
Figure 117: Vertical Path Run 4 191
Figure 118: Vertical Path Run 5 192
Figure 119: Vertical Path Run 6 192
Figure 120: Vertical Path Run 7 193
Figure 121: Vertical Path Run 8 193
Figure 122: Vertical Path Run 9 194
Figure 123: Vertical Path Run 10 194
Figure 124: Vertical Path Run 11 195
Figure 125: Vertical Path Run 12 195
Figure 126: Vertical Path Run 13 196
Figure 127: Vertical Path Run 14 196
Figure 128: Vertical Path Run 15 197
Figure 129: Vertical Path Run 16 197

Figure 130: Vertical Path Run 1 (Session 1-6) 198
Figure 131: Vertical Path Run 2 (Session 1-6) 198
Figure 132: Vertical Path Run 3 (Session 1-6) 199
Figure 133: Vertical Path Run 4 (Session 1-6) 199
Figure 134: Vertical Path Run 5 (Session 1-6) 200
Figure 135: Vertical Path Run 6 (Session 1-6) 200
Figure 136: Vertical Path Run 7 (Session 1-6) 201
Figure 137: Vertical Path Run 8 (Session 1-6) 201
Figure 138: Vertical Path Run 9 (Session 1-6) 202
Figure 139: Vertical Path Run 10 (Session 1-6) 202
Figure 140: Vertical Path Run 11 (Session 1-6) 203
Figure 141: Vertical Path Run 12 (Session 1-6) 203
Figure 142: Vertical Path Run 13 (Session 1-6) 204
Figure 143: Vertical Path Run 14 (Session 1-6) 204
Figure 144: Vertical Path Run 15 (Session 1-6) 205
Figure 145: Vertical Path Run 16 (Session 1-6) 205
Figure 146: Vertical Path Run 1 (Session 7-12) 206
Figure 147: Vertical Path Run 2 (Session 7-12) 206
Figure 148: Vertical Path Run 3 (Session 7-12) 207
Figure 149: Vertical Path Run 4 (Session 7-12) 207
Figure 150: Vertical Path Run 5 (Session 7-12) 208
Figure 151: Vertical Path Run 6 (Session 7-12) 208
Figure 152: Vertical Path Run 7 (Session 7-12) 209
Figure 153: Vertical Path Run 8 (Session 7-12) 209
Figure 154: Vertical Path Run 9 (Session 7-12) 210
Figure 155: Vertical Path Run 10 (Session 7-12) 210
Figure 156: Vertical Path Run 11 (Session 7-12) 211
Figure 157: Vertical Path Run 12 (Session 7-12) 211
Figure 158: Vertical Path Run 13 (Session 7-12) 212
Figure 159: Vertical Path Run 14 (Session 7-12) 212

Figure 160: Vertical Path Run 15 (Session 7-12) 213
Figure 161: Vertical Path Run 16 (Session 7-12) 213
Figure 162: Vertical Path Run 17 (Session 7-12) 214
Figure 163: R10 chart for threshold ILS 08R – steady mode (first threshold).................................. 215
Figure 164: R10 chart for threshold ILS 08R – switching mode (first threshold) 216
Figure 165: R10 chart for threshold ILS 09R – steady mode (second threshold)............................... 217
Figure 166: R10 chart for threshold ILS 09R – switching mode (second threshold) 218
Figure 167: R15 chart for threshold 08R 219
Figure 168: R15 chart for threshold 09R 220
Figure 169: R25 chart for threshold 08R 221
Figure 170: R25 chart for threshold 09R 222

1 Executive summary

This document presents the results of the V3 Validation activities performed in the framework of the PJ02 W2, for the solution PJ.02-W2-14.5 – "Increased Glide Slope to Second runway aiming point (IGS-to-SRAP)", throughout four RTS (Real-Time Simulation) exercises.

These Validation exercises were conducted to cover gaps identified following PJ02-02 validation activities, which were about:

1. The management of non-nominal situations from ATC side (go-around/missed approaches, interception of wrong glide, loss of LORD tool in heavy traffic situations). One simulation covered these points.
2. Ground aids (runway marking, runway lighting and the PAPI) for the pilots. Runway marking and PAPI were covered by one simulation and the lighting by two.

The conclusions of the ATC real-time simulation is that the proposed ways to manage the non-nominal situations are acceptable and manageable by the controllers.

For the grounds aids, the conclusions are that the steady solution of the lighting is seen as acceptable and safe by the pilots. Even if both the steady and switching solutions could be acceptable and may present advantages depending on the weather or visibility conditions, the steady solution which is easier and less expensive to develop is judged acceptable in all conditions.

2 Introduction

2.1 Purpose of the document

This document provides the Validation Report for PJ02-W2 Solution PJ.02-W2-14.5. It describes the results of validation exercises conducted in PJ02 W2 and provides a set of relevant conclusions and recommendations.

2.2 Intended readership

The intended readerships for this document are:

- PJ02 W2 Partners
- PJ19-W2
- ANS providers
- ATM infrastructure and equipment suppliers
- Airspace users
- Aircraft Manufacturer
- Airport owners/providers
- Affected NSA
- Affected employee unions.

2.3 Background

The validation exercises have been built considering the work performed in solution PJ02-02 in Wave 1.

The validation activities took into account the conclusions developed in PJ02-02 Validation report (D2.1.04 - SESAR PJ02-02 VALR - Ed. 00.01.00).

2.4 Structure of the document

The document is structured as follows:

- **Section 2 "Introduction"** describes the purpose of the document, the intended readership, the background and gives an explanation of the abbreviations and acronyms used throughout the document
- **Section 3 "Context of the Validation"** briefly reminds the scope of the validation and describes the exercises preparation and execution, as well as the deviations from the planned activities.

- **Section 4 "SESAR Solution PJ.02-W2-14.5 Validation Results"** provides the summary of exercises results and a more detailed reporting on the exercises results per validation objective.
- **Section 5 "Conclusions and recommendations"** presents the conclusions from the validation exercises and gives some recommendations.
- **Section 6 "References"** lists all the reference documents.
- **Sections 7 to 10** describe the validation exercises outputs (one chapter per exercise), with a detailed reporting on the exercise plan and results.
- **Appendix A** shows the vertical path of all flight simulation runs of exercise R10.
- **Appendix B** shows the vertical path of all flight simulation runs of exercise R15.
- **Appendix C** shows the vertical path of all flight simulation runs of exercise R25.
- **Appendix D** gives the chart used in R10.
- **Appendix E** gives the chart used in R15.
- **Appendix F** gives the chart used in R25.

2.5 Acronyms and Terminology

Acronym	Definition
ADD	Architecture Description Document
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATCO	Air Traffic Controller
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATM MP	Air Traffic Management Master Plan
BAD	Benefits Assessment Date
BAER	Benefit Assessment Equipment Rate
CBA	Cost Benefit Analysis
CC	Capability Configuration
CIA	Confidentiality, Integrity, Availability
CNS	Communication Navigation and Surveillance
CONOPS	Concept of Operations
CR	Change Request
DB	Deployment Baseline
DOD	Detailed Operational Description
E-ATM	European ATM Architecture
EATMAS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
EMI	ElectroMagnetic Interference
EMP	ElectroMagnetic Pulse
E-OCVM	European Operational Concept Validation Methodology
FAA	Federal Aviation Administration
FRD	Functional Requirements Document
HPAR	Human Performance Assessment Report
ICAO	International Civil Aviation Organization
IBP	Industrial Based Platform
IER	Information Exchange Requirement
IGS-to-SRAP	Increased Glide Slope to Second Runway Aiming Point
IRS	Interface Requirements Specification
INTEROP	Interoperability Requirements

ISRM	Information Services Reference Model
KPA	Key Performance Area
KPI	Key Performance Indicator
MSSC	Minimum Set of Security Controls
NA	Not Applicable
NAF	NATO Architecture Framework
NSOV	NAF Service Oriented View
NOV	NAF Operational View
NSV	NAF System View
OFA	Operational Focus Areas
OI	Operational Improvement
OPAR	Operational Performance Assessment Report
OSED	Operational Service and Environment Definition
PA	Primary Asset
PAR	Performance Assessment Report
PI	Performance Indicator
PIRM	Programme Information Reference Model
PRU	Performance Review Unit
QoS	Quality of Service
RBT	Reference Business / Mission Trajectory
SAC	Safety Criteria
SAR	Safety Assessment Report
SDD	Service Description Document
SecAR	Security Assessment Report
SecRAM	Security Risck Assesment Methodology
SESAR	Single European Sky ATM Research Programme
SMART	Specific, Measurable, Attainable, Realistic, Timely
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SO	Security Objective(s)
SoaML	Service Oriented Architecture Modelling Language
SPR	Safety and Performance Requirements
SRA	Security Risk Assessment
SUT	System Under Test
SWIM	System Wide Information Model
TRL	Technology Readiness Level
TS	Technical Specification
TVALP	Technical Validation Plan
TVALR	Technical Validation Report
UC	Use Case
UML	Unified Modelling Language
VALP	Validation Plan
VALR	Validation Report
VALS	Validation Strategy
VP	Plan
VR	Report
VS	Strategy
V&V	Validation and Verification
WP	Work Package
WSDL	Web Services Definition Language
XSD	XML Schema Definition

543 **Table 1: Acronyms and terminology**

3 Context of the Validation

3.1 SESAR Solution PJ.02-W2-14.5: a summary

SESAR Solution ID	SESAR Solution Description	Master or Contributing (M or C)	Contribution to the SESAR Solution short description	OI Steps ref. (from EATMA)	Enablers ref. (from EATMA)	Enabler Title	Required (R) or Optional (O)	Baseline or to be evolved (expected date)
PJ.02-W2-14.5 Increased Glide Slope to Second runway aiming point (IGS-to-SRAP)	This Solution introduces the Increased Glide Slope to a Second Runway Aiming Point (IGS-to-SRAP) as a new concept of enhanced approach operation. The distance between the second threshold and the nominal one is at least of 1100m. IGS-to-SRAP increases runway performance by using two active thresholds on a single runway and an increased glide slope to the second one. By doing so, the environmental impact (e.g. noise, fuel) should be	M	Contribution to capacity, environmental sustainability, safety and human performance	AO-0331	AERODROME-ATC-102	Aerodrome ATC system to support final approach operations (distinguish approach procedures)	R	30/11/2022
					AERODROME-ATC-94	Aerodrome ATC system to support IGS-to-SRAP operations (separation delivery)	O	30/11/2022
					AIPORT-56	Runway marking, lighting and PAPI for SRAP/IGS-to-SRAP approach procedures	R	30/11/2022
					APP ATC 163	Approach ATC system to support IGS-to-SRAP operations (separation delivery)	O	30/11/2022
					APP ATC 170	Approach ATC system upgraded to support approach procedure assignment	R	30/11/2022
					A/C-86	On-board assistance to aircraft energy management	O	30/11/2022
					A/C-87	On-board assistance to flare	O	30/11/2022
					REG-0533	Regulatory provisions for Increased Glide Slope to Second Runway Aiming Point operations (IGS-to-SRAP)	R	N/A
					HUM-024	Flight Crew new role for handling IGS-to-SRAP approach	R	30/11/2022
					HUM-033	ATC new role for handling IGS-to-SRAP approach	R	30/11/2022

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	reduced. In addition, runway throughput may be increased (e.g. via optimization of ROT and/or wake turbulence separations).				STD-112	Update of EASA/ICAO regulatory frameworks for new visual ground aids (SRAP)	R	N/A

Table 2: SESAR Solution(s) addressed in the Validation Report

3.2 Summary of the Validation Plan

3.2.1 Validation Plan Purpose

The Validation Plan for solution PJ.02-W2-14.5 describes how the points that were left open after PJ02 W1 solution PJ02-02 validation activities, have been covered in PJ02 W2. These W1 activities identified the need to perform additional validation activities to:

- Cover the non-nominal cases for the ATC part
- Further assess the solutions proposed for the runway lighting and marking, from the pilots' point of view.

3.2.2 Summary of Validation Objectives and success criteria

The validation objectives were developed in PJ02-02 in SESAR 2020 W1, and most of them were already validated in W1. The list below gives those that were identified as not being fully validated in W1 and that have been covered in W2.

[OBJ]

Identifier	OBJ-14.5-V3-VALP-0101
Objective	To confirm that ATC HMI for IGS-to-SRAP is usable and acceptable for the controller, during **non-nominal** situations Linked to W1 objective OBJ-02.02-V3-VALP-ITSR.0101 that covered ATC HMI in nominal situations only.
Title	IGS-to-SRAP impact on ATC HMI
Category	<Human Performance>
Key Environment Conditions	Non-nominal conditions, Traffic sample 2025, APT Large, APT Medium, TMA HC, TMA MC
V Phase	V3

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1103
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1006
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1110
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1108
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1111
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1107

[OBJ Suc]

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Identifier	Success Criterion
CRT-14.5-V3-VALP-0101-001	The usability of the HMI is rated as being acceptable in non-nominal situations
CRT-14.5-V3-VALP-0101-002	The HMI is rated as being useful in non-nominal situations
CRT-14.5-V3-VALP-0101-003	The proposed HMI supports the application of the IGS-to-SRAP procedure in non-nominal situations

[OBJ]

Identifier	OBJ-14.5-V3-VALP-0102a
Objective	To confirm that ATC separation delivery support functions for IGS-to-SRAP is usable and acceptable in **non-nominal** situations Linked to W1 objective OBJ-02.02-V3-VALP-ITSR.0102 that covered the ATC separation delivery support function, in nominal conditions only.
Title	Use of ATC separation delivery support function for IGS-to-SRAP
Category	<Human Performance>
Key Environment Conditions	Non-nominal conditions, Traffic sample 2025, APT Large, APT Medium, TMA HC, TMA MC
V Phase	V3

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1205
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1104
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1105
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1106

[OBJ Suc]

Identifier	Success Criterion
CRT-14.5-V3-VALP-0102a-001	The usability of the support tool (separation tool) is rated as being acceptable in non-nominal situations

CRT-14.5-V3-VALP-0102a-002	The support tool (separation tool)is rated as being useful in non-nominal situations
CRT-14.5-V3-VALP-0102a-003	The support tool (separation tool) supported the application of the IGS-to-SRAP procedure in non-nominal situations
CRT-14.5-V3-VALP-0102a-004	The ATCOs trust the support tool (separation tool) that facilitates the application of IGS-to-SRAP in non-nominal situations

[OBJ]

Identifier	OBJ-14.5-V3-VALP-0102b
Objective	To confirm that the glide alert functions is usable and acceptable for IGS-to-SRAP Linked to W1 objective OBJ-02.02-V3-VALP-ITSR.0102 that covered the ATC separation delivery support function only.
Title	Use of glide alert function for IGS-to-SRAP
Category	<Human Performance>
Key Environment Conditions	All conditions, Traffic sample 2025, APT Large, APT Medium, TMA HC, TMA MC
V Phase	V3

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1108

[OBJ Suc]

Identifier	Success Criterion
CRT-14.5-V3-VALP-0102b-001	The usability of the support tool (glide alert) is rated as being acceptable
CRT-14.5-V3-VALP-0102b-002	The support tool (glide alert) is rated as being useful
CRT-14.5-V3-VALP-0102b-003	The support tool (glide alert) supports the application of the IGS-to-SRAP procedure
CRT-14.5-V3-VALP-0102b-004	The ATCOs trust the support tool (glide alert) that facilitates the application of IGS-to-SRAP

[OBJ]

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Identifier	OBJ-14.5-V3-VALP-0103
Objective	To confirm that the IGS-to-SRAP does not negatively affect safety from ATC perspective, in **non-nominal** situations Linked to W1 objective OBJ-02.02-V3-VALP-ITSR.0103 that covered safety ATC perspective in nominal situations only.
Title	IGS-to-SRAP impact on safety ATC perspective
Category	<Safety>
Key Environment Conditions	Non-nominal conditions, Traffic sample 2025, APT Large, APT Medium, TMA HC, TMA MC
V Phase	V3

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1007
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-APT.1302
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-APT.1301
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1012

[OBJ Suc]

Identifier	Success Criterion
CRT-14.5-V3-VALP-0103-001	There is evidence that the level of operational safety is maintained and not negatively impacted when IGS-to-SRAP procedures are active, in non-nominal situations

[OBJ]

Identifier	OBJ-14.5-V3-VALP-0104
Objective	To confirm that the IGS-to-SRAP is operationally feasible from ATC perspective, in **non-nominal** situations Linked to W1 objective OBJ-02.02-V3-VALP-ITSR.0104that covered operational feasibility ATC perspective in nominal situations only.
Title	IGS-to-SRAP operational feasibility from ATC perspective
Category	<Operational Feasibility>
Key Environment Conditions	Non-nominal conditions, Traffic sample 2025, APT Large, APT Medium, TMA HC, TMA MC

V Phase	

577 [OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1008
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1009
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1014

578 [OBJ Suc]

Identifier	Success Criterion
CRT-14.5-V3-VALP-0104-001	IGS-to-SRAP is judged operational feasible from controller, in non-nominal situations
CRT-14.5-V3-VALP-0104-002	The Controller Workload (in all measured positions) in non-nominal situations when IGS-to-SRAP operations are active, is tolerable
CRT-14.5-V3-VALP-0104-003	The controller situational awareness is acceptable in non-nominal situations, when IGS-to-SRAP operations are active

579

580 [OBJ]

Identifier	OBJ-14.5-V3-VALP-0203
Objective	To confirm that IGS-to-SRAP do not negatively affect safety from the perspective of the crew. Linked to W1 objective OBJ-02.02-V3-VALP-ITSR.0203 that did not fully cover runway lighting, and did not cover runway marking.
Title	IGS-to-SRAP impact on safety crew perspective
Category	<Safety>
Key Environment Conditions	All conditions, Traffic sample 2025, APT Large, APT Medium, TMA HC, TMA MC
V Phase	V3

581 [OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-APT.1303

<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-ACFT.2101
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-ACFT.2102
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1112
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1201
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1211

[OBJ Suc]

Identifier	Success Criterion
CRT-14.5-V3-VALP-0203-001	There is evidence that the level of operational safety is maintained and not negatively impacted under IGS-to-SRAP procedures compared to the reference scenario from the perspective of the crew.

[OBJ]

Identifier	OBJ-14.5-V3-VALP-0204
Objective	To confirm that the IGS-to-SRAP is operationally feasible from crew perspective. Linked to W1 objective OBJ-02.02-V3-VALP-ITSR.0204 that did not fully cover runway lighting, and did not cover runway marking.
Title	IGS-to-SRAP operational feasibility from crew perspective
Category	<Operational Feasibility>
Key Environment Conditions	All conditions, Traffic sample 2025, APT Large, APT Medium, TMA HC, TMA MC
V Phase	V3

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-APT.1301
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-APT.1303
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-ACFT.2101
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-ACFT.2102
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-APT.1302
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-ACFT.2104

<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-ACFT.2108
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-ACFT.2105
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-ACFT.2103
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1211
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1201

586 [OBJ Suc]

Identifier	Success Criterion
CRT-14.5-V3-VALP-0204-001	Pilot succeeds to manage IGS-to-SRAP operation by applying existing SOPs
CRT-14.5-V3-VALP-0204-002	Pilots are confident when flying a IGS-to-SRAP operation

587

588 [OBJ]

Identifier	OBJ-14.5-V3-VALP-0301
Objective	To confirm that the phraseology used by ATCO and Flight Crew for IGS-to-SRAP is clearly understandable. Linked to W1 objective OBJ-02.02-V3-VALP-ITSR.0301 that covered only ATCO side.
Title	IGS-to-SRAP impact on phraseology
Category	<Human Performance>
Key Environment Conditions	All conditions, Traffic sample 2025, APT Large, APT Medium, TMA HC, TMA MC
V Phase	V3

589 [OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1005
<COVERS>	<ATMS Requirement>	REQ-14.5-SPRINTEROP-CTL.1013

590 [OBJ Suc]

Identifier	Success Criterion

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CRT-14.5-V3-VALP-0301-001	Controllers accept and judge the proposed phraseology as being appropriate for all encountered operating conditions
CRT-14.5-V3-VALP-0301-002	Proposed phraseology does not lead to errors related to perception & interpretation of auditory information.
CRT-14.5-V3-VALP-0301-003	Pilots accept and judge the proposed phraseology as being appropriate for all encountered operating conditions

For OBJ-14.5-V3-VALP-0101, OBJ-14.5-V3-VALP-0103 and OBJ-14.5-V3-VALP-0104, the gaps identified in W1 were about the management of non-nominal situations by ATC.

For OBJ-14.5-V3-VALP-0203 and OBJ-14.5-V3-VALP-0204, the needs for additional validation activities identified in W1 were about runway marking and lighting.

In addition, OBJ-14.5-V3-VALP-0301 was considered as non-fully validated on Phraseology for pilots.

3.2.3 Validation Assumptions

Refer to sections 7 to 10 for the assumptions per validation exercise.

3.2.4 Validation Exercises List

3.2.4.1 EXE-14.5-V3-VALP-R01

Identifier	EXE-14.5-VALP-R01
Title	R01 - Non nominal situations, , ATCO side
Description	The aim of this exercise is to assess: • the impact on controllers of go around/missed approach • the impact on controllers of a glide alert when an aircraft does not intercept the glide it is cleared to. • the impact on controllers of the loss of the separation assistance tool.
Expected achievements	To show that non-nominal situations are manageable by controllers when IGS-to-SRAP operations are active. These non-nominal situations are: Go arounds, in particular for aircraft flying on the lower glide Missed approaches, in particular for aircraft flying on the lower glide Interception of the wrong glide by an aircraft, with the support of a glide alert tool Loss of separation delivery tool
V Phase	V3

Use Cases	[NOV-5][IGS-to-SRAP-Non-Nominal-01] [NOV-5][IGS-to-SRAP-Non-Nominal-02] [NOV-5][IGS-to-SRAP-Non-Nominal-03]
Validation Technique	Real Time Simulation
KPA/TA Addressed	Safety
Start Date	June 14, 2021
End Date	June 18, 2021
Validation Coordinator	EUROCONTROL
Validation Platform	ECTRL ESCAPE ECTRL eDEP
Validation Location	ECTRL Brétigny Brétigny
Status	< Validated >
Dependencies	

[EXE Trace]

Linked Element Type	EXE-14.5-VALP-R01
<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<Validation Objective>	OBJ-14.5-V3-VALP-0101
<Validation Objective>	OBJ-14.5-V3-VALP-0102a
<Validation Objective>	OBJ-14.5-V3-VALP-0102b
<Validation Objective>	OBJ-14.5-V3-VALP-0103
<Validation Objective>	OBJ-14.5-V3-VALP-0104
<Validation Objective>	OBJ-14.5-V3-VALP-0301

Table 3: R01 Validation Exercise layout

3.2.4.2 EXE-14.5-V3-VALP-R10

Identifier	EXE-14.5-VALP-R10
Title	R02 - Runway lighting
Description	Further assessment of the proposed solutions for runway marking and lighting. The aim of the RTS is to assess operational acceptability of IGS-to-SRAP from pilots' point of view. A series of cockpit simulations using a high-level professional Level D/Type 7 flight crew training simulator will be conducted. The purpose is to collect pilots' feedback on the additional threshold operation (acceptability, workload, operational procedures), on how this threshold is shown on the runway and about the corresponding lighting. Different visibility conditions will be simulated and the aircraft following the enhanced procedure will be mixed with aircraft following ILS to normal threshold.

Expected achievements	To get pilots' feedback: – on the additional threshold operation (acceptability, workload, operational procedures), – on the corresponding lighting.
V Phase	V3
Use Cases	[NOV-5][EAO-03]
Validation Technique	Real Time Simulation
KPA/TA Addressed	Safety
Start Date	Mar 4, 2021
End Date	Mar 13, 2021
Validation Coordinator	EUROCONTROL
Validation Platform	LAT A319 Simulator
Validation Location	Frankfurt
Status	< Validated >
Dependencies	

[EXE Trace]

Linked Element Type	EXE-14.5-VALP-R10
<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<Validation Objective>	OBJ-14.5-V3-VALP-0203
<Validation Objective>	OBJ-14.5-V3-VALP-0204
<Validation Objective>	OBJ-14.5-V3-VALP-0301

Table 4: R10 Validation Exercise layout

3.2.4.3 EXE-14.5-V3-VALP-R15

Identifier	EXE-14.5-VALP-R15
Title	R03 - Runway marking

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Description	Assessment of different solutions of runway marking for IGS-to-SRAP threshold. The aim of the RTS is to assess operational acceptability of IGS-to-SRAP from pilots' point of view. A series of cockpit simulations using a high-level professional Level D/Type 7 flight crew training simulator will be conducted. The purpose is to collect pilots' feedback on the additional threshold operation (acceptability, workload, operational procedures), on how this threshold is shown on the runway and about the corresponding markings. Different visibility conditions will be simulated and the aircraft following the enhanced procedure will be mixed with aircraft following ILS to normal threshold. It has to be noted that this exercise will be common with SRAP marking evaluation. All results obtained with one or the other procedure will be valid for both.
Expected achievements	To get pilots' feedback: – on the additional threshold operations (acceptability, workload, operational procedures), – on how the additional threshold and aiming points are marked on the runway.
V Phase	V3
Use Cases	[NOV-5][EAO-03]
Validation Technique	Real Time Simulation
KPA/TA Addressed	Safety
Start Date	Mar 18, 2021
End Date	Apr 24, 2021
Validation Coordinator	EUROCONTROL
Validation Platform	LAT A319 Simulator
Validation Location	Frankfurt
Status	<Validated>
Dependencies	

[EXE Trace]

Linked Element Type	EXE-14.5-VALP-R15
<SESAR Solution>	PJ.02-W2-PJ.02-W2-14.5
<Validation Objective>	OBJ-14.5-V3-VALP-0203
<Validation Objective>	OBJ-14.5-V3-VALP-0204
<Validation Objective>	OBJ-14.5-V3-VALP-0301

Table 5: R15 Validation Exercise Layout

3.2.4.4 EXE-14.5-V3-VALP-R25

R25 validation was added after VALP was finalised because after analysis of R10 results it appeared that the opinion of the pilots about the two lighting solutions proposed in R10 were rather balanced, one option being preferred on some visibility cases and the other one, in other conditions.

So it looked appropriate to run another set of flight simulations to assess only the steady solution which is much cheaper and easier to implement. For that validation, all the pilots that flew in the simulator had never flown in previous sessions about the lighting options, neither in W2, nor in W1, and so had never seen the switching solution.

Identifier	EXE-14.5-V3-VALP-R25
Title	R25 - Runway lighting
Description	The main goal of the simulation is to further assess the steady proposed solution for runway lighting. In addition, the aim of the RTS is to assess operational acceptability of IGS-to-SRAP from pilot's point of view. A series of cockpit simulations using a high-level professional Level D/Type 7 flight crew training simulator will be conducted. The purpose is to collect pilot feedback on the additional threshold operation (acceptability, workload, operational procedures), on how this threshold is shown on the runway and about the steady lighting. Different visibility conditions will be simulated and the aircraft following the enhanced procedure will be mixed with aircraft following ILS to normal threshold. The pilots participating to that exercise will have not participated to R10 nor to any flight simulation on IGS-to-SRAP lighting in PJ02 W1.
Expected achievements	To get pilot feedback: - on the steady lighting - on the additional threshold operation (acceptability, workload, operational procedures),
V Phase	V3
Use Cases	[NOV-5][EAO-03]
Validation Technique	Real Time Simulation
KPA/TA Addressed	Safety
Start Date	Nov 1, 2021
End Date	Nov 22, 2021
Validation Coordinator	EUROCONTROL
Validation Platform	LAT A319 Simulator
Validation Location	Frankfurt
Status	<validated>
Dependencies	

3.3 Deviations

3.3.1 Deviations with respect to the SJU Project Handbook

None.

3.3.2 Deviations with respect to the Validation Plan

As explained in section 3.2.4.4, exercise R25 has been added after the completion of the VALP.

4 SESAR Solution PJ.02-W2-14.5 Validation Results

4.1 Summary of SESAR Solution PJ.02-W2-14.5 Validation Results

SESAR Solution Validation Objective ID	SESAR Solution Validation Objective Title	SESAR Solution Success Criterion ID	SESAR Solution Success Criterion	SESAR Solution Validation Results	SESAR Solution Validation Objective Status
OBJ-14.5-V3-VALP-0101	To confirm that ATC HMI for IGS-to-SRAP is usable and acceptable for the controller, during non-nominal situations	CRT-14.5-V3-VALP-0101-001	The usability of the HMI is rated as being acceptable in non-nominal situations	Results from the simulation show that it is possible to use the HMI; however, the HMI would benefit from certain information to be able to react to certain non-nominal The participants suggested that a tool to visualise the vertical position of the aircraft on the glide would be helpful such as Vertical Speed information or Approach Path Monitoring. This will be particularly useful to aid the non-nominal situations where an aircraft intercepts the wrong glide triggering an alert and where a pilot initiated a missed approach. During the separation delivery tool failure, an alert/status indicator should appear on the ATCOs' HMI if the failure is detected by the system.	Ok
		CRT-14.5-V3-VALP-0101-002	The HMI is rated as being useful in non-nominal situations		Ok
		CRT-14.5-V3-VALP-0101-003	The proposed HMI supports the application of the IGS-to-SRAP procedure in non-nominal situations		Ok
OBJ-14.5-V3-VALP-0102a	To confirm that the ATC separation delivery support function for IGS-to-SRAP is usable and acceptable in non-nominal situations	CRT-14.5-V3-VALP-0102a-001	The usability of the support tool (separation tool) is rated as being acceptable in non-nominal situations	Results from the simulation show that the separation delivery tool is acceptable according to the participants' subjective feedback.	Ok
		CRT-14.5-V3-VALP-0102a-002	The support tool (separation tool) is rated as being useful in non-nominal situations	Results from the simulation show that the separation delivery tool is useful according to the participants' subjective feedback.	Ok

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				It was concluded that IGS-to-SRAP arrival procedures would not be possible without the separation delivery tool. It is strongly recommended that the wake/MRS indicator be always shown, even when the ROT is the most constraining. This is because ROT is desirable but not a safety issue, whereas wake is a safety critical issue.	
		CRT-14.5-V3-VALP-0102a-003	The support tool (separation tool) supports the application of the IGS-to-SRAP procedure in non-nominal situations	Results from the simulation show that the separation delivery tool supports IGS-to-SRAP arrival procedures during non-nominal situations according to the participants' subjective feedback. It was concluded that IGS-to-SRAP arrival procedures would not be possible without the separation delivery tool. It is strongly recommended that the wake/MRS indicator be always shown, even when the ROT is the most constraining. This is because ROT is desirable but not a safety issue, whereas wake is a safety critical issue.	Ok
		CRT-14.5-V3-VALP-0102a-004	The ATCOs trust the support tool (separation tool) that facilitates the application of IGS-to-SRAP in non-nominal situations	Results from the simulation show that the separation delivery tool is trusted according to the participants' subjective feedback.	Ok
OBJ-14.5-V3-VALP-0102b	To confirm that the glide alert functions is usable and acceptable for IGS-to-SRAP	CRT-14.5-V3-VALP-0102b-001	The usability of the wrong glideslope alert support tool is rated as being acceptable.	Results from the simulation show that the alert when an aircraft intercepts the wrong glideslope is acceptable according to the ATCO subjective feedback. This is if the requirement that the alert must be reliable is met.	Ok
		CRT-14.5-V3-VALP-0102b-002	The support tool (glide alert) is rated as being useful in non-nominal situations	Results from the simulation show that the alert when an aircraft intercepts the wrong glideslope is useful according to the participants' subjective feedback.	Ok
		CRT-14.5-V3-VALP-0102b-003	The support tool (glide alert) supports the application of the IGS-to-	Results from the simulation show that the alert when an aircraft intercepts the wrong glideslope supports IGS-to-SRAP arrival procedures during non-nominal situations according to the participants' subjective feedback.	Ok

			SRAP procedure in non-nominal situations		
		CRT-14.5-V3-VALP-0102b-004	The ATCOs trust the support tool (glide alert) that facilitates the application of IGS-to-SRAP in non-nominal situations	Results from the simulation show that participants trusted that the glide alert would appear for all aircraft that intercepted the wrong glideslope. However, they found the prototype alert used during the simulation was unreliable as it was too sensitive and produced extra alerts that were false according to subjective feedback. A requirement for the alert has been formulated as the conclusion of the simulation that, with future alerting system industrial development alert must be sufficiently reliable.	OK provided the tool is sufficiently reliable.
OBJ-14.5-V3-VALP-0103	To confirm that IGS-to-SRAP approach procedures do not negatively affect safety from ATC perspective, in non-nominal situations	CRT-14.5-V3-VALP-0103-001	There is evidence that the level of operational safety is maintained and not negatively impacted when IGS-to-SRAP procedures are active, in non-nominal situations	Results from the simulation show that participants found the procedures to be able to resolve the situation safely and in a timely manner.	Ok
OBJ-14.5-V3-VALP-0104	To confirm that IGS-to-SRAP is operationally feasible from ATC perspective, in non-nominal situations	CRT-14.5-V3-VALP-0104-001	SRAP is judged operational feasible from controller, in non-nominal situations	Results from the simulation show that the IGS-to-SRAP arrival procedures are feasible during non-nominal situations according to subjective feedback.	Ok
		CRT-14.5-V3-VALP-0104-002	The Controller Workload (in all measured positions) in non-nominal situations when IGS-to-SRAP operations are active, is tolerable	Results from the simulation show that controller workload is tolerable for IGS-to-SRAP arrival procedures during non-nominal situations according to subjective feedback and sector performance metrics.	Ok

		CRT-14.5-V3-VALP-0104-003	The controller situational awareness is acceptable in non-nominal situations, when IGS-to-SRAP operations are active	Results from the simulation show that controller situational awareness is acceptable for IGS-to-SRAP arrival procedures during non-nominal situations according to subjective feedback.	Ok
OBJ-14.5-V3-VALP-0203	To confirm that IGS-to-SRAP does not negatively affect safety from the perspective of the crew	CRT-14.5-V3-VALP-0203	There is evidence that the level of operational safety is maintained and not negatively impacted under IGS-to-SRAP procedures compared to the reference scenario, from the perspective of the crew		OK for lighting Ok for marking with standard ICAO marking duplication or chequered marking.
OBJ-14.5-V3-VALP-0204	To confirm that the Second Runway Aiming Point (SRAP) is operationally feasible from crew perspective	CRT-14.5-V3-VALP-0204-001	Pilot succeeds to manage IGS-to-SRAP operation by applying existing SOPs.		OK
		CRT-14.5-V3-VALP-0204-002	Pilots are confident when flying a IGS-to-SRAP operation		OK
OBJ-14.5-V3-VALP-0301	To confirm that the phraseology used by ATCO and Flight Crew for IGS-to-SRAP is clearly understandable	CRT-14.5-V3-VALP-0301-002	Proposed phraseology does not lead to errors related to perception & interpretation of auditory information.		OK
		CRT-14.5-V3-VALP-0301-003	Pilots accept and judge the proposed phraseology as being appropriate for all encountered operating		Ok

627 **Table 6: Summary of Validation Exercises Results**

4.2 Detailed analysis of SESAR Solution Validation Results per Validation objective

4.2.1 OBJ-14.2-V3-VALP-0101 Results

The HMI was found to be useful and acceptable in supporting the tasks related to IGS-to-SRAP approach procedures during non-nominal situations. One participant disagreed with this statement; however, the explanation from their comments and debriefs pointed out that this was due to unfamiliarity with the display of the Tower HMI and a strip less environment. The participants stated that on the Tower HMI it was difficult to see the black chevrons against the black distance markers. This is not an issue for the concept as the Tower HMI used was not the CDG Tower HMI and rather a generic HMI for the purpose of the simulation. In real operations, an ANSP would be able to tailor the HMI to suit their needs. The participants also stated that they occasionally mistook between the speed indicator and the wake category on the aircraft's electronic label; this was due to lack of training and unfamiliarity when working with electronic labels as the participants are working with paper flight strips.

The participants suggested that additional information about the aircraft's vertical speed, which was not available during the simulation, would be useful for the purpose of non-nominal situations during IGS-to-SRAP approach procedures. In particular for the pilot initiated missed approaches and an aircraft flying on the wrong glideslope. Vertical speed information will allow controllers to notice vertical deviations sooner and allow them to react quicker. Equally, the participants stated that it would be desirable to have a tool that immediately alerts ATCOS when there is an aircraft performing a missed approach.

For the separation delivery tool failure, the participants stated that an alert / status indicator would be desirable on the TWR and APP HMIs.

4.2.2 OBJ-14.2-V3-VALP-0102a Results

The participants agreed with all of the statements that the separation delivery tool was useful, acceptable, trusted and supports the IGS-to-SRAP approach procedures during non-nominal situations. The participants concluded that IGS-to-SRAP arrival procedures would not be possible without the separation delivery tool, in the conditions of the simulation.

4.2.3 OBJ-14.2-V3-VALP-0102b Results

Overall, the participants agreed that the wrong glideslope alert is useful, necessary and suitable for IGS-to-SRAP approach procedures. The participants also agreed that the design of the glide alert was clear, immediately noticeable and contained all the required information.

During the simulation, the prototype wrong glideslope alert was too sensitive, in that the alert would appear when an aircraft was slightly higher than the glide even though it had intercepted the correct glideslope, which should not have resulted in an alert. The purpose of the alert is to warn ATCOs when an aircraft has intercepted the wrong glideslope. Therefore, during the simulation many "false" alerts appeared on the HMI, which increased the task load, workload and communication load of the participants. Hence, a participant disagreed with the statements that the prototype alert was reliable and worked accurately. This will not be acceptable during real operations as it increases the workload and communication load of the ATCO. A requirement is needed stating that the wrong glideslope alert must be sufficiently reliable.

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4.2.4 OBJ-14.2-V3-VALP-0103 and OBJ-14.2-V3-VALP-0104 Results

The rules with increased separation defined to manage the non-nominal situations were found to be easy enough to remember.

Extensive training should be developed to train controllers on the management of non-nominal situations, in particular for the loss of the separation management tool, and regular training session must be organised as refresher.

The need to be able to easily access the separation table in use and the simplified one to be used (such as RECAT-EU and RECAT-EU+3NM as used in R01) in the event of a failure of the separation delivery tool was identified.

The participants found that whilst all IGS-to-SRAP non-nominal situations increase workload, it remains nonetheless tolerable. However, only with regular training and when a coordinator is available to support the ITM ATCO during the failure of the separation delivery tool non-nominal situation. They did not identify any safety issues and that each of the non-nominal situations were able to be resolved safely and within a timely manner

Overall, the situational awareness was high and sufficient for non-nominal situations during IGS-to-SRAP arrival procedures according to the participant feedback. However, there should be requirements developed:

- The coordinator assistant must be available to aid the ITM ATCO in the event of the separation delivery tool failure;
- An ATCO must be confident of the position of an aircraft in order to consider an aircraft as stabilised (160 knots and behind the ITD indicator) in the event of the separation delivery tool failure;
- The alert for when an aircraft intercepts the wrong glideslope must be sufficiently reliable.

They also recommended that a tool to visualise the vertical position of the aircraft on the glide would be helpful for ATCOs for the purpose of the wrong glideslope alert, such as Vertical Speed information or Approach Path Monitoring.

For the wrong glideslope alert situation, participants recommended that the following requirement be developed: "the approach sectors should inform the tower if an aircraft is flying a different procedure, especially during IGS-to-SRAP arrival procedures". This is so that that TWR ATCO is fully aware of the situation when an aircraft not supposed to fly a IGS-to-SRAP approach (typically of Heavy or Super Heavy category) is flying the IGS-to-SRAP procedure, and able to plan and monitor the situation more carefully, in particular with the different runway aiming points where the ATCO should know if an aircraft has changed its landing runway (27L or 28L).

For the separation delivery tool failure, participants stated that teamwork is essential. As a result of the simulation, a requirement must be developed that the coordinator/assistant must aid the ITM sector for checking the separations between aircraft and suggesting which aircraft should be sent around.

There should also be communication between the sectors about which aircraft have been sent around and a communication to the TWR ATCO informing them of the final aircraft in the sequence that will be flying on the upper glideslope and performing an IGS-to-SRAP arrival procedure. This being the sequence immediately after the separation delivery tool failure and the final aircraft that will fly the upper glideslope until the tool and nominal operations return.

Participant feedback concluded that the following are needed for the implementation of IGS-to-SRAP:

1. The procedure to manage an alert caused by an aircraft intercepting the wrong glideslope must be regularly briefed and included in the refresher training.
2. The procedure to manage a go-around or missed approach must be regularly briefed and included in the refresher training.
3. The procedure to manage the failure of the separation delivery tool must be included in the regular non-nominal/emergency training.
4. SRAP operations with high traffic density are not possible without a separation delivery tool.
5. SRAP operations with high traffic density are not possible without a sequencer.
6. Extensive training will be required to become confident with the IGS-to-SRAP concept, separation delivery tool and non-nominal procedures:
    a. The **wrong glideslope alert** procedure must have regular briefing and be included in the refresher training.
    b. The **go-around/missed approach** procedure must be regular briefing of the procedure and should be included in the refresher training.
    c. The **separation delivery tool failure** procedure should be treated as a rare, emergency procedure. It will require extensive training and should be included in the regular training session.

4.2.5 OBJ-14.2-V3-VALP-0203 Results

Based on Validation Exercises R10, R15 and R25 results, the objective to confirm that IGS-to-SRAP does not negatively affect safety from the perspective of the crew is validated if the options selected for the runway marking are Option 1 or 2 of Figure 64, which are the ICAO duplication white marking or the chequered white marking.

Concerning the lighting, the analysis of R10 results show a very little decrease of safety, not specific to one lighting solution or the other. But when considering the results from R25, that decrease almost completely disappears when the steady dual approach lighting system solution is used in any case. From pilot perspective the level of safety is not influenced using the steady approach light configuration under various circumstances (reduced visibility, crosswind). Only a few runs without any tendency regarding visibility or wind have been rated with a decrease of safety. Briefings and familiarisation of flight Crews will be therefore key to maintain an acceptable level of safety for all Airspace Users.

So the configuration which consists of the steady lighting and the ICAO duplication white marking or the chequered white marking is the one that ensures that safety is not negatively affected by the use of IGS-to-SRAP procedures.

4.2.6 OBJ-14.2-V3-VALP-0204 Results

Based on Validation Exercises R10, R15 and R25 results, the objective to confirm that the Second Runway Aiming Point (SRAP) is operationally feasible from the crew perspective is validated, which is fully in line with the results already obtained in PJ02-02 validation activities for IGS-to-SRAP.

More than 95% of the pilots indicated that they executed all tasks in line with the SOPs and that they can imagine using the concept of Secondary Runway Aiming Point in an every-day operation. Some pilots stated that there already some airports using displaced threshold which is causing no operational problems. Consequently, it can be concluded that the concept is operational feasible.

4.2.7 OBJ-14.2-V3-VALP-0301 Results

Based on Validation Exercises R10, R15 and R25 results, the objective to confirm that the phraseology used by ATCO and Flight Crew for IGS-to-SRAP is clearly understandable, is validated from pilots' point of view.

The pilots found the phraseology well adapted and giving them useful and necessary information. In particular, all pilots stated that the information from ATC about the preceding aircraft and the flown glide raised their situational awareness regarding the intended approach and related threshold.

Despite the procedure naming and phraseology have been based on standard conventions, one controller found it a bit confusing. Such potential for confusion should be further reassessed in future operational demonstrations phase.

Even if it was not the case in the validation activities conducted in W1, some participants found the phraseology for the TWR ATCO to be too long and time consuming, especially if the ATCO also manages departures on the same frequency. The participants suggested that if two aircraft are expected to land using the same runway aiming point then the ATCO should not have to provide the runway in the message. The phraseology at the TWR should be further investigated in future operational demonstrations phase.

4.3 Confidence in Validation Results

4.3.1 Limitations of Validation Results

4.3.1.1 Quality of Validation Results

4.3.1.1.1 From pilots' side

The simulations were run in a professional Level D certified flight simulator of type Airbus A319. The approaches were flown by certified type rated airline pilots. So the validation results are considered to be of high quality and trustful.

4.3.1.1.2 From ATC side

From the ATC side, the procedure was tested in one airport environment based on a major European airport that is supposed to be representative of airports where the procedure could be implemented.

However the following issues affected the quality of the results:

1. There were a few technical issues, which may have negatively affected the human performance results. In particular, workload and situational awareness.
2. The number of non-nominal situations that occurred within a short amount of time (50 minutes to 1 hour) were exaggerated in order to be able to complete the experimental design within a week and to test the non-nominal situations under different conditions. This could have had a negative impact on the human performance results.
3. The traffic sample was adapted for the needs of the simulation and was not familiar to the ATCOs. It may have caused some confusion as flights and callsigns appeared different

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directions to those that they are familiar. This was to balance the number of aircraft from both directions (North-East (LORNI) and North-West (MOPAR)).

4.3.1.2 Significance of Validation Results

4.3.1.2.1 From pilots' side

The results of the simulations are operationally significant as they were run using the highest level of realism concerning the cockpit environment and visual system and operated by certified airline pilots.

4.3.1.2.2 From ATC side

Statistical Significance

Six runs assessed the IGS-to-SRAP operations with seven non-nominal situations with four participants. Each participant was able to assess the concept from each sector position providing the maximum confidence in the feedback with the limited number of participants.

Whilst six runs does not provide high statistical significance, a further nine exercises using ISGS and IGS-to-SRAP procedures tested these same procedures where a lot of the feedback was very similar and applicable to all three Enhanced Arrival Procedures, increasing the statistical significance.

In addition, 33 non-nominal situations occurred over the six runs (70 non-nominal situations over all 15 runs) and were tested at different points during the traffic sample, which provided a variation in the conditions, complexity and anticipation for the participants. These non-nominal situations were tested multiple times within one exercise (with the exception of the separation delivery tool failure, which was only possible to test once per exercise). Considering all of the feedback from all 15 runs and all 70 non-nominal situations, the statistical significance increases and can be considered high.

Considering the limited amount of time and number of participants, the confidence in the variation of the feedback provided was maximised and is sufficient to validate the concept.

Operational Significance

The traffic sample contained similar callsigns to the usual traffic at CDG; however, the traffic itself was different. Some traffic would arrive from different directions compared to their expectations and certain aircraft types were included in the traffic sample, which would not arrive at CDG in reality. This could have caused some confusion and surprise the participants.

The traffic sample also did not include departures or runway crossings that the ATCOs would usually have to manage as well, therefore, reducing the perceived workload for the ATCOs. However, the purpose was not to apply the true CDG environment but to have a representative environment for large European airports, and focusing on the segregated mode of operations on arrival runway with high density traffic.

The system was paperless; however, the CDG environment uses paper strips. This would have increased the workload and lowered the situational awareness. The HMI was also different to their HMI in operations.

In addition, participants usually coordinate with more actors when performing these tasks, this ended up increasing their workload.

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5 Conclusions and recommendations

5.1 Conclusions

5.1.1 Conclusions on SESAR Solution maturity

5.1.1.1 Pilots' side

Pilots found the approaches fully acceptable and feasible to fly. The general concept for the usage of a second runway aiming point was accepted and the benefits with respect of capacity and improved separation clearly understood. The influence of adverse weather could not be clearly identified. Moreover, most of the pilots stated that they can imagine having the IGS-to-SRAP solution available in daily operation.

The steady approach light configuration provided a fully accepted and robust option to provide IGS-to-SRAP operations.

Furthermore, the provided option for the runway designator for the second threshold seems to be the best compromise for raising situational awareness during short final and limitations regarding FMS coding possibilities.

5.1.1.2 ATC side

From the ATC side, the purpose of validation activity R01 was to assess the way to manage of the following non-nominal situations which are considered to be very challenging for the ATCOs.

The management of the non-nominal cases was defined as follows:

Wrong glide alert

"When there is a Glide Alert warning, the controller shall:

- *Ask pilot to "confirm type of approach and landing runway";*
- *If the concerned aircraft has a RECAT-EU wake turbulence category of CAT A "Super heavy", CAT B "Upper Heavy" or CAT C "Lower Heavy" on upper glide – instruct go-around;*
- *For any other RECAT-EU wake turbulence category:*
  - *update CWP HMI to the approach procedure actually flown (to update the separation delivery tool indicators);*
  - *Check the position of the concerned aircraft, leading aircraft and following aircraft against their indicators;*
  - *If any under separated, instruct go-around to the flight which triggered the glide alert".*

Go-arounds/ missed approaches

- *"Instruct concerned aircraft to go-around as per procedure;*
- *If the concerned aircraft was performing a Missed Approach / Go-around from the ILS lower glideslope with a follower on upper glide;*
  - *compare separation between the concerned aircraft and the following aircraft against RECAT-EU minima;*

- *If less than RECAT minima: instruct go-around to the following aircraft with "Turn left/right immediately" instruction" so that the two aircraft are on diverging flightpaths.*

Loss of separation delivery tool

When there is a failure of the separation delivery tool:

- *"For pairs of aircraft for which the ATCO is confident that were ON or BEHIND the ITD and stabilised at 160kts - continue on final;*
- *For non-stabilised pairs (upper-lower, lower-upper or same slope):*
    - *If any S/G/H aircraft on Upper Glide → instruct go-around;*
    - *For Upper - lower glide pairs ensure RECAT-EU + 3NM minimum separation (if not possible, instruct go-around to a/c on upper glide);*
    - *For remaining traffic on final (i.e. lower-upper and same slope pairs) → ensure RECAT-EU separation minima (if not possible, instruct go-around to a/c on upper glide);*
- *For all aircraft that have not yet intercepted the glide and localiser:*
    - *Progressively re-assign on conventional glide (ILS) (vectoring as appropriate if necessary)."*

The procedures defined to manage the non-nominal cases were found very feasible by the controllers, but requesting extensive training and regular briefing including refresher training.

5.1.2 Conclusions on concept clarification

No need for concept clarification was identified.

5.1.3 Conclusions on technical feasibility

5.1.3.1.1 HMI

The following conclusions related to the HMI for non-nominal situations were captured during the simulation, linked to the management of the non-nominal situations:

- Additional information is desired by the ATCO to visualise the vertical position of the aircraft, such as Vertical Speed information or Approach Path Monitoring. This would help the ATCOs to identify any aircraft that intercepts the wrong glideslope and to identify any pilot initiated missed approaches. This should be further investigated locally.
- An alert / status indicator shall be shown on the TWR and APP controllers' HMI when the separation delivery tool fails.
- As there are multiple interception points for IGS-to-SRAP arrival procedures, the interception points displayed on the HMI used in the simulation sometimes became confusing for the participants. It is required that the interception points should be clear and distinguishable. This should be further investigated locally.

5.1.3.1.2 Separation Delivery Tool

The following conclusions related to the separation delivery tool were captured during the simulation:

- The separation delivery tool is useful, acceptable, trusted and supports the IGS-to-SRAP approach procedures during non-nominal situations.
- SRAP arrival procedures during high traffic density would not be possible without the separation delivery tool.

- Additional information for the wake/MRS indicator to be shown always is desired. Therefore, when the ROT indicator is the most constraining time separation, the wake/MRS indicator should also be shown because wake is a safety issue whereas ROT is useful but it is not safety related.

5.1.3.1.3 Wrong Glideslope Alert

The following conclusions related to the wrong glideslope alert were captured during the simulation:

- The wrong glideslope alert is useful, necessary and suitable for IGS-to-SRAP approach procedures. The design of the wrong glideslope alert was clear, immediately noticeable and contained all the required information.
- A requirement must be derived stating that the wrong glideslope alert it must be sufficiently reliable, and subject to local safety assessment.

5.1.4 Conclusions on performance assessments

The following conclusions related to non-nominal situations with IGS-to-SRAP arrival procedures were captured during the validation activities:

- ATC side
  - The procedures for non-nominal situations during IGS-to-SRAP arrival procedures do not cause any safety concern provided that the safety requirements [39] derived from the simulation findings are met. Further details can be found within the Safety Assessment Report (SAR) [40].
  - Workload is tolerable for handling IGS-to-SRAP non-nominal situations procedures.
  - The situational awareness was sufficient for the IGS-to-SRAP non-nominal situations procedures.
  - Non-nominal situations will always increase the task load and are never easy to manage. Extensive training will be required for each procedure.
  - Teamwork and coordination is essential. During the separation delivery tool failure, the workload for the ITM sector is too high. The ITM ATCO will require an assistant to help them with the procedures such as checking the separation between pairs and identifying which aircraft must be sent to go-around. The APP sector must also communicate to the TWR sector the last aircraft in the sequence that will perform an IGS-to-SRAP approach. This being the sequence immediately after the separation delivery tool failure and the final aircraft that will fly the upper glideslope until the tool and nominal operations return. During the wrong glideslope alert, the APP sector should communicate to the TWR whether an aircraft triggered a glide alert before it is transferred to TWR.
  - Phraseology was considered to be adequate overall.

5.2 Recommendations

5.2.1 Recommendations for next phase

5.2.1.1 ATC side

The following items are required for the transition of IGS-to-SRAP procedures into implementation:

- the procedure to manage an alert caused by an aircraft intercepting the wrong glideslope should be regularly briefed and included in the refresher training.

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- the procedure to manage a go-around or missed approach should be regularly briefed and included in the refresher training.
- the procedure to manage the failure of the separation delivery tool should be included in the regular non-nominal/emergency training.
- SRAP operations with high traffic density are not possible without a separation delivery tool.
- SRAP operations with high traffic density are not possible without a sequencing tool.
- Extensive training will be required to become confident with the IGS-to-SRAP concept and separation delivery tool
- ANSPs should locally consider the necessary tools and information required in order to best detect deviations from the glideslopes during V5 deployment phases. These should help during the non-nominal situations: go-around/missed approach and wrong glideslope alert. The participants recommended that the APP and TWR sector have a tool to plot the vertical position of the aircraft, such as Vertical Speed information or Approach Path Monitoring. Equally, an alert when aircraft perform a pilot initiated missed approach would be desirable for all circumstances; this is an existing problem.

5.2.1.2 Pilots' side

The following recommendations were identified:

- The configuration which consists of the steady lighting and the ICAO duplication white marking or the chequered white marking is the one that ensures that safety is not negatively affected by the use of IGS-to-SRAP procedures.
- Touchdown zone marking should be on the runway
- Pilots' briefing shall include the particularities linked to IGS-to-SRAP, in particular the PAPI location for normal or IGS-to-SRAP approach.
- Pilots shall readback the landing clearance indicating first or second threshold.
- Training on different approach types to IGS-to-SRAP has to be ensured.
- In the cockpit, special focus has to be put on the briefing:
    - Briefing has to include the expected lighting configuration
    - Which threshold is used (standard or IGS-to-SRAP)
    - Special briefing is needed in case of 3.5°approach
    - Landing distance available (especially for IGS-to-SRAP)
- ATC should communicate the approach type of the previous aircraft
- The approach naming shall be indicated by a different runway number (e.g. xLS 08R & xLS 09R).
- Charts shall include:
    - For both standard and IGS-to-SRAP procedures, the indication about PAPI location for the procedure
    - For IGS-to-SRAP procedure, the indication of the second threshold location, highlighted in red, and the corresponding vertical profile.

5.2.2 Recommendations for updating ATM Master Plan Level 2

Roadmap level 2 was modified by updating the OI AO-0331 description to precise that the solution is only for a minimum distance of 1100m between the two thresholds.

Indeed, the runway marking solutions assessed for a lower distance in R15 (side markings) were considered as not acceptable by the pilots. In case there would a need for a lower distance, a new OI should be created and associated marking designed and evaluated.

5.2.3 Recommendations on regulation and standardisation initiatives

Regarding IGS-to-SRAP visual aid, the selected best option for, with steady dual approach CAT I lighting system and the ICAO duplication white marking or the chequered white marking, should be the basis for necessary regulation / standardisation development in support of harmonised and interoperable operations.

Engagement with regulatory bodies, EASA and ICAO should be undertaken to seek the necessary regulatory evolution associated to IGS-to-SRAP visual aid (AMC/GM to Aerodrome regulation EU 139/2014 and ICAO Annex 14) and AMC/GM to Common Requirements regulation EU 2020/469 Part-ATS).

Regarding ATS, the IGS-to-SRAP procedure and phraseology should also be subject to the necessary regulatory framework.

Besides these aspects, there is also a need to seek for regulatory endorsement of the adaptation of wake turbulence separation minima applicable to IGS-to-SRAP operations. In this view, EUROCONTROL intends to develop and release a generic safety case to be submitted to EASA (using a similar approach as previously applied for RECAT-EU and TBS wake minima).

Note that some of these activities have already been initiated as part of SESAR2020 W2 VLD1 DREAMS project and are subject to cross projects coordination.

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6 References

6.1 Applicable Documents

Content Integration

1. B.04.01 D138 EATMA Guidance Material
2. EATMA Community pages
3. SESAR ATM Lexicon

Content Development

4. B4.2 D106 Transition Concept of Operations SESAR 2020

System and Service Development

5. 08.01.01 D52: SWIM Foundation v2
6. 08.01.01 D49: SWIM Compliance Criteria
7. 08.01.03 D47: AIRM v4.1.0
8. 08.03.10 D45: ISRM Foundation v00.08.00
9. B.04.03 D102 SESAR Working Method on Services
10. B.04.03 D128 ADD SESAR1
11. B.04.05 Common Service Foundation Method

Performance Management

12. B.04.01 D108 SESAR 2020 Transition Performance Framework
13. B.04.01 D42 SESAR2020 Transition Validation
14. B.05 D86 Guidance on KPIs and Data Collection support to SESAR 2020 transition.
15. 16.06.06-D68 Part 1 –SESAR Cost Benefit Analysis – Integrated Model
16. 16.06.06-D51-SESAR_1 Business Case Consolidated_Deliverable-00.01.00 and CBA
17. Method to assess cost of European ATM improvements and technologies, EUROCONTROL (2014)
18. ATM Cost Breakdown Structure_ed02_2014
19. Standard Inputs for EUROCONTROL Cost Benefit Analyses
20. 16.06.06_D26-08 ATM CBA Quality Checklist
21. 16.06.06_D26_04_Guidelines_for_Producing_Benefit_and_Impact_Mechanisms

Validation

22. 03.00 D16 WP3 Engineering methodology
23. Transition VALS SESAR 2020 - Consolidated deliverable with contribution from Operational Federating Projects
24. European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

System Engineering

25. SESAR 2020 Requirements and Validation Guidelines

Safety

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26. SESAR, Safety Reference Material, Edition 4.0, April 2016
27. SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016
28. SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015
29. SESAR, Resilience Engineering Guidance, May 2016

Human Performance

30. 16.06.05 D 27 HP Reference Material D27
31. 16.04.02 D04 e-HP Repository - Release note

Environment Assessment

32. SESAR, Environment Reference Material, alias, "Environmental impact assessment as part of the global SESAR validation", Project 16.06.03, Deliverable D26, 2014.
33. ICAO CAEP – "Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes" document, Doc 10031.

Security

34. 16.06.02 D103 SESAR Security Ref Material Level
35. 16.06.02 D137 Minimum Set of Security Controls (MSSCs).
36. 16.06.02 D131 Security Database Application (CTRL_S)

6.2 Reference Documents

37. D4.5.004 - PJ.02-W2-14.5 VALP Final, Ed. 00.01.00 - 28 May 2021
38. D2.1.04 - SESAR PJ02-02 VALR, Ed. 00.01.00 – 19 March 2020
39. D4.5.002 - PJ.02-W2-14.5 SPR-INTEROP/OSED Part I, Ed. 00.01.00 – 22 September 2022
40. D4.5.002 - PJ.02-W2-14.5 SPR-INTEROP/OSED Part II, Ed. 00.01.00 – 5 August 2022

7 Validation Exercise EXE-14.5-V3-VALP-R01 Report

7.1 Summary of the Validation Exercise EXE-14.5-V3-VALP-R01 Plan

7.1.1 Validation Exercise description, scope

This section describes the key validation objectives and the validation environment of the exercise in terms of technique, operational environment, roles and actors, traffic, scenarios and platform configuration.

7.1.1.1 Validation Technique and Platform

This validation activity was a development of a Real Time Simulations (RTS) from Wave 1, EXE-02.02-V3-VALP-R03, which took place in December 2018. This exercise measured the operational and technical feasibility of IGS-to-SRAP approach procedures in particular using the ORD tool for support. The recommendations made at the end of Wave 1 became the key objectives of this validation activity (see [38]). These were:

- To evaluate the impact of the IGS-to-SRAP, on Air Traffic Controllers (ATCOs) during non-nominal situations;
- To develop the procedures for recovering operations safely during non-nominal situations;
- To introduce and assess the usability and acceptability of a support tool that will alert ATCOs when an aircraft joins the wrong glide slope.

Following the analysis of the objectives, stakeholders' validation expectations and concept maturity, this validation activity was conducted as a human-in-the-loop RTS.

The EUROCONTROL ESCAPE platform was one of the tools for this RTS. The ESCAPE simulation platform provides a combination of air, ground, simulation supervision and preparation, and analysis capabilities, which are used by validation projects for their specific needs. The main objective of ESCAPE is in fact to provide means to validate new components/concepts before they are introduced in operations.

The EUROCONTROL eDEP platform was the second tool for this RTS. The eDEP simulation platform combines an ATC system simulator with AIR, FDPS and HMI functionalities and Tower (TWR) system simulator. eDEP was connected to ESCAPE and a graphical display to provide the simulation environment.

7.1.1.2 Simulation Operating Environment

The environment used was Paris Charles de Gaulle (CDG) airport, with approach and tower positions.

Paris CDG airport has two patterns of operations depending mainly on the wind direction: East and West configurations. This validation exercise only concerned the West configuration, which is historically slightly more predominant.

During this simulation, aircraft intercepted at only one interception altitude. This was at 5000ft in the Paris CDG environment.

The exercise focused on segregated mode of operations with runway 27L being used as a landing runway only. Departures were not simulated in this validation exercise. No traffic was simulated on runway 27R in this exercise.

Figure 1 shows the northern section of Paris CDG including runway 27L. Runway 27L is the inner runway from the Northern couplet and has 4200m in length.

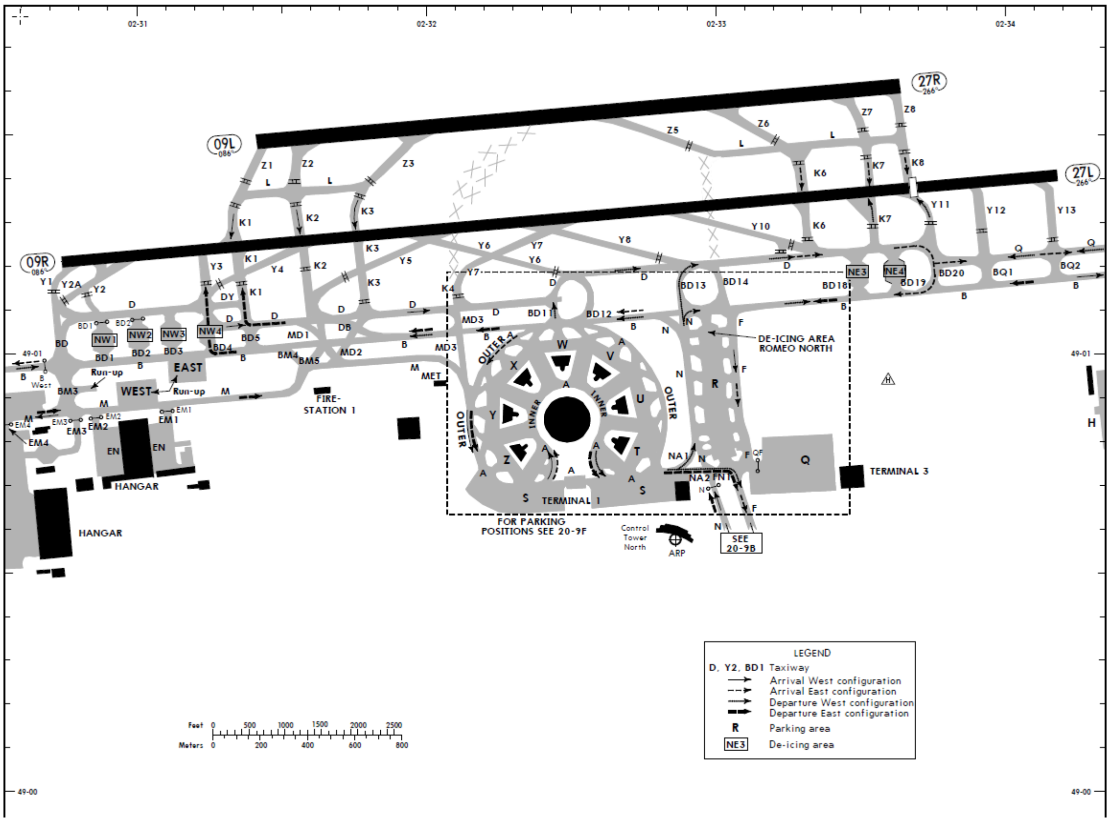

Figure 1: Northern section of Paris CDG including RWY27L

The following sectors based on Paris CDG configuration used:

Two approach sectors:

- Initial Approach position (INI) which managed the initial flow of arrivals from multiple directions.
- Final Approach position (ITM) which received sequenced traffic from INI and vector the aircraft onto the ILS, merging different traffic streams where necessary.
- Unmeasured Coordinator (COR) position which handled communication between the Approach and Tower as well as aiding in sequencing.

One Tower sector:

- Tower position (TWR) which managed the arrivals landing on RWY27L and RWY28L

7.1.1.3 Roles and Actors

There were four ATCO positions available: INI, ITM, TWR and COR. These were three approach positions (INI, ITM, COR) and one tower position (TWR). Although only the INI, ITM and TWR positions were measured.

Four Paris Charles-de-Gaulle (CDG) controllers sat at these positions. They rotated during the simulation week in order to experience the management of these procedures at all positions.

In addition, six pseudo pilots supported the simulation; two pilots handled traffic for the Initial Approach position (INI), three pilots handled traffic for the Final Approach position (ITM) and one pilot handled traffic for the Tower (TWR) position.

7.1.1.4 Traffic Sample

There was one traffic sample for the RTS. There was an additional traffic sample, which is exactly the same traffic samples except for the call signs, which were changed to avoid simulation-learning effects by ATCOs.

The traffic sample had high-peak traffic with 37 arrivals within 50 minutes, which corresponds approximately to 30% more than today's maximum of 39 arrivals per hour on runway 27L. IGS-to-SRAP has a positive impact on the capacity; therefore, these approaches will be suitable for peak-traffic and hub airports. It particularly has an impact with a high mix of "Heavy" with "Medium" aircraft when operating with a refined separation scheme.

The sample included more HEAVY / CAT-B and CAT-C aircraft and more LIGHT / CAT-F than today at Paris CDG. The traffic mix at major EU airports is expected to evolve towards larger aircraft in the future, increasing the Heavy aircraft proportion in the traffic. Table 7 shows the mix of aircraft by the RECAT-EU wake turbulence categories.

RECAT-EU WTC	Count	Percentage
CAT_A	1	2,8%
CAT_B	10	27,8%
CAT_C	2	5,6%
CAT_D	16	44,4%
CAT_E	5	13.9%
CAT_F	2	5,6%

Table 7: Percentage of Aircraft per RECAT-EU Category for Traffic Sample

The choice of using a higher number of CAT-F was done for impact assessment purposes as type CAT-F aircraft can get higher benefits from reduced separation minima flying an enhanced approach procedure. In addition, this type of aircraft normally presents more advanced technology and equipment to comply with those procedures based on satellite navigation.

The traffic samples were based on real flights using Paris CDG (Network Manager´s data); hence, they were realistic in terms of aircraft types, call signs and traffic mix compared to the current Paris CDG traffic.

The arrival times of the aircraft were modified to suit the northern environment of the airport and to ensure the high traffic density was maintained throughout the simulation exercise. During the simulation, only one runway, 27L, was simulated. Crossing traffic within the airport and traffic landing in other airports were excluded.

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7.1.2 Summary of Validation Exercise #01 Validation Objectives and success criteria

Table 8 describes the validation objectives applicable to the exercises.

SESAR Solution Validation Objective	SESAR solution success criteria	Coverage and comments on the SESAR solution validation objective in exercise R01	Exercise validation objective	Exercise success criteria
OBJ-14.5-V3-VALP-0101 To confirm that ATC HMI for IGS-to-SRAP is usable and acceptable for the controller, during non-nominal situations	CRT-14.5-V3-VALP-0101-001: The usability of the HMI is rated as being acceptable CRT-14.5-V3-VALP-0101-002: The HMI is rated as being useful CRT-14.5-V3-VALP-0101-003: The proposed HMI supports the application of the IGS-to-SRAP procedure	Fully covered	R01-OBJ-14.5-V3-VALP-0101: To assess the usability and acceptability of the ATC HMI for IGS-to-SRAP approach procedures during non-nominal cases	R01-CRT-14.5-V3-VALP-0101-001: The usability of the HMI is rated as being acceptable R01-CRT-14.5-V3-VALP-0101-002: The HMI is rated as being useful R01-CRT-14.5-V3-VALP-0101-003: The proposed HMI supports the application of the IGS-to-SRAP approach procedure
OBJ-14.5-V3-VALP-0102a To confirm that the ATC separation delivery support function for IGS-to-SRAP is usable and acceptable in non-nominal situations	CRT-14.5-V3-VALP-0102a-001: The usability of the support tool (separation tool) is rated as being acceptable in non-nominal situations CRT-14.5-V3-VALP-0102a-002: The support tool (separation tool) is rated as being useful in non-nominal situations	Fully covered	R01-OBJ-14.5-V3-VALP-0102a: To assess the usability and acceptability of the ATC support functions for IGS-to-SRAP approach procedures during non-nominal cases	R01-CRT-14.5-V3-VALP-0102a-001: The usability of the support tool is rated as being acceptable during non-nominal cases R01-CRT-14.5-V3-VALP-0102a-002: The support tool is rated as being useful during non-nominal cases R01-CRT-14.5-V3-VALP-0102a-003: The support tool supports the application of the

SESAR Solution Validation Objective	SESAR solution success criteria	Coverage and comments on the SESAR solution validation objective in exercise R01	Exercise validation objective	Exercise success criteria
	CRT-14.5-V3-VALP-0102a-003: The support tool (separation tool) supports the application of the IGS-to-SRAP operational procedure in non-nominal situations CRT-14.5-V3-VALP-0102a-004: The ATCOs trust the support tool (separation tool) that facilitates the application of IGS-to-SRAP in non-nominal situations.			IGS-to-SRAP approach procedures during non-nominal cases R01-CRT-14.5-V3-VALP-0102a-004: The ATCOs trust the support tool that facilitates the application of IGS-to-SRAP during non-nominal cases
OBJ-14.5-V3-VALP-0102b To confirm that the glide alert functions is usable and acceptable for IGS-to-SRAP	CRT-14.5-V3-VALP-0102b-001: The usability of the support tool (glide alert) is rated as being acceptable in non-nominal situations CRT-14.5-V3-VALP-0102b-002: The support tool (glide alert) is rated as being useful in non-nominal situations CRT-14.5-V3-VALP-0102b-003: The support tool (glide alert) supports the application of the	Fully covered	R01-OBJ-14.5-V3-VALP-0102b: To assess the usability and acceptability of the wrong glideslope alert support tool for IGS-to-SRAP arrival procedures	R01-CRT-14.5-V3-VALP-0102a-001: The usability of the wrong glideslope alert support tool is rated as being acceptable R01-CRT-14.5-V3-VALP-0102a-002: The wrong glideslope alert support tool is rated as being useful R01-CRT-14.5-V3-VALP-0102a-003: The wrong glideslope alert support tool supports the application of the IGS-to-SRAP operational procedure

SESAR Solution Validation Objective	SESAR solution success criteria	Coverage and comments on the SESAR solution validation objective in exercise R01	Exercise validation objective	Exercise success criteria
	IGS-to-SRAP procedure in non-nominal situations CRT-14.5-V3-VALP-0102b-004: The ATCOs trust the support tool (glide alert) that facilitates the application of IGS-to-SRAP in non-nominal situations			R01-CRT-14.5-V3-VALP-0102a-004: The ATCOs trust the wrong glideslope alert support tool that facilitates the application of IGS-to-SRAP
OBJ-14.5-V3-VALP-0103 To confirm that IGS-to-SRAP approach procedures do not negatively affect safety from ATC perspective, in non-nominal situations	CRT-14.5-V3-VALP-0103-001: There is evidence that the level of operational safety is maintained and not negatively impacted under IGS-to-SRAP procedures compared to the reference scenario from ATC perspective, in non-nominal situations.	Fully covered	R01-OBJ-14.5-V3-VALP-0103: To assess the safety performance of IGS-to-SRAP approach procedures during non-nominal cases from an ATC perspective	R01-CRT-14.5-V3-VALP-0103-001: The level of operational safety is acceptable for IGS-to-SRAP approach procedures during non-nominal cases from an ATC perspective
OBJ-14.5-V3-VALP-0104 To confirm that IGS-to-SRAP is operationally feasible from ATC perspective, in non-nominal situations	CRT-14.5-V3-VALP-0104-001: IGS-to-SRAP is judged as operationally feasible from controller, in non-nominal situations CRT-14.5-V3-VALP-0104-002: The Controller Workload (in all measured positions) in non-nominal situations	Fully covered	R01-OBJ-14.5-V3-VALP-0104: To assess the operational feasibility of IGS-to-SRAP approach procedures during non-nominal cases from an ATC perspective	R01-CRT-14.5-V3-VALP-0104-001: IGS-to-SRAP approach procedures during non-nominal cases is operationally feasible according to controller feedback R01-CRT-14.5-V3-VALP-0104-002: The controller Workload is tolerable for IGS-to-SRAP approach procedures during

SESAR Solution Validation Objective	SESAR solution success criteria	Coverage and comments on the SESAR solution validation objective in exercise R01	Exercise validation objective	Exercise success criteria
	when IGS-to-SRAP operations are active, is tolerable CRT-14.5-V3-VALP-0104-003: The controller situational awareness is acceptable in non-nominal situations, when IGS-to-SRAP operations are active			non-nominal situations R01-CRT-14.5-V3-VALP-0104-003: The controller Situational Awareness is acceptable for IGS-to-SRAP approach procedures during non-nominal situations R01-CRT-14.5-V3-VALP-0104-004: Procedures to manage the non-nominal cases are further refined if required

Table 8: Validation Objectives addressed in Validation Exercise R01

7.1.3 Summary of Validation Exercise EXE-14.5-V3-VALP-R01 Validation scenarios

7.1.3.1 Reference Scenarios

There was no reference scenario during this simulation, as there is no need for a comparative analysis as well as, there are no existing operations which could be used for comparison.

The evidence that were collected were mostly subjective data from the ATCOs, who will support the objectives by assessing the acceptability of the procedures, human performance and safety and help to develop these procedures.

7.1.3.2 Solution Scenarios

7.1.3.2.1 Nominal Case

The RTS simulated the concept IGS-to-SRAP. During the simulation, the increased glide slope proposed was at 3.5° and aircraft following this procedure landed on 28L, a second threshold displaced of 1100m from the conventional threshold on 27L. The aiming point associated to this second threshold was at 400m from the second threshold (based on ICAO Annex 14). Refer to Figure 2 for the depiction of the

IGS-to-SRAP procedure that is represented by the red dotted slope, the green dotted line representing the conventional ILS procedure.

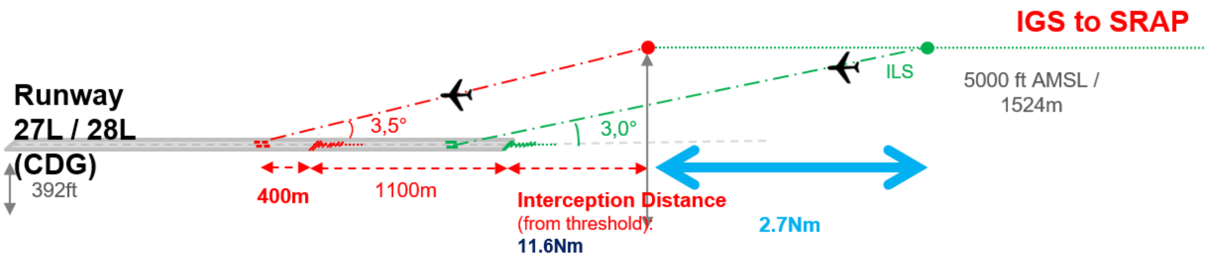

Figure 2: IGS-to-SRAP procedure (red slope)

Conventional approach procedures using ILS at 3° were also simulated when aircraft were not equipped with GBAS or RNAV.

ATCOs carried out the following procedures for IGS-to-SRAP approach procedures, named GLS W or RNP W:

1. The INI controller decided whether IGS-to-SRAP approach procedures are appropriate. The ATCO did this by selecting the indication for the chosen procedure in the drop down menu of the aircraft label on the HMI;
2. The ITM controller cleared the previously selected procedure by selecting the respective clearance in the HMI;
3. Aircraft flying an IGS-to-SRAP approach procedure and aircraft flying the conventional ILS approach intercepted at 5000ft;
4. Aircraft of the “Super” and “Heavy” wake categories were put on a lower glide and flew a conventional 3° ILS approach procedure. “Medium” and “light” aircraft that were GBAS or RNAV equipped were put on the upper glide with vectoring and flew a 3.5° IGS-to-SRAP approach, whilst aircraft that were not capable informed ATC and were put on the lower glideslope assigned to a conventional 3° ILS approach procedure.

<u>Phraseology</u>

The phraseology of the instructions given by the ATCO were as follows:

INI:

Expect ILS approach runway 27L
Expect GLS W approach runway 28L
Expect RNP W approach runway 28L

ITM:

Intercept LOC runway 27L (for the ILS 27L)
Intercept final runway 28L (for GLS W approach)
Intercept final runway 28L (for RNAV W approach)
Cleared for ILS approach runway 27L (cleared to descent)
Cleared for GLS W approach runway 28L (cleared to descent)
Cleared for RNAV W approach runway 28L (cleared to descent)

TWR:

Preceding traffic is *XYZ123* on the lower glide, *Wind*, clear to land runway 27L (for ILS approach)

- Preceding traffic is *XYZ123* on the upper glide, *Wind*, Clear to land runway 28L (for GLS W approach)
- Preceding traffic is *XYZ123* on the upper glide, *Wind*, Clear to land runway 28L (for RNAV W approach)

The pilots read back accordingly.

Simulation Operating Environment

In addition to the simulation operating environment described in section 7.1.1.2, the following characteristics were included during the simulation in order to enable IGS-to-SRAP approach procedures.

A second threshold and aiming point were implemented 1100m further from the current 27L threshold and aiming point. This distance was validated in Wave 1 and chosen such that there is no direct overlap between the runway markings corresponding to each of the two thresholds and touchdown zone markers. A specific runway designator, 28L, was also allocated to the second threshold to increase the distinction with the first threshold 27L.

Figure 3 depicts the runway markings design adopted for IGS-to-SRAP to be displayed on tower controller 3D external view.

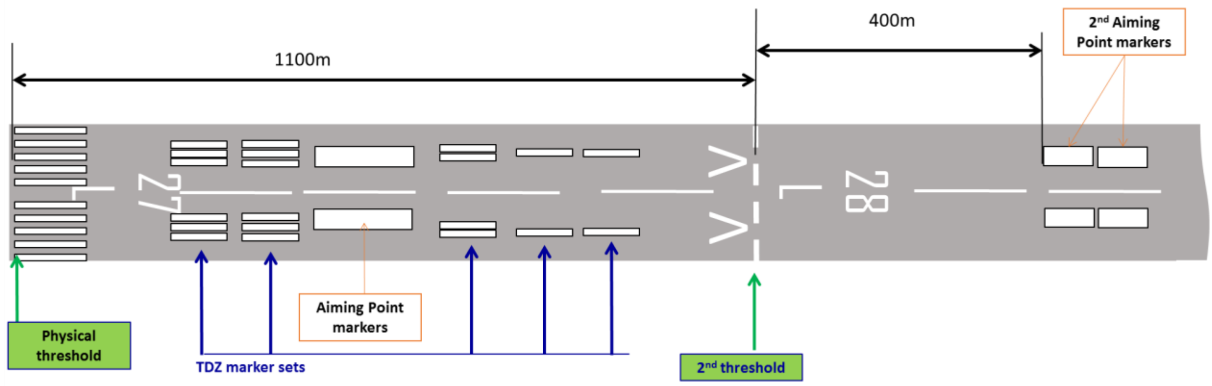

Figure 3: runway 27L markings for IGS-to-SRAP

Figure 4 shows the 27L and 28L runway layout for TWR controller that was used in R01. The green symbols show runway 28L threshold and aiming point. Only the threshold of the first aircraft to land was shown on the TWR controller HMI. The feature allowing the controller to visualise the threshold of any aircraft has been suppressed as considered useless by controllers.

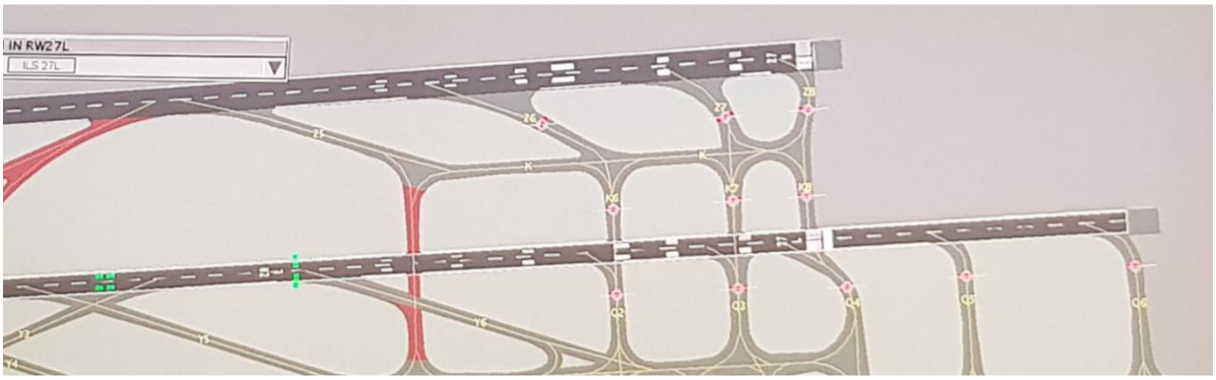

Figure 4: Runway 27L and 28L as shown on TWR CWP for R01

<u>**Wake Separation**</u>

IGS-to-SRAP arrival procedures introduce a new variability in aircraft approach paths where the final approach glide path, which is higher than the conventional ILS. Operations of enhanced arrival procedures will be mixed with conventional traffic (i.e. 3° glide slope); therefore, from any given distance after the runway conventional threshold, an aircraft flying IGS-to-SRAP approach procedures will be above an aircraft flying an ILS procedure. This will have an impact on the risk of wake vortex encounters (WVE). As a result, the following combinations must be specify the wake separation minima:

Leader EAP / follower EAP – separated using DBS RECAT-EU;
Leader ILS / follower EAP – separations decrease;
Leader EAP / follower ILS – separations increase;
Leader ILS / follower ILS – separated using DBS RECAT-EU.

In order to deliver these wake separations, support tools described below, were required to aid the controller, namely the LORD tool.

<u>**Controller Support Functions for IGS-to-SRAP**</u>

The following support functions and tools were identified to be able to operate IGS-to-SRAP approach procedures:

1. **ATC flight information and surveillance function for APP / TWR:** The INI controller decided the appropriate approach for an aircraft by clicking on the flight label and selecting from a list of eligible procedures according to the aircraft's capabilities. An example of the list for a GBAS equipped aircraft for an IGS-to-SRAP procedure is shown below:

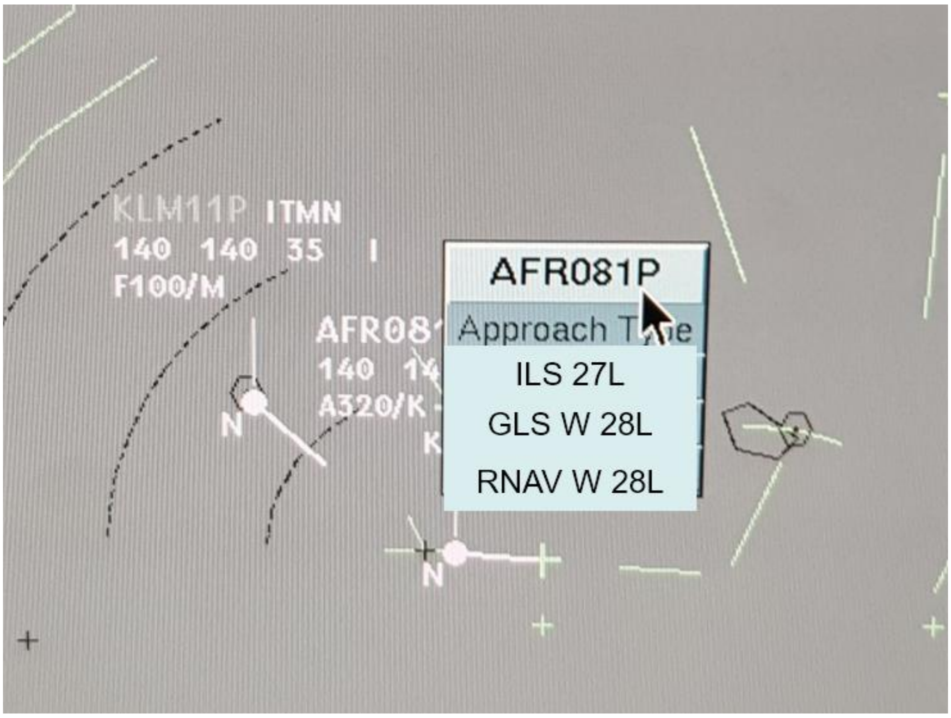

Figure 5: illustration of approach menu displayed in the case the aircraft selected is GBAS capable

Then the ITM either cleared the aircraft based on the INI's selection for either intercept or a direct clearance or the ITM reverted to the ILS procedure.

2. **ATC separation delivery function for APP / TWR:** The "LORD" tool developed by EUROCONTROL was used as ATC Separation delivery to support the IGS-to-SRAP approach procedures. A Separation tool is required as the separation scheme whilst using IGS-to-SRAP is so complex and is especially required in high-density environments. In the LORD tool implemented for the RTS, the separation delivery function was provided by the two Target Distance Indicator (TDIs) which provided an indication of the required separation minima on the final approach for each aircraft pair. The TDI takes into consideration the following operational constraints for each aircraft pair: Wake Turbulence separation (WT), Minimum Radar Separation (MRS) and Runway Occupancy Time (ROT). TDIs consist of a Final Target Distance indicator (FTD) and an Initial Target Distance indicator (ITD).

   The calculated FTD indication represents the required separation minimum (wake turbulence or surveillance) or spacing (runway occupancy time or gap), depending on the most constraining factor to be applied at the point of separation delivery (i.e. the runway threshold).

   The calculated ITD indication represents the additional buffer being necessary above the FTD value, taking into account the speed profile behaviour of both the lead and the follower aircraft type, and the predicted compression from aircraft deceleration to the landing stabilization speed, aiming to deliver the FTD minima at the separation delivery point.

   In the Approach Control positions, the most relevant indicator is the ITD as it displays the recommended spacing such that the separation minimum will not be infringed at the separation delivery point.

   For the tower controller, the relevant separation indication is the FTD as it displays the separation minimum to be delivered at the separation delivery point that shall not be infringed; therefore, the FTD only is constantly displayed on the tower runway CWP HMI. The ITD is still available and can be displayed on selection on a 'need-to-know basis', however, the FTD presents the most constraining separation to the controllers.

A representation of the ITD and FTD indicators in the Separation delivery function - ORD tool, is shown in Figure 6 and Figure 7.

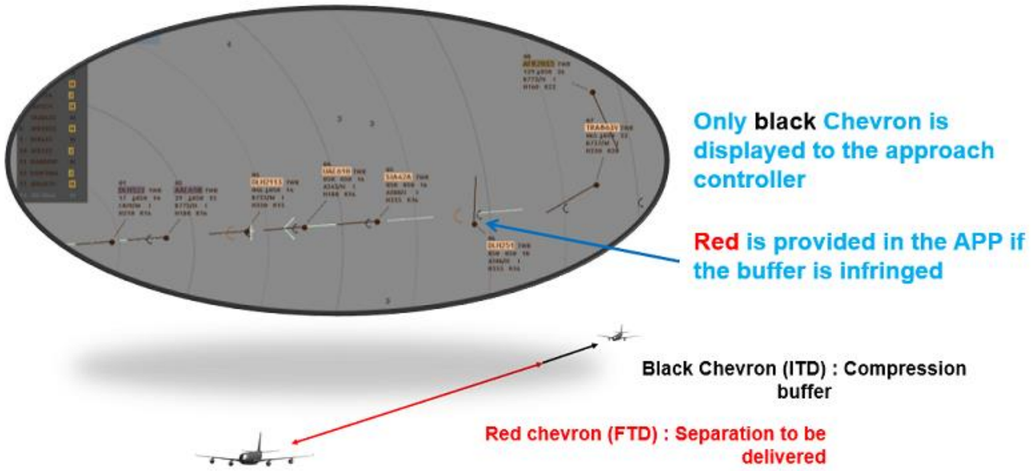

Figure 6: Illustration of red chevron displayed in case of infringement as displayed on the CWP HMI

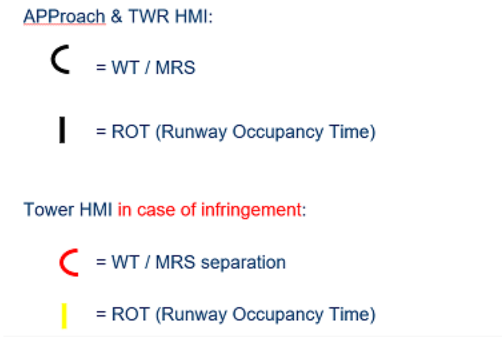

Figure 7: FTD and ITD shape and colours as displayed on the CWP HMI

Several alerts were displayed on the Approach Surveillance Display and on the integrated (air and ground) Tower Working Position Display, depending on the type of infringement or imminent infringement detected.

1. **Automatic FTD** pops-up when the ITD is infringed if the difference between the leader's FTD and ITD is less than 0.3NM and the aircraft is 0.3NM from the leader's ITD.
2. **Catch-up alert** is triggered when the speed difference between the follower and the ITD is greater than 12 knots and if within the following 60 seconds the ITD will be infringed.
3. **Speed alert** is triggered when there is a 20 knot difference between the aircraft speed and the 160 knot reference speed used by the LORD tool within the last 10NM from the threshold.

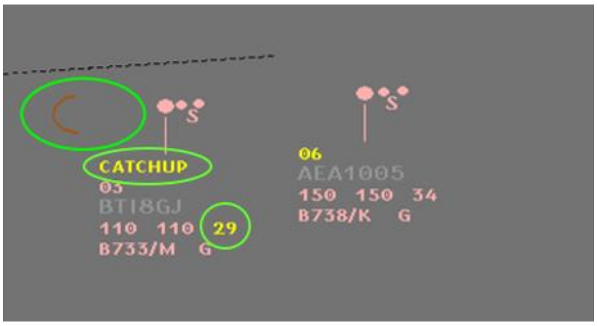

Figure 8: Automatic FTD Pop-up, Catch-Up and Speed Alert displayed on the CWP HMI

3. **ATC trajectory references for APP:** the CWP HMI will provide visual references of the minimum length of the intermediate approach segment as well as the glideslope interception points.

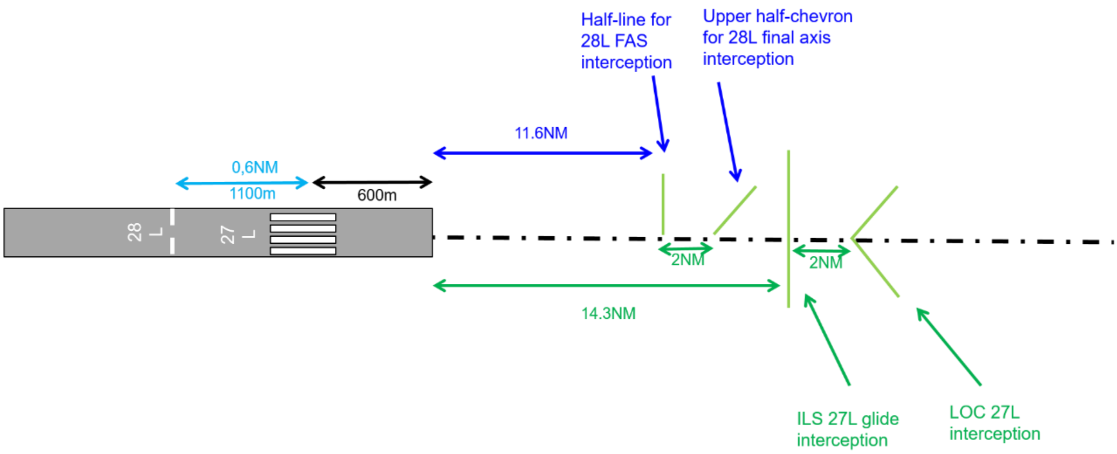

Figure 9: ILS and IGS-to-SRAP interception point display design for R01

4. **ATC trajectory references for TWR:** the CWP HMI will automatically highlight of the aiming point and threshold concerned by the next landing aircraft.

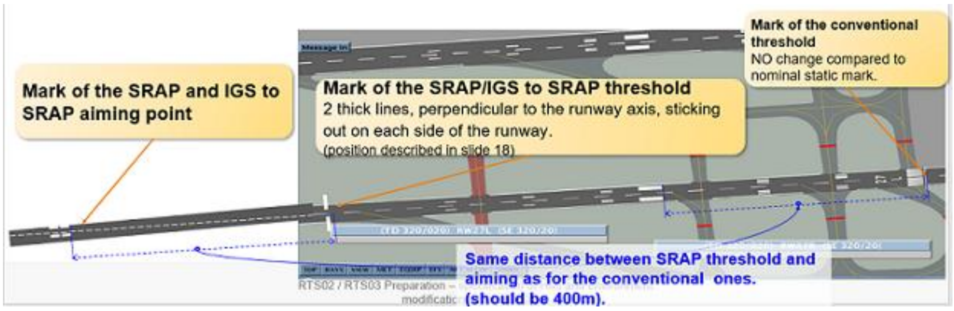

Figure 10: Aiming points on the runway as displayed on CWP HMI

7.1.3.2.2 Non-Nominal Cases

The objective of the simulation was to assess the acceptability of recovering operations during non-nominal situations whilst using IGS-to-SRAP approach procedures and to develop the procedures on how to handle these situations. Therefore, a set of non-nominal cases have been developed by the concept, safety and human performance experts. Four non-nominal cases have been identified:

1. **Go-arounds** by the Leader aircraft (controller instructed) and **Missed Approaches** (pilot initiated) where the Follower aircraft is on the higher glideslope;
    a. When both Leader and Follower aircrafts are managed by the TWR controller;
    b. When the Leader aircraft is managed by the TWR controller and the Follower aircraft is managed by the APP controller.
2. Aircraft intercepts the **wrong glideslope**;
    a. When an aircraft allocated to the lower glideslope intercepts the upper glideslope incorrectly;
    b. When an aircraft allocated to the upper glideslope intercepts the lower glideslope incorrectly;
3. **Separation delivery tool failure (ORD tool failure)**.

The non-nominal situations that will be simulated for the IGS-to-SRAP concept are shown in Figure 11.

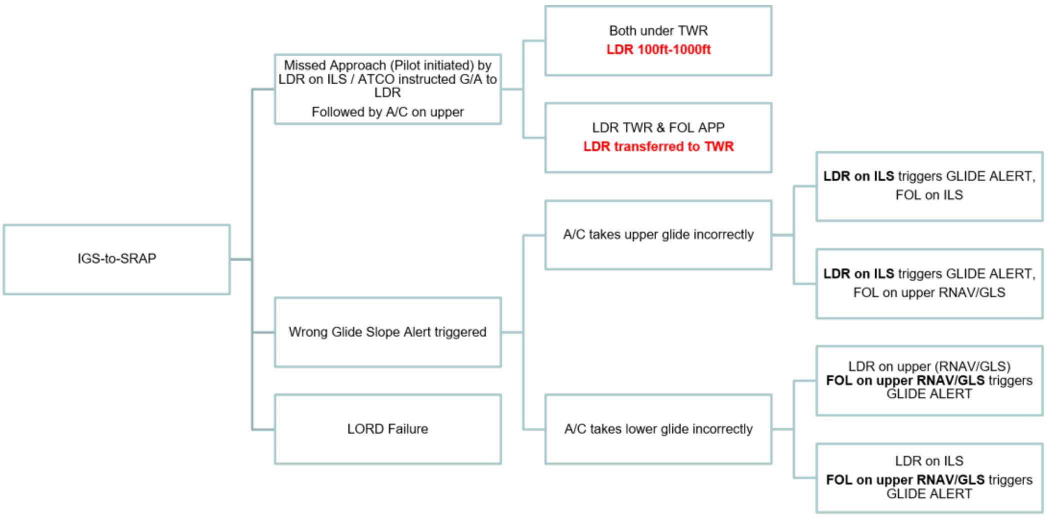

Figure 11: Non-Nominal Cases to be validated

Two workshops were held on 19th November 2020 and 7th May 2021 with Paris CDG controllers to begin the development of the procedures during these particular non-nominal cases. These procedures were then assessed during the simulation and enhanced where required, to end up with the procedures described below.

ATCOs carried out the following procedures in the event of these non-nominal cases during the RTS. The RTS aimed to validate these procedures and to refine them where needed.

7.1.3.2.2.1 Go-Around / Missed Approach Procedure

- *Instruct concerned aircraft to go-around as per procedure;*
- *If the concerned aircraft was performing a Missed Approach / Go-around from the ILS lower glideslope with a follower on upper glide;*
    - *compare separation between the concerned aircraft and the following aircraft against RECAT-EU minima;*
    - *If less than RECAT minima: instruct go-around to the following aircraft with "Turn left/right immediately" instruction" so that the two aircraft are on diverging flightpaths.*

7.1.3.2.2.2 Wrong Glideslope Alert Procedure

An outcome of the Wave 1 assessments formulated the following OSED requirement: “Approach Executive Control shall be alerted when an aircraft is not complying / deviating from the assigned published final approach profile.” Therefore an alert was triggered when an aircraft intercepted the wrong glideslope. The following procedure was carried out by the controller:

“When there is a Glide Alert warning, the controller shall:

- *Ask pilot to “confirm type of approach and landing runway”;*
- *If the concerned aircraft has a RECAT-EU wake turbulence category of CAT A "Super heavy", CAT B "Upper Heavy" or CAT C "Lower Heavy" on upper glide – instruct go-around;*
- *For any other RECAT-EU wake turbulence category:*
    - *update CWP HMI to the approach procedure actually flown (to update the separation delivery tool indicators);*
    - *Check the position of the concerned aircraft, leading aircraft and following aircraft against their indicators;*

1. *If any under separated, instruct go-around to the flight which triggered the glide alert”.*

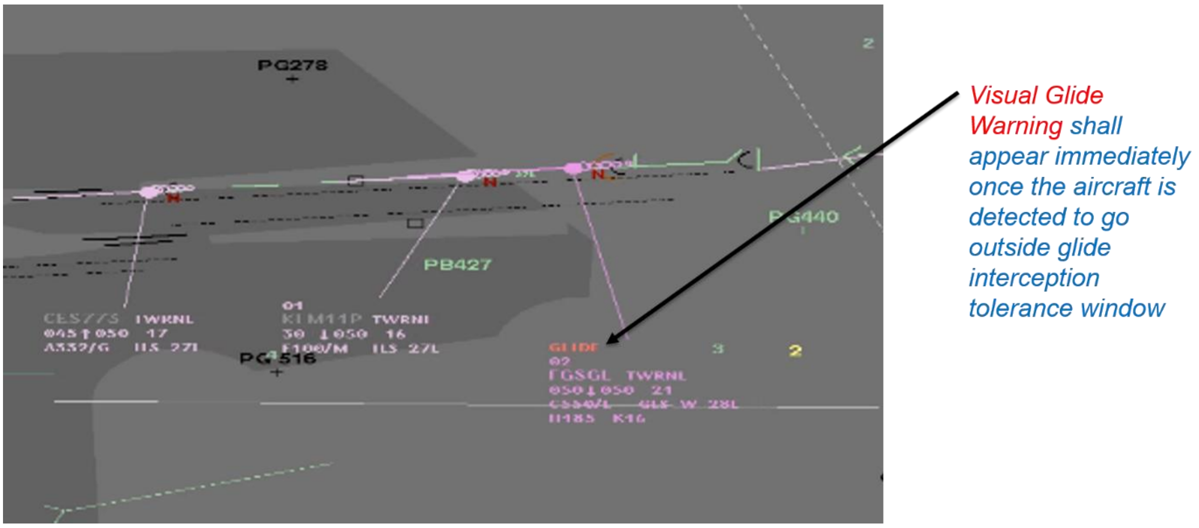

Figure 12: CWP HMI for Wrong Glideslope Alert

The alert was triggered 12.9NM from the runway threshold when an aircraft deviated outside of the glideslope cones as shown in Figure 13 and deactivated 0.5NM from the runway threshold.

The ILS glideslope cone aperture was 0.30 degrees from the 3 degree glideslope and the IGS-to-SRAP glideslope cone aperture was 0.34 degrees from the 3.5 degree glideslope.

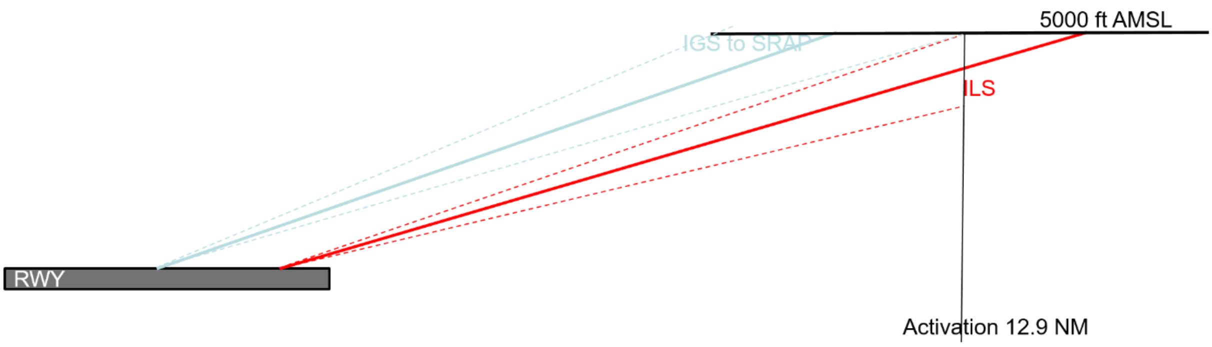

Figure 13: IGS-to-SRAP Wrong Glideslope Alert Cone Activation

7.1.3.2.2.3 ORD Failure Procedure

When there was a failure of the separation delivery tool, the following procedure was used and assessed for IGS-to-SRAP arrival procedures:

- *"For pairs of aircraft for which the ATCO is confident that were ON or BEHIND the ITD and stabilised at 160kts - continue on final;*
- *For non-stabilised pairs (upper-lower, lower-upper or same slope):*
  - *If any S/G/H aircraft on Upper Glide ➔ instruct go-around;*
  - *For* **Upper - lower glide pairs**, *➔ ensure* ***RECAT-EU + 3NM*** *minimum separation (if not possible, instruct go-around to a/c on upper glide);*
  - *For remaining traffic on final (i.e. lower-upper and same slope pairs), ➔ ensure* ***RECAT-EU*** *separation minima (if not possible, instruct go-around to a/c on upper glide);*
- *For all aircraft that have not yet intercepted the glide and localiser:*
  - *Progressively re-assign on conventional glide (ILS) (vectoring as appropriate if necessary).*

7.1.3.3 Experimental Design

During the simulation week, 16 one-hour long runs were planned; however, one run was not possible to conduct due to a technical problem. The simulation platform was not able to load for this lost run due to external factors, which did not affect the platform in any other runs. This run could not be recovered as it took a large amount of time to find the reason for this technical error and there was no possibility to recover the lost time during the week. Therefore, only 15 one-hour long runs were conducted. This is not a concern, as a minimum of 12 runs was required for statistical significance and maximum participant feedback. Each of these 15 runs simulated one of the Enhanced Arrival Procedures: ISGS, SRAP and IGS-SRAP.

In total, 19 non-nominal situations occurred over the 15 runs:

- seven non-nominal situations were planned to occur over six runs. Due to a technical problem, these seven non-nominal situations occurred five IGS-to-SRAP runs;
- five non-nominal situations occurred over four ISGS runs; and
- seven non-nominal situations occurred over six SRAP runs.

It was key not to simulate too many non-nominal situations during the run as not to overwhelm the participants and not to increase the complexity, workload or task load of the controllers. No more than four non-nominal situations per sector occurred during one run for IGS-to-SRAP or SRAP and no more than five non-nominal situations per sector occurred during one run for ISGS.

The four participants rotated over the four positions during the week. The aim of the RTS was to produce and collect rich subjective feedback from the participants on acceptability and the procedures to manage the non-nominal situations. There was no need for comparative analysis, therefore it did not matter which controller simulated each run. Therefore, the controllers rotated after each run to gain as much exposure to each EAP, each position and each non-nominal situation.

The RTS followed a randomised /between subject design where the participants rotated and experienced each scenario on each position. The exercise design and combination of factors and levels during the simulation are shown in Table 9. The crosses which are struck through and highlighted in grey were originally planned but did not take place. The crosses which are highlighted in yellow were not originally planned but took place.

EAP			Scenarios		Positions			
SRAP	IGS	IGS-to-SRAP	ORD failure & Other Events (Glide & G/A)	All other events except ORD Failure (Glide & G/A)	INI	ITM	TWR	COR
	X		X		X			
	X		X			X		
	X		X				X	
	X		X					X
X			X			X		
X			X					X
X			X		X			
X			X	~~X~~		X		
X			X				X	
X				X				X
		X	X		X			
		X	X				X	
		X		X	X			
		X	X			X		
		~~X~~		~~X~~			~~X~~	
		X	X					X

Table 9: RTS Experimental Design

The one run highlighted in yellow was not planned to take place. Originally it was planned to run four runs for SRAP with an ORD failure and two runs without the failure. In the end, we decided to run five with the ORD failure and we added an additional experiment to see how the ATCOs behaved once the ORD tool returned after having failed.

The one IGS-to-SRAP run highlighted in grey and crossed out did not take place as there was an unexpected technical error. The simulation platform was not able to load for this run due to external factors which did not affect the platform in any other runs. This run could not be recovered as it took a large amount of time to find the reason for this technical error and there was no possibility to recover the lost time during the week.

The controller roster designed followed the following principals:

1. Each participant rotated and experienced each CWP each day.
2. Each participant experienced the ISGS approach with an ORD failure scenario at each CWP.

3. Each participant experienced the IGS-to-SRAP all non-nominal situations with an ORD Failure at each CWP.
4. Each participant experienced the SRAP all non-nominal situations with an ORD Failure at each CWP.
5. Where a participant experienced two IGS-to-SRAP runs at the same CWP, one run included an ORD failure scenario with one traffic sample and the second run with be a scenario will all other non-nominal situations (no ORD failure) with the other traffic sample.
6. Where a participant experienced two SRAP runs at the COR position, one run included an ORD failure scenario with one traffic sample and the second run with be a scenario will all other non-nominal situations (no ORD failure) with the other traffic sample.
7. Where a participant experienced two SRAP runs at the ITM position, both runs included an ORD failure scenario with one traffic sample, however, the second run included the return of the ORD tool after the failure.

Figure 14 shows the timetable and controller rotation that was followed during the simulation.

Date	Time approx	Run	EAP	Traffic	Event	INI	ITM	TWR	COR
14-06-2021 DAY 1	08:45:00	Coffee & Set Up Simulator							
	09:00:00	Briefing							
	10:00:00	Training A	SRAP	T1	Glide LORD failure	B	C	D	A
	10:30:00	Coffee & Set Up Simulator							
	10:45:00	Training B	IGS-to-SRAP	T2	Glide G/A LORD failure	A	B	C	D
	11:15:00	Coffee & Set Up Simulator							
	11:15:00	Lunch							
	13:40:00	Training C	SRAP	T2	Glide G/A LORD failure	D	A	B	C
	14:10:00	Coffee & Set Up Simulator							
	14:25:00	Training D	IGS-to-SRAP	T1	Glide G/A LORD failure	C	D	A	B
	14:55:00	PTQ							
	~~13:45:00~~	~~Coffee & Set Up Simulator~~							
	~~15:00:00~~	~~1~~	~~IGS-to-SRAP~~	~~T2~~	~~Glide G/A~~	~~C~~	~~D~~	~~A~~	~~B~~
	~~15:30:00~~	~~PEQ & Debrief~~							
	15:10:00	Coffee & Set Up Simulator							
	15:25:00	2	IGS	T1	Glide LORD failure	A	B	C	D
	16:40:00	PEQ & Debrief							
	17:10:00	End of Day 1							
15-06-2021 DAY 2	08:45:00	Coffee & Set Up Simulator							
	09:00:00	3	SRAP	T2	Glide G/A LORD failure	C	D	A	B
	10:15:00	PEQ & Debrief							
	10:45:00	Coffee & Set Up Simulator							
	11:00:00	4	IGS-to-SRAP	T1	Glide LORD failure	A	B	C	D
	12:15:00	PEQ & Debrief							
	12:45:00	Lunch							
	13:30:00	Coffee & Set Up Simulator							
	13:45:00	5	IGS	T1	Glide LORD failure	D	A	B	C
	15:00:00	PEQ & Debrief							
	15:30:00	Coffee & Set Up Simulator							
	15:20:00	6	SRAP	T2	Glide G/A	B	C	D	A
	16:35:00	PEQ & Debrief							
	17:05:00	End of Day 2							
16-06-2021 DAY 3	08:45:00	Coffee & Set Up Simulator							
	09:00:00	7	IGS	T2	Glide LORD failure	C	D	A	B
	10:15:00	PEQ & Debrief							
	10:45:00	Coffee & Set Up Simulator							
	11:10:00	8	SRAP	T1	Glide G/A LORD failure	B	C	D	A
	12:15:00	PEQ & Debrief							
	12:45:00	Lunch							
	13:30:00	Coffee & Set Up Simulator							
	13:45:00	9	IGS-to-SRAP	T2	Glide G/A	A	B	C	D
	15:00:00	PEQ & Debrief							
	15:30:00	Coffee & Set Up Simulator							
	15:40:00	10	SRAP	T1	Glide G/A LORD failure	D	A	B	C
	16:55:00	PEQ & Debrief							
	17:30:00	End of Day 3							
17-06-2021 DAY 4	08:45:00	Coffee & Set Up Simulator							
	09:20:00	11	IGS-to-SRAP	T1	Glide G/A LORD failure	D	A	B	C
	10:15:00	PEQ & Debrief							
	10:45:00	Coffee & Set Up Simulator							
	11:00:00	12	IGS	T2	Glide LORD failure	B	C	D	A
	12:15:00	PEQ & Debrief							
	12:45:00	Lunch							
	13:30:00	Coffee & Set Up Simulator							
	13:30:00	13	SRAP	T2	Glide G/A LORD failure	A	B	C	D
	14:30:00	PEQ & Debrief							
	15:00:00	Coffee & Set Up Simulator							
	15:15:00	14	IGS-to-SRAP	T1	Glide G/A LORD failure	C	D	A	B
	16:30:00	PEQ & Debrief							
	17:00:00	End of Day 4							
18-06-2021 DAY 5	08:45:00	Coffee & Set Up Simulator							
	09:00:00	15	IGS-to-SRAP	T1	Glide G/A LORD failure	B	C	D	A
	10:15:00	PEQ & Debrief							
	10:45:00	Coffee & Set Up Simulator							
	11:00:00	16	SRAP	T2	Glide G/A	D	A	B	C
	12:15:00	PEQ & Debrief							
	12:45:00	Lunch							
	13:45:00	PSQ							
	14:45:00	Coffee							
	15:00:00	Final Debrief							
	17:00:00	AOB							
	17:30:00	End of Day 5							

Figure 14: Timetable and Controller Rotation for Simulation R01

7.1.4 Summary of Validation Exercise #01 Validation Assumptions

Identifier	Title	Description	Justification	Impact on Assessment
R01-ASS-01	Aircraft equipage capabilities	92% of the aircraft in the traffic sample are able to fly IGS-to-SRAP enabled by a specified system: RNAV or GBAS. 56% are planned for an RNAV or GBAS approach.	To be in line with the forecast for 2030	HIGH

Identifier	Title	Description	Justification	Impact on Assessment
R01-ASS-02	Separation standards and responsibilities	The minimum radar separation and runway related spacing constraints have to be respected if the ORD tool is not available.	For realistic simulation environment	HIGH
R01-ASS-03	No wind conditions	There will be no wind conditions simulated	This will not influence the results as the ORD tool considers the wind in the separation that it provides and the controllers will follow the chevrons provided by the ORD tool.	N/A
R01-ASS-04	Traffic Sample	Observed traffic figures have been augmented to represent traffic in 2030.	This is required to understand the feasibility of the concepts during the expected implementation time.	HIGH
R01-ASS-05	Runway Occupancy Times (ROT)	The same runway occupancy times are used for both runway thresholds.	This will not influence the results as the ORD tool considers the ROT in the separation that it provides and the controllers will follow the chevrons provided by the ORD tool.	N/A
R01-ASS-06	Go-Arounds and Missed Approaches	Aircraft performing a go-around or a missed approach are not re-introduced into the sequence, but are "killed".	The purpose of the simulation is to assess how the missed approach or go-around is managed at the moment that they occur. Once managed, the controller returned to nominal situation.	LOW
R01-ASS-07	No crossing Traffic	The simulation only includes North arrivals. No departures or traffic from other surrounding airports.	The simulation environment is supposed to be generic for all airports. This is also required to understand the feasibility of the concepts during the expected implementation time.	LOW
R01-ASS-08	Aircraft General Characteristics	All aircraft have the same nominal characteristics.	For a realistic simulation environment	HIGH
R01-ASS-09	Airspace Organisation	European airspace will be based on current ICAO	For a realistic simulation environment	HIGH

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Identifier	Title	Description	Justification	Impact on Assessment
		ATS classifications, regulations and applicable rules, including VFR and IFR.		
R01-ASS-10	Actor Compliance	General Compliance by all actors with existing standards and guidelines.	For a realistic simulation environment	HIGH
R01-ASS-11	Standards	Airport standards and responsibilities are unchanged.	For a realistic simulation environment	HIGH
R01-ASS-12	Training	All staff have appropriate training and competencies. Even though the traffic level at Paris CDG has decreased significantly due to the COVID-19 pandemic, it is assumed that controllers are still able to manage the level of traffic.	For a realistic simulation environment	HIGH

Table 10: R01 Validation Assumptions overview

7.2 Deviation from the planned activities

Only one deviation has been identified. During the simulation, there was a technical problem on the first day. This resulted in a delay and finally, it was not possible to conduct the first, planned, measured run. This decision was chosen in order to ensure that the participants had enough training prior to the measured runs. In the plan, 12 runs were important and required to be conducted. The remaining four runs allowed buffer in the timetable and spare runs if necessary. Therefore, the training runs were prioritised and one of these remaining runs was sacrificed.

7.3 Validation Exercise EXE-14.5-V3-VALP-R01 Results

7.3.1 Summary of Validation Exercise #01 Results

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
R01-OBJ-14.5-V3-VALP-0101	To assess the usability and acceptability of the ATC HMI for IGS-to-SRAP arrival procedures during non-nominal situations	R01-CRT-14.5-V3-VALP-0101-001	The usability of the HMI is rated as being acceptable during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that it is possible to use the HMI however; the HMI is lacking certain information to be able to react to certain non-nominal. The participants suggested that a tool to visualise the vertical position of the aircraft on the glide would be helpful such as Vertical Speed information or Approach Path Monitoring. This will be particularly useful to aid the non-nominal situations where an aircraft intercepts the wrong glide triggering an alert and where a pilot initiated a missed approach. During the separation delivery tool failure, an alert/status indicator should appear on the ATCOs' HMI. It should also be noted that the display of the multiple interception points should be clear and distinguishable.	OK
		R01-CRT-14.5-V3-VALP-0101-002	The HMI is rated as being useful during non-nominal situations	Approach Tower High-Traffic Levels	Results from the simulation show that it is possible to use the HMI however; the HMI is lacking certain information to be able to	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
				Arrivals only	react to certain non-nominal. The participants suggested that a tool to visualise the vertical position of the aircraft on the glide would be helpful such as Vertical Speed information or Approach Path Monitoring. This will be particularly useful to aid the non-nominal situations where an aircraft intercepts the wrong glide triggering an alert and where a pilot initiated a missed approach. During the separation delivery tool failure, an alert/status indicator should appear on the ATCOs' HMI. It should also be noted that the display of the multiple interception points should be clear and distinguishable.	
		R01-CRT-14.5-V3-VALP-0101-003	The proposed HMI supports the application of the IGS-to-SRAP procedure during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that it is possible to use the HMI however; the HMI is lacking certain information to be able to react to certain non-nominal. The participants suggested that a tool to visualise the vertical position of the aircraft on the glide would be helpful such as Vertical Speed information or Approach Path Monitoring. This will be particularly	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
					useful to aid the non-nominal situations where an aircraft intercepts the wrong glide triggering an alert and where a pilot initiated a missed approach. During the separation delivery tool failure, an alert/status indicator should appear on the ATCOs' HMI. It should also be noted that the display of the multiple interception points should be clear and distinguishable.	
R01-OBJ-14.5-V3-VALP-0102a	To assess the usability and acceptability of the ATC separation delivery support tool for IGS-to-SRAP arrival procedures during non-nominal situations	R01-CRT-14.5-V3-VALP-0102a-001	The usability of the separation delivery support tool is rated as being acceptable during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that the separation delivery tool is acceptable according to the ATCO subjective feedback.	OK
		R01-CRT-14.5-V3-VALP-0102a-002	The separation delivery support tool is rated as being useful during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that the separation delivery tool is useful according to the participants' subjective feedback. It was concluded that IGS-to-SRAP arrival procedures would not be possible without the separation delivery tool. It is strongly recommended that the wake/MRS	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
					indicator be always shown, even when the ROT is the most constraining. This is because ROT is desirable but not a safety issue, whereas wake is a safety critical issue.	
		R01-CRT-14.5-V3-VALP-0102a-003	The separation delivery support tool supports the application of the IGS-to-SRAP operational procedure during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that the separation delivery tool is useful according to the participants' subjective feedback. It was concluded that IGS-to-SRAP arrival procedures would not be possible without the separation delivery tool. It is strongly recommended that the wake/MRS indicator be always shown, even when the ROT is the most constraining. This is because ROT is desirable but not a safety issue, whereas wake is a safety critical issue.	OK
		R01-CRT-14.5-V3-VALP-0102a-04	The ATCOs trust the separation delivery support tool that facilities the application of IGS-to-SRAP during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that the separation delivery tool is trusted according to the participants' subjective feedback.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
R01-OBJ-14.5-V3-VALP-0102b	To assess the usability and acceptability of the wrong glideslope alert support tool for IGS-to-SRAP arrival procedures	R01-CRT-14.5-V3-VALP-0102b-01	The usability of the wrong glideslope alert support tool is rated as being acceptable	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that the alert when an aircraft intercepts the wrong glideslope is acceptable according to the ATCO subjective feedback. This is if the requirement for the alert that the alert must be reliable and there must not be any false alerts is met.	OK
		R01-CRT-14.5-V3-VALP-0102b-02	The wrong glideslope alert support tool is rated as being useful	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that the alert when an aircraft intercepts the wrong glideslope is useful according to the participants' subjective feedback.	OK
		R01-CRT-14.5-V3-VALP-0102b-03	The wrong glideslope alert support tool supports the application of the IGS-to-SRAP operational procedure	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that the alert when an aircraft intercepts the wrong glideslope supports IGS-to-SRAP arrival procedures during non-nominal situations according to the participants' subjective feedback.	OK
		R01-CRT-14.5-V3-VALP-0102b-04	The ATCOs trust the wrong glideslope alert support tool that facilities the application of IGS-to-SRAP	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that participants trusted that the glide alert would appear for all aircraft that intercepted the wrong glideslope. However, they found the prototype alert used during the simulation was unreliable as it was too sensitive and produced extra alerts that were false according to subjective feedback.	Partially OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
					A requirement for the alert has been formulated as the conclusion of the simulation that the alert must be reliable and there must not be any false alerts.	
R01-OBJ-14.5-V3-VALP-0103	To assess the safety performance of IGS-to-SRAP arrival procedures during non-nominal situations from an ATC perspective	R01-CRT-14.5-V3-VALP-0103-001	The level of operational safety is acceptable for IGS-to-SRAP during non-nominal situations from an ATC perspective	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that participants found the procedures to be able to resolve the situation safely and in a timely manner. Safety requirements have been derived.	OK
R01-OBJ-14.5-V3-VALP-0104 …	To assess the operational feasibility of IGS-to-SRAP arrival procedures during non-nominal situations from an ATC perspective	R01-CRT-14.5-V3-VALP-0104-001	The IGS-to-SRAP procedure is judged as operationally feasible from controllers during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that the IGS-to-SRAP arrival procedures are feasible during non-nominal situations according to subjective feedback.	OK
		R01-CRT-14.5-V3-VALP-0104-002	The Controller Workload is tolerable for IGS-to-SRAP procedures during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that controller workload is tolerable for IGS-to-SRAP arrival procedures during non-nominal situations according to subjective feedback and sector performance metrics. Some concerns were expressed about overloaded ITM sectors, as IGS-to-SRAP procedures seem to have more aircraft on the final axis due to the	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
					reduction in separation. This should be investigated locally.	
		R01-CRT-14.5-V3-VALP-0104-003	The Controller Situational Awareness is acceptable for IGS-to-SRAP arrival procedures during non-nominal situations	Approach Tower High-Traffic Levels Arrivals only	Results from the simulation show that controller workload is tolerable for IGS-to-SRAP arrival procedures during non-nominal situations according to subjective feedback and sector performance metrics. Some concerns were expressed about overloaded ITM sectors, as IGS-to-SRAP procedures seem to have more aircraft on the final axis due to the reduction in separation. This should be investigated locally.	OK
		R01-CRT-14.5-V3-VALP-0104-004	Procedures to manage the non-nominal situations are further refined if required	Approach Tower High-Traffic Levels Arrivals only	The simulation lead to the development of particular requirements for each non-nominal situation during IGS-to-SRAP arrival procedures.	OK

Table 11: Validation Results for Exercise R01

7.3.2 Analysis of Exercise R01 Results per Validation objective

During the simulation, three sectors were analysed by four CDG ATCOs over five exercises. This allowed each participant to experience non-nominal situations for IGS-to-SRAP arrival procedures on each sector position. Data was collected from system data logs, ISA ratings by participants provided every two minutes during the exercise, Post-Exercise Questionnaires (PEQ) completed by participants at the end of each exercise, Post-Simulation Questionnaires (PSQ) completed by participants at the end of the simulation and debriefs after each exercise and at the end of the simulation. The following section presents the results of the simulation per validation objective.

In addition to results linked to the purpose of the exercise that was to assess the management of non-nominal situations when IGS-to-SRAP was active, a number of comments from the controllers concern the ORD tool, and are not necessarily linked to non-nominal situations. These comments are gathered in section 7.3.2.5.

Some comments about phraseology that was not an objective of R01 from ATCO side, can be as well found in the same section.

7.3.2.1 R01-OBJ-14.5-V3-VALP-0101 Results

HMI usability was assessed using completely subjective data comprised of agreement scales, dichotomous scales, open responses from the PSQ, and debriefs.

Figure 15 presents the HMI usability assessment from the participants' responses to the PSQ.

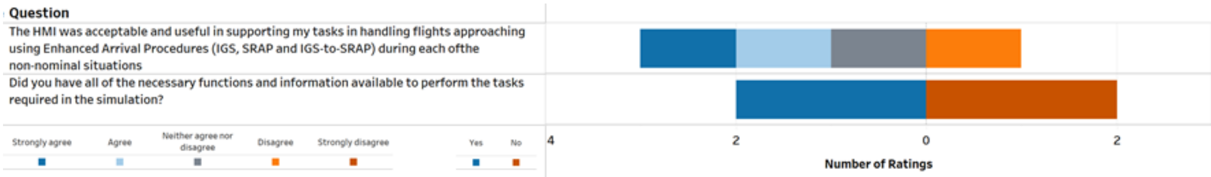

Figure 15: Subjective Feedback from Post-Simulation Questionnaire on HMI usability

Overall, the HMI was found to be useful and acceptable in supporting the tasks related to IGS-to-SRAP approach procedures during non-nominal situations. One participant disagreed with this statement; however, the explanation from their comments and debriefs pointed out that this was due to unfamiliarity with the display of the Tower HMI and electronic labels.

The participants suggested that additional information about the aircraft's vertical speed, which was not available during the simulation, would be useful for the purpose of non-nominal situations during IGS-to-SRAP approach procedures. In particular for pilot initiated missed approaches and an aircraft flying on the wrong glideslope. Vertical speed information will allow controllers to notice vertical deviations sooner and allow them to react quicker. Equally, the participants stated that it would be desirable to have a tool that immediately alerts ATCOs when there is an aircraft performing a missed approach.

For the separation delivery tool failure, the participants stated that an alert / status indicator would be desirable on the TWR and APP HMIs.

7.3.2.2 R01-OBJ-14.5-V3-VALP-0102a Results

The separation delivery tool usability and acceptability for IGS-to-SRAP arrival procedures during non-nominal situations was assessed using completely subjective data comprised of agreement scales, SATI trust assessment from the SHAPE questionnaires and open responses from the Post-Exercise Questionnaire (PEQ), PSQ and debriefs.

Figure 16 and Figure 17 present the separation delivery tool usability assessment from the participants' responses to the PEQ and PSQ respectively. During the simulation, EUROCONTROL's LORD separation delivery tool was used and assessed, therefore the questions have been directed for the LORD tool. This tool has been assessed with IGS-to-SRAP procedures and developed in the previous simulation EXE-02.02-V3-VALP-R03 for SESAR Wave 1 PJ02-02 RTS from Wave 1, which took place in December 2018 [38].

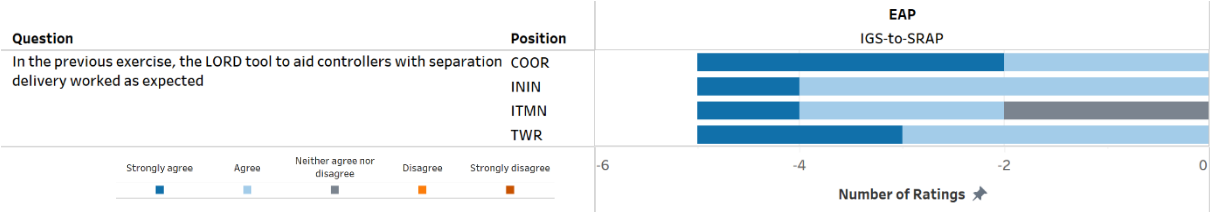

Figure 16: Subjective Feedback from Post-Exercise Questionnaires on ORD tool usability

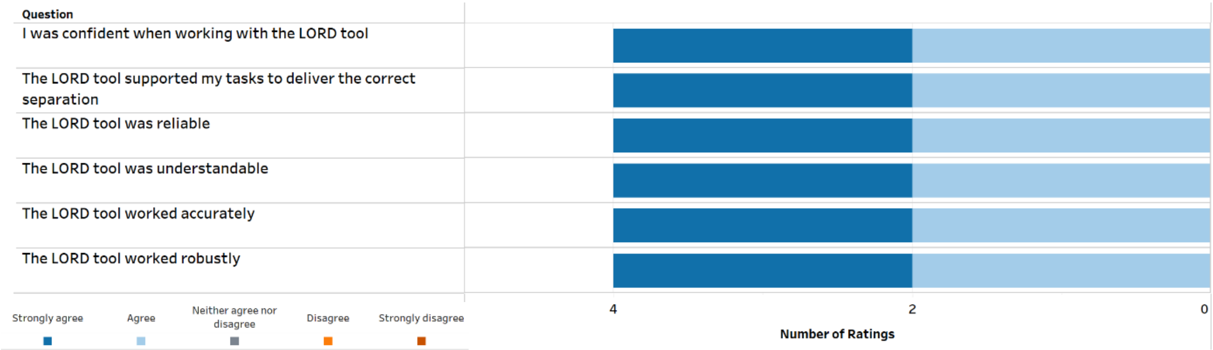

Figure 17: Subjective Feedback from Post-Simulation Questionnaires on ORD tool usability

The participants agreed with all of the statements that the separation delivery tool was useful, acceptable, trusted and that it supports the IGS-to-SRAP approach procedures during non-nominal situations. The participants concluded that IGS-to-SRAP arrival procedures would not be possible without the separation delivery tool.

7.3.2.3 R01-OBJ-14.5-V3-VALP-0102b Results

The wrong glideslope alert usability and acceptability for IGS-to-SRAP arrival procedures during non-nominal situations was assessed using completely subjective data comprised of agreement scales, SATI trust assessment from the SHAPE questionnaires and open responses from the PEQ, PSQ and debriefs.

Figure 18 and Figure 19 present the wrong glideslope alert usability assessment from the participants' responses to the PEQ and PSQ respectively. A first prototype wrong glideslope alert tool was developed, used and assessed during this simulation as an outcome from Wave 1.

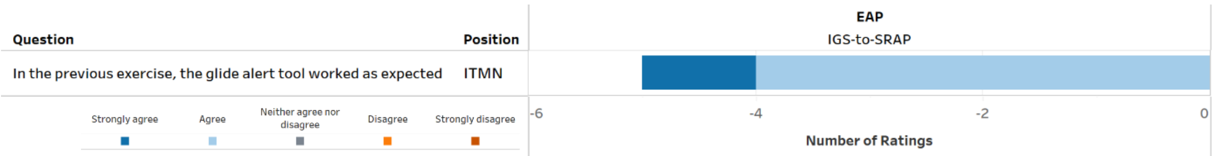

Figure 18: Subjective Feedback from Post-Exercise Questionnaires on Wrong Glideslope Alert usability

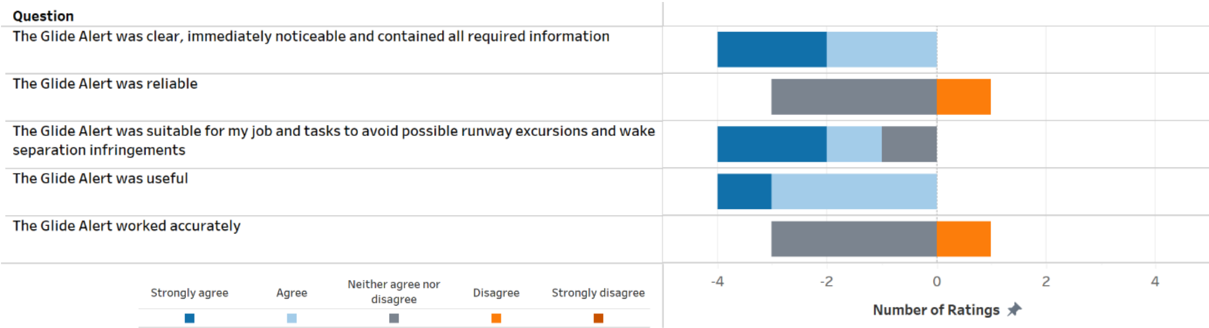

Figure 19: Subjective Feedback from Post-Simulation Questionnaire on Wrong Glideslope Alert usability

Overall, the participants agreed that the wrong glideslope alert is useful, necessary and suitable for IGS-to-SRAP approach procedures. The participants also agreed that the design of the glide alert was clear, immediately noticeable and contained all the required information.

During the simulation, the prototype wrong glideslope alert was too sensitive, in that the alert would appear when an aircraft was slightly higher than the glide even though it had intercepted the correct glideslope, which should not have resulted in an alert. The purpose of the alert is to warn ATCOs when an aircraft has intercepted the wrong glideslope. Therefore, during the simulation many "false" alerts appeared on the HMI, which increased the task load, workload and communication load of the participants. Hence, a participant disagreed with the statements that the alert was reliable and worked accurately. This will not be acceptable during real operations as it increases the workload and communication load of the ATCO. A requirement is needed stating that the wrong glideslope alert must be sufficiently reliable.

7.3.2.4 R01-OBJ-14.5-V3-VALP-013 and R01-OBJ-14.5-V3-VALP-0104 Results

This section combines the Safety, Human Performance (HP) and Operational Feasibility assessment as the HP arguments (2 and 3) covered in the safety assessment. This section is rich in data, therefore will be divided into four sections:

- Human Performance focusing on the overall workload, situational awareness, teamwork, phraseology and transition.
- Safety assessment of each non-nominal procedure.
- Operational Feasibility of each non-nominal procedure.

7.3.2.4.1 Human Performance

This section presents the human performance results for IGS-to-SRAP arrival procedures during non-nominal situations. The data collected is both objective and subjective data. The objective data is collected from the system data recordings providing information about ATCO task load and factors that affect the ATCO performance. The majority of the data collected is subjective data comprised of Bedford workload ratings, ISA ratings, agreement scales, frequency scales, 5- point and 7-point scales and open responses collected from the Post-Exercise Questionnaire (PEQ), PSQ and debriefs. The human performance assessment will be divided into 4 sections: Workload, Situational Awareness, Teamwork, Phraseology and Transition.

7.3.2.4.1.1 Workload

This section presents the workload analysis of each sector including the results related to:

- sector performance, which includes a dashboard made up of four parts:

  - Instantaneous self-assessment (top left), which reports the sum of ISA ratings. ISA results are graphed by using diverging stack bars. Specifically, each bar depicts a total number of 142 ratings for the initial approach sector (INI), 139 ratings for the final approach sector (ITM) and 114 ratings for the tower sector (TWR) over the six exercises;
  - Sector load (top right), which reports the average number of aircraft on frequency per exercise;
  - Radio transmissions (bottom left), which reports the average number of radio calls (received and sent) per exercise;
  - Pilot instructions (bottom right), which reports the average total number of pilot instructions, broken down by category per exercise.
- further investigation into the sector performance including two dashboards:
  - one that the relationship between ISA workload ratings and the non-nominal situations;
  - the second that explore the relationship between ISA workload ratings and the traffic load.
- subjective feedback, which includes a dashboard including assessments from the PEQ and PSQ, as well as the outcome of the debrief discussions:
  - bespoke questions about the workload related to managing the non-nominal situations where participants were asked to rate their agreement with the statements;
  - Bedford workload rating scale which was included in the PEQ after each exercise where participants rate their workload on a global 10-point scale;
  - workload drivers, related to radio transmissions (R/T), coordination, monitoring, planning and conflict detection.

7.3.2.4.1.1.1 Sector Performance

Figure 20 presents a dashboard with the sector performance indicators for each sector over the six exercises with non-nominal situations for IGS-to-SRAP arrival procedures.

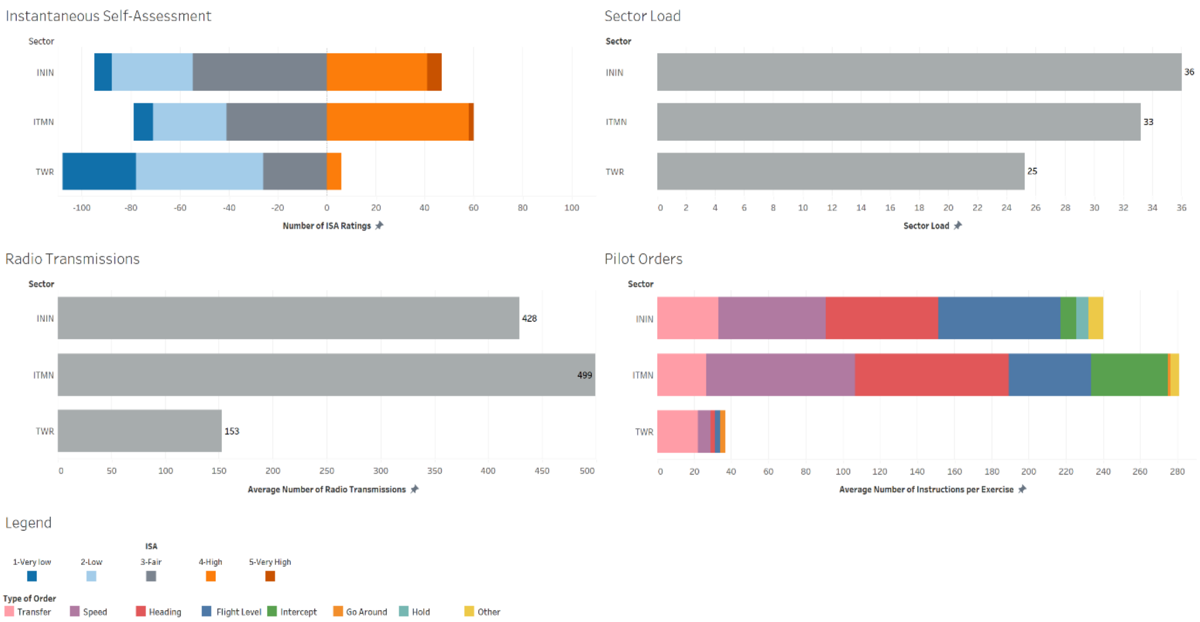

Figure 20: Sector Performance (ISA ratings, Sector Load, R/T Load and Instructions given to Pilots)

For all three sectors, the majority of the ISA ratings remain within acceptable limits (ISA rating of 3 or lower): 67% of ratings were acceptable for INI with an overall average of 3.0; 57% were acceptable for

ITM with an overall average of 3.1; and 95% were acceptable for TWR with an overall average of 2.1. Although, 33% of the time, the participants at the INI sector rated their workload as high or very high and 43% of the time, the participants at the ITM sector rated their workload high or very high, this is frequent and may not be tolerable.

This pattern of ISA ratings can be explained when looking at the three other sector performance metrics. TWR has much fewer aircraft, radio transmissions and pilot instructions. The radio transmissions and pilot orders metrics show that the ITM ATCO performs the most communication even though it had less traffic than the INI sector. Therefore, the ITM sector has the highest workload of the three sectors.

Figure 111 found in Appendix A shows further exploration into the ISA ratings per each exercise (exercise name at the top of each graph). Each graph shows the ISA rating provided by the participant for that two-minute interval and the number of non-nominal events that occurred within that two-minute interval.

There is clear evidence in Figure 111 to support that the workload remains tolerable for IGS-to-SRAP arrival procedures with non-nominal situations for the TWR sector, as also confirmed by participant feedback. The separation delivery tool failure appears to slightly increase the workload of the controllers as expected during a non-nominal situation; however, the workload remains tolerable.

For the INI sector, it is evident that the ratings vary depending on the participant providing these ratings; two of the participants provided mostly ISA ratings with the acceptable limits (rating of 3 or below), whereas the two ATCOs (where one sat on the same position twice) provided mostly unacceptable levels of workload. However, as the INI sector is only concerned by the separation delivery tool failure, it suggests that there could be another cause for the workload increase such as the traffic sample as explained below.

Feedback from the participants during debriefs suggested that the traffic sample largely affected their workload as the traffic levels were very high; in particular as the controllers have not had much recent experience with peak traffic loads due to the COVID-19 pandemic which reduced traffic significantly. Another factor that increased the workload particularly at the INI sector was the lack of certain actors during the simulation which led INI to open holding patterns; for CDG specific operations, the ATCOs do not often open holding patterns and rather reduce the speeds of aircraft much earlier by contacting the ACC sectors. There were also a few technical issues during certain exercises that increased the workload at times (further details can be found in section 7.3.4). Additional findings can be found in section 7.3.2.4.1.1.2.

For the ITM sector, it is evident that the ratings vary on the ATCO providing these ratings: three of the participants provided mostly ISA ratings with the acceptable limits (rating of 3 or below), whereas one participant (that sat on the same position twice) provided mostly unacceptable levels of workload most of the time. Investigating the relationship between the non-nominal situations and ISA ratings at the ITM sector, the separation delivery tool failure shows that it increases workload. The other non-nominal cases (go-around and wrong glideslope alert) do not show an influence on workload. The participants also stated that the IGS-to-SRAP arrival procedures seem to increase the number of aircraft on the final axis, which could lead to a risk overload in the ITM sector. In addition, like for the INI position, the traffic sample with very high traffic loads impacted the workload; in particular as the controllers have not had much recent experience with peak traffic loads due to the COVID-19 pandemic which reduced traffic significantly. The workload was always high and only some participants noted that the non-nominal situations caused a spike in workload, therefore, it was mostly caused by the traffic sample.

Overall, when the non-nominal situations occur, the participants reported that this always interrupts their thought process, which can lead to postponing messages and planning. Nevertheless, during the simulation, whilst these non-nominal situations caused an unexpected extra task, the participants found the workload to be manageable. The participants commented that the failure of the separation delivery tool noticeably increased their workload when returning to current operations with RECAT-EU separations. Whereas, the wrong glideslope alert and the go-arounds do not have much effect on workload according to the participants.

Following the feedback from the participants about the traffic load, Figure 21 shows a dashboard exploring the relationship between the average ISA rating and the average number of aircraft on frequency per two-minute interval over the duration of the exercises for each sector.

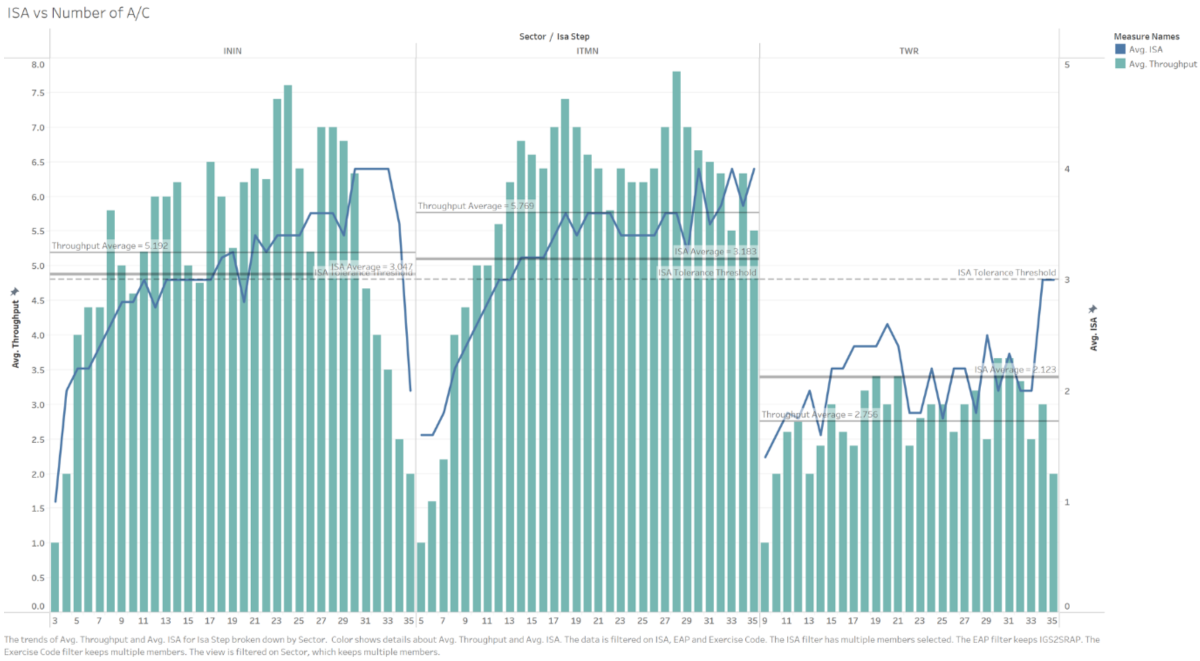

Figure 21: Overall Trend for the average number of aircraft on frequency and average ISA ratings per each two-minute interval during the five IGS-to-SRAP exercises

There is a clear trend that a higher number of aircraft on frequency causes a higher ISA rating confirming the participants' feedback. Additional findings can be found in section 7.3.2.4.1.1.2.

To conclude, the traffic sample is most likely the cause of the large percentage of high ISA workload ratings during the exercise as well as other simulation and external factors. The separation delivery tool failure increases the workload slightly; however, the workload remains the same for the wrong glideslope alert and the multiple go-arounds.

7.3.2.4.1.1.2 Subjective Feedback

Participants were asked to provide feedback at the end of each exercise using the PEQ and at the end of the RTS using the PSQ assessing their workload across all runs. The Bedford Rating Scale was used in conjunction with tailored questions and statements, that have allowed the ATCOs to rate workload in different ways.

Figure 22 shows the participant's assessment of the task load during each exercise.

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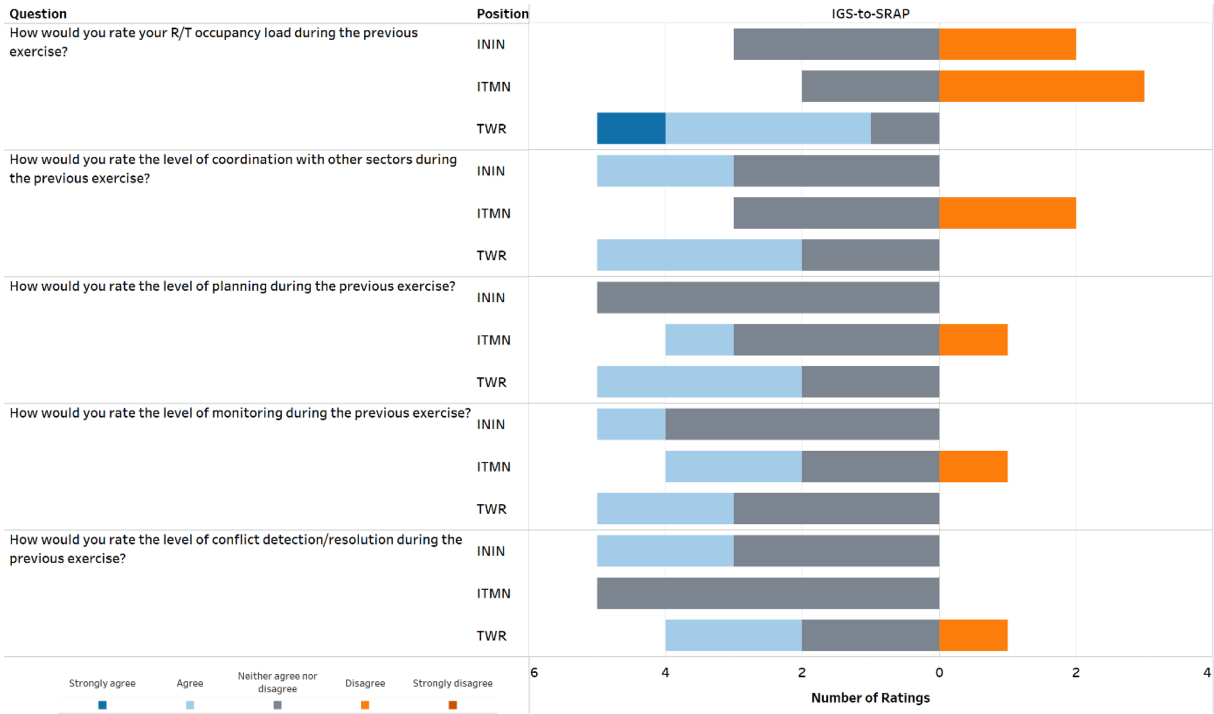

Figure 22: Subjective Feedback from Post-Exercise Questionnaire on Workload

The task load questions gained mostly positive ratings although received a few negative responses indicating high task load during some exercises. For the TWR position, the high level rating of conflict detection was due to an error in understanding the rating scale according to the comment provided which was positive: “traffic load was low enough to be available for extra tasks such as anticipating conflicts”.

For the radio transmission load, both the INI and ITM sector show high levels of communication due to high levels of traffic, opening of holding patterns, falling behind traffic after an unexpected event and a technical error, according to the participants’ comments. The level of coordination was rated high twice for the ITM sector due to the coordination with the INI sector to adjust the sequences and with the TWR sector during non-nominal events. The level of planning was rated high once for the ITM sector due to having to readjust the sequence based on their previous actions. The level of monitoring was rated high once for the ITM sector due to having to manage the speeds more often than usual. These mostly do not show concern related to the non-nominal procedures as these explanations are related to simulation limitations such as the high traffic loads, having to open holding patterns, as there was no ACC actor and also missing a sequencer and a full assistant. However, it should be noted that it something goes wrong with high traffic levels, the ATCO can fall behind traffic; in particular for IGS-to-SRAP, which reduces spacing.

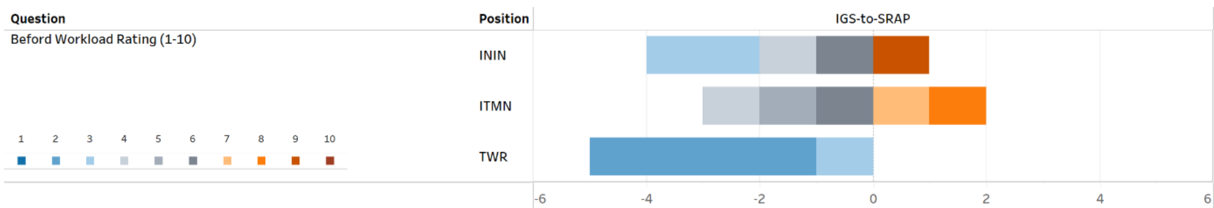

Figure 23: Bedford Workload Rating Feedback from Post-Exercise Questionnaire

Bedford workload ratings after each exercise showed in Figure 28 that for the TWR sector, the workload remained within the acceptable limits always (a rating lower than 7). For the INI sector, the workload remained acceptable with the exception of one run where the participant commented that they had to open holding patterns, which provided too much workload. In the CDG approach operations, they do not usually manage traffic with holding patterns and usually contact the ACC sectors to reduce the speeds. As there were no ACC actors involved in the simulation this had an impact on the participants' workload. For the ITM sector, the workload was rated within tolerable limits (a rating between 4 and 6) for three exercises and unacceptable for two exercises (higher than 6). One of the participants commented that this was due to the sector being very busy and leaving no room for any errors. If an error occurs then the ATCO could be behind the traffic. This is particularly true for IGS-to-SRAP which reduces spacing and was perceived to increase the number of aircraft on the final axis.

Overall, whilst there were often high ISA ratings and negative task load ratings, the participants' found that whilst all IGS-to-SRAP non-nominal situations increase workload, it remains nonetheless tolerable. However, only with regular training and when a coordinator is available to support the ITM ATCO during the failure of the separation delivery tool non-nominal situation. It should also be noted that the traffic sample caused a large portion of the increase in workload for the participants; in particular as the controllers have not had much recent experience with peak traffic loads due to the COVID-19 pandemic which reduced traffic significantly.

7.3.2.4.1.2 Situational Awareness

Situational awareness was assessed using the SASHA assessment and bespoke questions with agreement scales, 7-point scales and open responses within the PEQ at the end of each exercise. It was also assessed using bespoke questions with agreement scales within the PSQ at the end of the simulation.

Figure 29 presents a dashboard with the situational awareness assessment from the participants' responses to the PEQ.

Figure 24: Subjective Feedback from Post-Exercise Questionnaire on Situational Awareness

Situational awareness remained high in all exercises and all sectors, except for one exercise at the INI sector and two exercises at the ITM sector during the simulation. This can be explained from subjective feedback, in which the participants stated that the INI had opened holding patterns and ITM made a human error and experienced a technical error, causing them to fall behind traffic. A participant also stated that the go-around situation at the ITM sector caused them to fall behind traffic. It should be noted that these were impacted due to simulation limitation such as a lack of actors causing INI sector to hold aircraft, the technical error causing the ITM ATCO to fall behind traffic and the high traffic sample not allowing for any human error.

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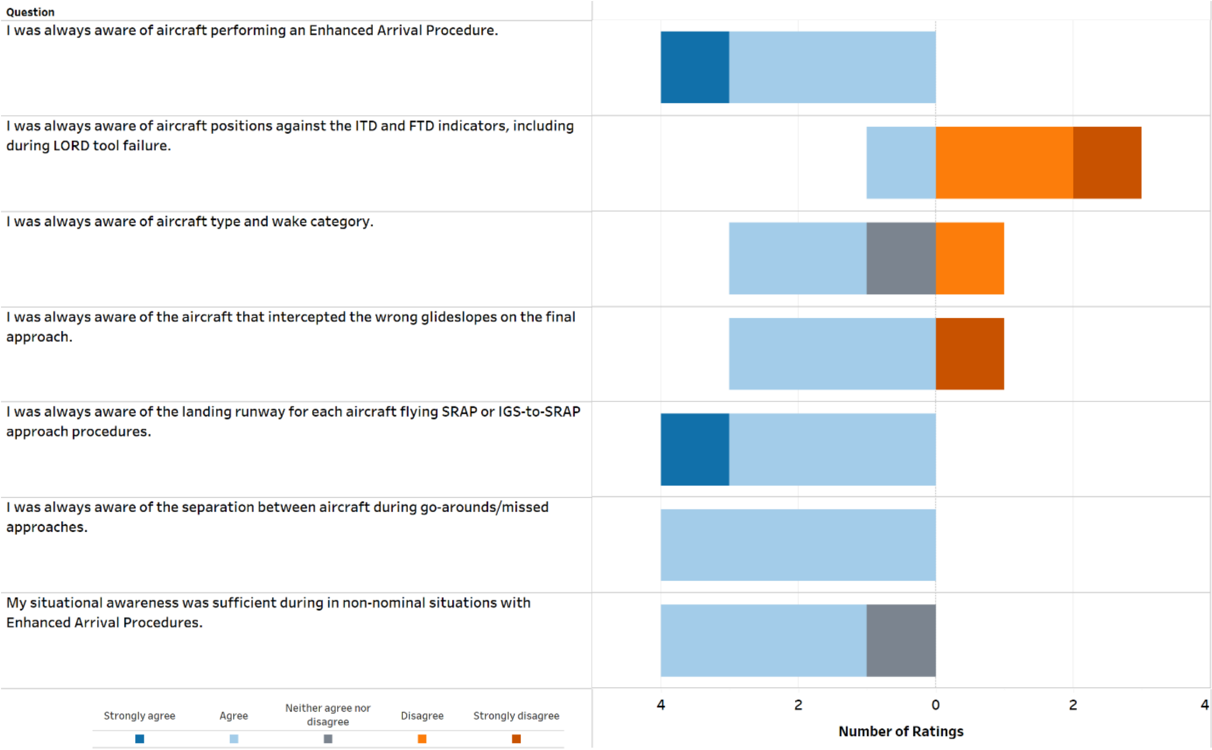

Figure 25: Subjective Feedback from Post-Simulation Questionnaire on Situational Awareness

Results from the PSQ show that some participants disagreed with some statements, however, these are not impeding the overall situational awareness.

Three out of four participants disagreed with the statement: "I was always aware of aircraft position against the ITD and FTD indicators, including during LORD tool failures". The participants provided the explanation that "the awareness of the position of aircraft relative to their respective ITD/FTD quickly vanished due to the high increase in workload". This does not impede the overall situational awareness as they are able to follow the procedure. The participants agreed that when there is an ORD tool failure and the ATCO is confident that the aircraft is stabilised then it would be rather penalising to send it around. Therefore, the procedure of managing a separation delivery tool failure should state that "an ATCO must be confident of the position of an aircraft against its ITD at the time of the tool failure, in order to consider an aircraft as stabilised (160 knots and behind the ITD indicator)". If the ATCO is not confident, then the ATCO should treat this aircraft as not yet stabilised. It should also be noted that during the simulation, there were no cases of an aircraft that continued down the final where it infringed the ITD, including when the separation delivery tool failed.

A participant disagreed with the statement: "I was always aware of the aircraft type and wake category", providing the explanation that with the separation delivery tool, the participant "focused less on the wake turbulence category and concentrated more on the [indicators]". Therefore, this is not a concern for the participant's situational awareness as the separation delivery tool embeds and displays this information. In addition, it shows that the participant had trust in the separation delivery tool to provide the correct spacing between two aircraft pairs.

A participant disagreed with the statement: "I was always aware of the aircraft that intercepted the wrong glideslope on the final approach", providing an explanation that "it is difficult to identify if an aircraft is too high on [its allocated glideslope]". The participants did not have much trust in the prototype glide alert used during the simulation, as there were many occasions where an aircraft intercepted the correct glideslope too high which incorrectly triggered the alert; therefore, there

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should be a requirement to ensure that the alert for when an aircraft intercepts the wrong glideslope must be sufficiently reliable. Additionally, the participants also recommended that a tool to visualise the vertical position of the aircraft on the glide would be helpful for ATCOs for the purpose of the wrong glideslope alert, such as Vertical Speed information or Approach Path Monitoring. In the real CDG operations, they have Vertical Speed information which increases their awareness and anticipation.

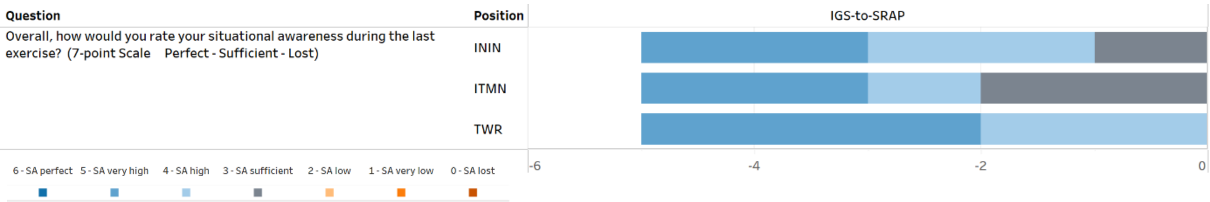

Figure 26: Overall Situational Awareness

Overall, the situational awareness was sufficient for non-nominal situations during IGS-to-SRAP arrival procedures according to the participant feedback. However, there should be requirements developed:

- The coordinator assistant must be available to aid the ITM ATCO in the event of the separation delivery tool failure;
- An ATCO must be confident of the position of an aircraft in order to consider an aircraft as stabilised (160 knots and behind the ITD indicator) in the event of the separation delivery tool failure;
- The alert for when an aircraft intercepts the wrong glideslope must be sufficiently reliable.

They also recommended that a tool to visualise the vertical position of the aircraft on the glide would be helpful for ATCOs for the purpose of the wrong glideslope alert, such as Vertical Speed information or Approach Path Monitoring.

7.3.2.4.1.3 Teamwork

For this RTS, teamwork was assessed using bespoke questions with an agreement scale rating as part of the PEQ after each run and using a selection of questions from the STQ-s SHAPE questionnaire as part of the PSQ at the end of the simulation, where participants rated whether they agreed or disagreed with the statements. The results of the questionnaires are shown in Appendix B.

The responses related to the statements about teamwork remain consistent where all participants are in agreement with the statements indicating that the non-nominal situations during IGS-to-SRAP arrival procedures do not have an effect on the teamwork. Nevertheless, one participant disagreed with the statement "The system enabled the team to prioritise tasks efficiently", providing feedback that in the simulation some necessary actors were not available, specifically for sequencing of flights which is normally decided amongst a team.

According to feedback from debriefs, it was evident that for all non-nominal events communication between different sectors and other actors is necessary. Some important actors were missing during the simulation, namely, enroute (ACC), departures (DEP), a sequencer and a full assistant for the CDG environment.

For the wrong glideslope alert situation, participants recommended that the following requirement be developed: “the approach sectors should inform the tower if an aircraft is flying a different procedure, especially during IGS-to-SRAP arrival procedures”. This is so that that TWR ATCO is fully aware of the situation, in particular when an aircraft not supposed to fly a IGS-to-SRAP approach (typically of Heavy or Super Heavy category) is flying the IGS-to-SRAP procedure, and able to plan and monitor the situation more carefully, in particular with the different runway aiming points where the ATCO should know if an aircraft has changed its landing runway (27L or 28L).

For go-arounds and missed approaches, participants stated that for CDG specific operations the TWR ATCO would also communicate to the INI and DEP sector about the aircraft going around. For other airport environments, go-arounds and missed approaches will require communication to other sectors where the aircraft going around or breaking off may affect other flights and where the aircraft will transfer to another sector to be reintegrated into the sequence.

For the separation delivery tool failure, participants stated that teamwork is essential. During the simulation, the coordinator was not intended to carry out tasks during the non-nominal procedures; however, due to the high workload for the ITM ATCO during the separation delivery tool failure, the coordinator aided the ITM ATCO for this non-nominal procedure. As a result of the simulation, a requirement must be developed that the coordinator/assistant must aid the ITM sector for checking the separations between aircraft and suggesting which aircraft should be sent around. There should also be communication between the sectors about which aircraft have been sent around and a communication to the TWR ATCO informing them of the final aircraft in the sequence that will be flying on the upper glideslope and performing an IGS-to-SRAP arrival procedure. This being the sequence immediately after the separation delivery tool failure and the final aircraft that will fly the upper glideslope until the tool and nominal operations return.

Overall, the ability of the participants to work as a team during the simulation was good and led to requirements updates for the procedures.

7.3.2.4.1.4 Transition

Transition was assessed using completely subjective feedback from the PSQ at the end of the simulation and debriefs.

Participants were asked one question in the PSQ about potential barriers towards the implementation of IGS-to-SRAP arrival procedures where they were to respond either yes or no, with the option of detailing their answer in a comment section. Figure 27 shows the participant responses on transition.

Figure 27: Subjective Feedback from Post-Simulation Questionnaires on Transition

Three participants could foresee potential barriers towards the implementation of IGS-to-SRAP procedures. All participants expressed concerns that there will be a need for recurrent and extensive training for the procedures to manage non-nominal situations in particular for the separation delivery tool failure. A participant also expressed concerns about managing departures on the same frequencies, in particular during heavy traffic situations. This will require further investigation.

Another participant also expressed a concern that an adapted AMAN tool would be necessary; in the existing requirements, a sequencing tool is required for IGS-to-SRAP operations for high traffic levels, so this should not be an issue. Debrief feedback also mentioned the need for the separation delivery tool in order to perform IGS-to-SRAP arrival procedures during high traffic levels as assessed in the simulation.

Participant feedback concluded that the following are needed for the implementation of IGS-to-SRAP:

1. the procedure to manage an alert caused by an aircraft intercepting the wrong glideslope should be regularly briefed and included in the refresher training.
2. the procedure to manage a go-around or missed approach should be regularly briefed and included in the refresher training.
3. the procedure to manage the failure of the separation delivery tool should be included in the regular non-nominal/emergency training.
4. IGS-to-SRAP operations with high traffic density are not possible without a separation delivery tool.
5. IGS-to-SRAP operations with high traffic density are not possible without a sequencer.
6. Extensive training will be required to become confident with the IGS-to-SRAP concept, separation delivery tool and non-nominal procedures:
    a. The **wrong glideslope alert** procedure should have regular briefing and be included in the refresher training.
    b. The **go-around/missed approach** procedure should be regular briefing of the procedure and should be included in the refresher training.
    c. The **separation delivery tool failure** procedure should be treated as a rare, emergency procedure. It will require extensive training and should be included in the regular training session. At CDG, this is twice in 3 years (non-nominal events training at approach and at tower).

However, one participant stated concerns about the ITM sector becoming overloaded due to the IGS-to-SRAP procedure, which results in more aircraft on the final axis due to the reduced spacing between pairs. This was also confirmed during debriefs with other participants. One suggestion was that the aircraft could be transferred earlier to the TWR sector; however, not all airports operate with early transfer to tower and early landing clearance like in the CDG operations and during the simulation the TWR position did not perform all their tasks as today such as departures and runway crossings. This could also be a simulation effect due to the high sector load in the traffic sample used and the fact that the participants are no longer in the habit of managing such high traffic loads due to the COVID-19 pandemic. This should be further investigated locally, particularly in environments that do not transfer aircraft so early to tower and where tower perform all activities.

7.3.2.4.2 Safety

The overall safety assessment has been based on qualitative data collected from debriefs, PEQs, and PSQ comprised of agreement scales, dichotomous scales and open responses.

Figure 28 and Figure 29 presents the safety assessment from the ATCOs' responses to the PEQ and PSQ.

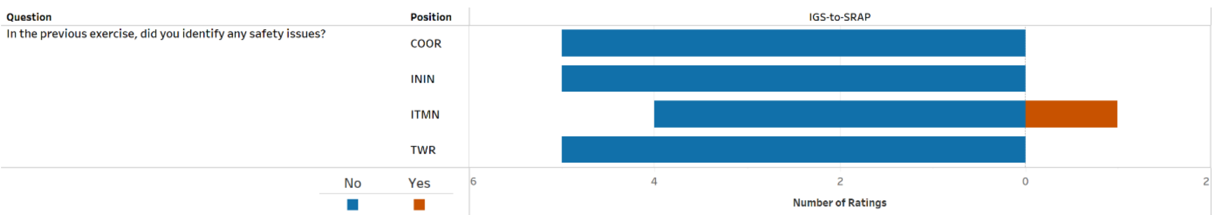

Figure 28: Subjective Feedback from Post-Exercise Questionnaire on the Safety Performance

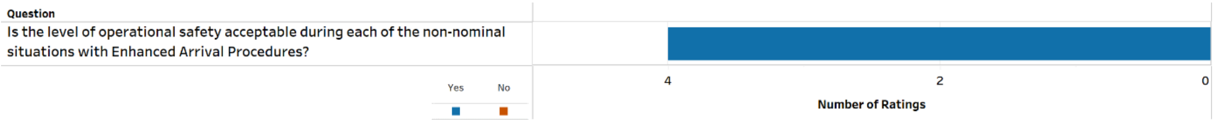

Figure 29: Subjective Feedback from Post-Simulation Questionnaires on the Safety Performance

After all of the exercises, the participants stated that they did not identify any safety issues and that each of the non-nominal situations were able to be resolved safely and within a timely manner, except for one participant at the ITM sector during one exercise. This participant stated that workload was high and they were behind traffic. At the ITM sector with IGS-to-SRAP arrival operations, the ITM ATCO is at risk of being overloaded due to the reduction in separation between two pairs meaning that more aircraft fly along the final approach axis. It should also be noted that the traffic sample was very charged and higher than the usual throughput at CDG. In addition, the participants were not so familiar with high peak operations currently, due to the disruption the COVID-19 pandemic caused in the aviation sector.

Overall, the participants were asked if the level of operational safety was acceptable during each of the non-nominal situations, all of the participants agreed.

7.3.2.4.3 Operational Feasibility

The operational feasibility of the procedures for managing non-nominal situations for IGS-to-SRAP arrival procedures was assessed using completely subjective data comprised of agreement scales from the PEQ, PSQ and debriefs.

Figure 30 presents a dashboard with the participants' PSQ responses about the overall operational feasibility of IGS-to-SRAP arrival procedures with non-nominal situation.

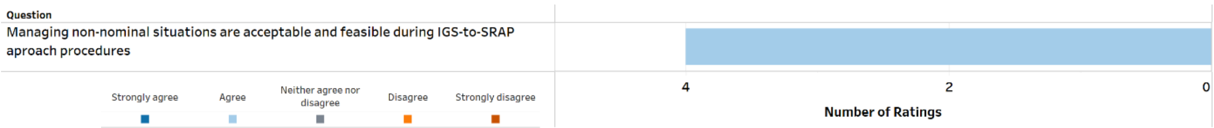

Figure 30: Subjective Feedback from Post-Simulation Questionnaires on the Operational Feasibility

Overall, the participants found that all of the non-nominal situations during IGS-to-SRAP approach procedures are acceptable and feasible provided the requirements are met and ATCOs are provided extensive and regular training as described in section 7.3.2.4.1.4.

The CDG ATCOs commented that IGS-to-SRAP arrival procedures probably would not be applicable to the CDG environment due to their specific operations, however, the IGS-to-SRAP arrival procedures would most likely be well suited for an airport with a dedicated runway for landings only.

7.3.2.4.4 Non-nominal Procedures

During each exercise of IGS-to-SRAP, the participant was able to experience the three non-nominal situations on each sector, therefore were able to make an assessment. The participants provided their feedback through debriefs after each exercise and at the end of the simulation. This section presents the safety and HP results of the simulation for IGS-to-SRAP arrival procedures per non-nominal situation. It will also address the participants' opinions of each procedure and define the requirement for any modifications to the procedure that are necessary.

7.3.2.4.4.1 Glide Alert Triggered by an Aircraft Intercepting the Wrong Glideslope

When the wrong glide path is intercepted, the cases described in section 7.1.3.2.2 were used and assessed for IGS-to-SRAP arrival procedures.

Table 12 presents the number of alerts that appeared due to an aircraft intercepting the wrong glideslope and the time to react to the alert across five exercises using IGS-to-SRAP arrival procedures.

Event	Event Count	Reactionary Event	Reactionary Event Count	Average Reaction Time (s)
Glide Alert	7	Change Approach	5	13
		Go Around	5	67

Table 12: Time to React to the Wrong Glideslope Alert

Out of the seven glide alerts over the five exercises, the participants immediately updated the aircraft's procedure on the HMI for five of these glide alerts. Therefore, the participants immediately sent two aircraft to go-around as it would have had a heavy wake turbulence category. As there were a total of five go-arounds following a glide alert, two were immediate, then three of these go-arounds were following an update in the approach procedure where either that aircraft or the one in front or behind infringed its indicator.

It took the participants an average of 13 seconds to react to a glide alert with an update in the aircraft's procedure on the HMI and consequently updating the indicators from the separation delivery tool. The participants found that the alert is clear and noticeable, as shown in Figure 19 in section 7.3.2.3.

It took the participants an average of 67 seconds to react to a glide alert by instructing the aircraft to go-around, including the three instances where the participants updated the approach beforehand. The participants stated that it is a very manageable task and not very time consuming. IGS-to-SRAP procedures are intended for high peak traffic to benefit from the capacity increases; therefore, there is a possibility of an ATCO having lower situational awareness and high workload in such instances. Often during the exercises, a participant would update the indicators of an aircraft which triggered a glide alert. If as a result they saw any aircraft between their ITD and FTD indicators then they would manage this aircraft with speed management and monitor the situation while continuing with other tasks. The participants found this working method acceptable and suggest that there should be no hard rule to send the aircraft immediately to go-around. During one exercise, a participant stated that one glide alert resulted in the controller to be behind traffic as the aircraft with the glide alert took a lot of their focus and the workload in general was high due to the sector load. When it is busier, it could be easier to send the aircraft around immediately and to prevent any knock-on effect to the following aircrafts. This will be for the controller to decide.

Figure 31 shows the participant's safety assessment of the wrong glideslope alert procedure after each exercise from the PEQ. The participants expressed that the defined procedure was feasible, acceptable and can be resolved safely with a tolerable workload and sufficient situational awareness.

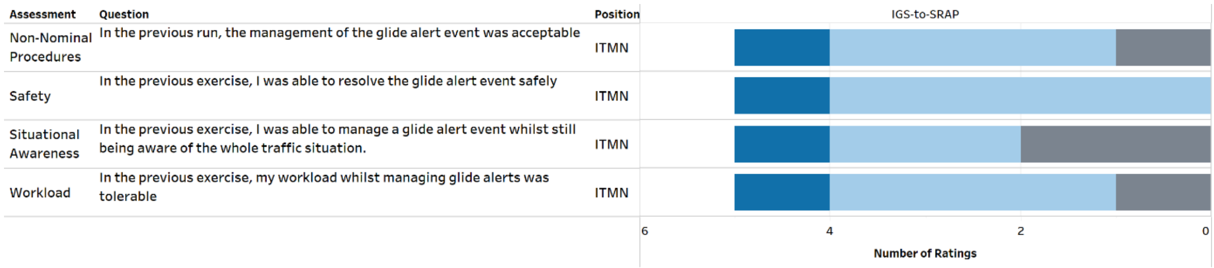

Figure 31: Subjective Feedback from Post-Exercise Questionnaires on the Safety performance, Human Performance and User acceptance of the Wrong Glideslope Alert Procedures

Overall, the participants stated that this procedure very feasible. No modifications to the procedures are required; however, some requirements and recommendations have been suggested.

During the debriefs, the participants agreed that an aircraft with a RECAT-EU wake turbulence category of CAT A "Super heavy", CAT B "Upper Heavy" or CAT C "Lower Heavy" should be required to intercept the lower glide, as intended in the concept description. This is due to capacity benefits and safety reasons. If an aircraft with a Heavy RECAT-EU wake turbulence category intercepted the upper glideslope, the participants and concept safety expert concluded that it would be safer to send the concerned aircraft to go around immediately. During the simulation, there was an instance where the glide alert was triggered by a heavy aircraft and the participant mistakenly updated the landing procedure on the CWP and the aircraft intercepted the upper glide. Consequently, the separation delivery tool indicators for the following aircraft jumped significantly behind which caused confusion for the participant to locate the updated indicators. This led to low situational awareness for the participant and led to an unsolved loss of separation. This situation led to a safety concern and the decision to send heavy aircraft around immediately if found on the upper glide. However, there are situations when the separation behind is fine regardless of the fact that a heavy aircraft is on the upper glide. This part of the procedure should be further investigated locally to see whether it could be improved so that it is less penalising.

Other feedback from participants was the suggestion that a tool to visualise the vertical position of the aircraft on the glide would be helpful for ATCOs such as Vertical Speed information or Approach Path Monitoring. It should be further investigated locally if this vertical profile-plotting tool is necessary for the Tower and Approach controllers.

Regarding phraseology, it has been concluded that ATCO should always ask the pilot to confirm the type of approach and the landing runway as it is important that the ATCOs are aware of the situation and the pilots are aware of the reason for possible go-arounds.

In terms of teamwork and communication, the participants stated that the approach sectors should notify the tower of any flights that triggered a glide alert, in order to have full awareness of the situation, to plan and monitor the situation more carefully. In particular with the different runway aiming points where the ATCO should know if an aircraft has changed its landing runway (27L or 28L). The approach controller shall evaluate the need for such a coordination on a case by case basis.

The participants stated that the glide alert tool must be reliable and there should be no false alerts as this increases the workload and communication load of the ATCO.

7.3.2.4.4.2 Go-Arounds/Missed Approaches by Leading Aircraft with Possible Follower Go-Around

When an aircraft is sent around or when a missed approach takes place the procedure described in section 7.1.3.2.2 was used and assessed for IGS-to-SRAP arrival procedures.

Table 13 shows the total number of missed approaches and the related losses of separation compared to the applicable minima for the IGS-to-SRAP runs.

Run	NGA[1]	NGA ILS	NGA EAP	N[2] Wake sep loss	N surv sep loss	N Wake sep loss [<0.25 NM]	N Wake sep loss [0.25, 0.5 NM]	N Wake sep loss [0.5 NM, 1NM]	N Wake sep loss [>1 NM]
T1IGS2SRAP_210615_121646	7	6	1	0	2	0	0	0	0
T1IGS2SRAP_210617_101439	6	2	4	0	1	0	0	0	0
T1IGS2SRAP_210617_163437	4	3	1	0	0	0	0	0	0
T1IGS2SRAP_210618_101927	2	2	0	0	0	0	0	0	0
T2IGS2SRAP_210616_145110	8	5	3	1	1	1	0	0	0
Total	27	18	9	1	4	1	0	0	0

Table 13: Number of Go-arounds/Missed Approaches and related loss of separation

Between two and eight missed approaches or go-around were performed in each IGS-to-SRAP exercise out of a total of 27. 18 were for flights following the conventional ILS 27L glide and nine on the IGS-to-SRAP glide. In those 27 cases, only one led to a loss of wake separation (separation below FTD and vertical separation lower than 1000ft) with maximum 0.25 NM of under-separation. No large under-separation was observed. For the case with the loss of wake separation, the separation was lost before the go-around and recovered (with 1000ft vertical separation) after 8 seconds.

Table 14 shows the total number of double go-arounds and the related losses of separation compared to the RECAT-EU minima for the IGS-to-SRAP runs.

Run	NGA	N Wake sep loss	N Wake sep loss <0.25 NM	N Wake sep loss [0.25, 0.5 NM[	N Wake sep loss [0.5 NM, 1NM[]	N Wake sep loss >1 NM
T1IGS2SRAP_210615_121646	1	1	1	0	0	0
T1IGS2SRAP_210617_101439	1	0	0	0	0	0
T1IGS2SRAP_210617_163437	0	-	-	-	-	-
T1IGS2SRAP_210618_101927	0	-	-	-	-	-
T2IGS2SRAP_210616_145110	1	0	0	0	0	0
Total	3	1	1	0	0	0

Table 14: Number of Go-arounds/Missed Approaches and related loss of separation for the ILS-IGS-to-SRAP pairs that resulted in a double go-around

[1] Number of Go-Arounds

[2] Number of

A maximum of one double go-around for ILS-IGS2SRAP pairs was observed for each exercise for a total of 3. In those 3 cases, only 1 led to a loss of wake separation (separation below RECAT minima) with maximum 0.25 NM of under-separation. No large under-separation was observed.

For the case with loss of wake separation, shown in Figure 32, the RECAT separation was lost at the time the leader went around. A diverging heading was then instructed to the leader and 1 second after the loss of separation, the leader and follower trajectories were diverging and no wake separation minima were thus required (applicable minima is then 3 NM horizontal or 1000 ft vertical). Note that at the time of the loss of wake separation, more than 1000 ft vertical separation was observed between the two flights.

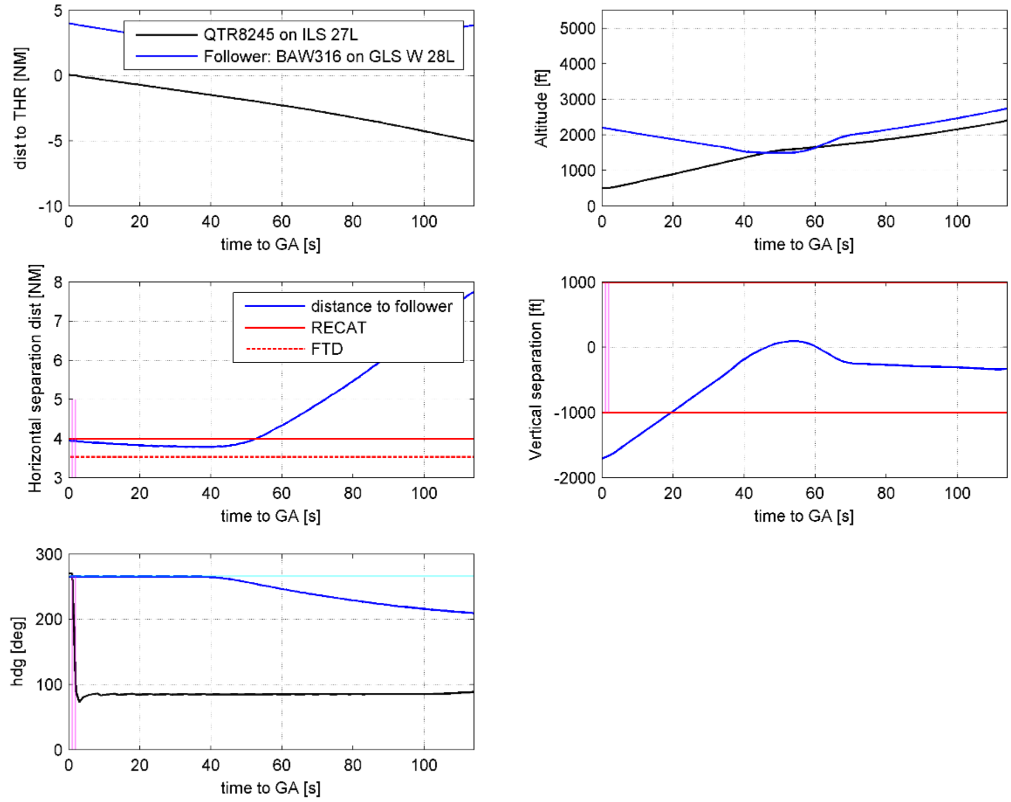

Figure 32: Detailed separations after double go-around for the ILS-IGS2SRAP case with loss of wake separation

Table 15 shows the average amount of time that it took the participant to send the following aircraft around across all of the five exercises with IGS-to-SRAP arrival procedures.

Event	Reactionary Event Count	Reactionary Event	Reactionary Event Count	Average Reaction Time (s)
Go-around	8	Go Around	2	38

Table 15: Time to React to a Go-Around from a Heavy Aircraft on ILS approach with IGS-to-SRAP approach following where separation is less than RECAT-EU

Overall, it seems that these reaction times were enough not to create large under-separations with IGS-to-SRAP procedures. The double go-around was under-separated very briefly for one second and for less than 0.25NM as shown in Table 14.

It should be noted that due to the traffic mix at CDG, there are many CAT-B and CAT-D pairs where the most constraining is the ROT spacing. Therefore, there was not a lot of opportunity to create the correct situation that results in a reduced separation that requires a double go-around. Hence, the reason for only one measurement of the double go-around.

In terms of being able to spot the missed approach of the leading aircraft, the participants expressed that it is easy as per the current procedures, the pilots always tell the controller when a missed approach is taking place. Nevertheless, to strengthen this, a requirement is needed to reinforce that the pilot shall communicate to the controller about a missed approach as soon as practicable when applying IGS-to-SRAP. However, as the procedure for pilots initiating a missed approach is to fly, navigate and then communicate, the participants also stated that there can be delays in the communication to the ATCO. Therefore, the participants stated that a tool would be required to alert the ATCOs immediately when an aircraft is performing a missed approach in order to be able to react immediately and avoid the follower flying into the wake of the leader. Existing tools are available such as the Vertical Speed alert or the APW, which are used at CDG airport. There should also be further investigation into the amount of time that it takes a pilot to communicate a missed approach to the ATCO. In terms of appreciating the RECAT-EU separation behind the leader which performs the GA/MA in the simulation, the TWR ATCO could make use of the distance markers presented on the TWR HMI, which made it easy for them to measure the distance behind the leader.

The participants found this procedure to be feasible, acceptable and able to be resolved safely whilst maintaining a tolerable workload and sufficient situational awareness, as shown in Figure 33, which presents the subjective feedback from the PEQ.

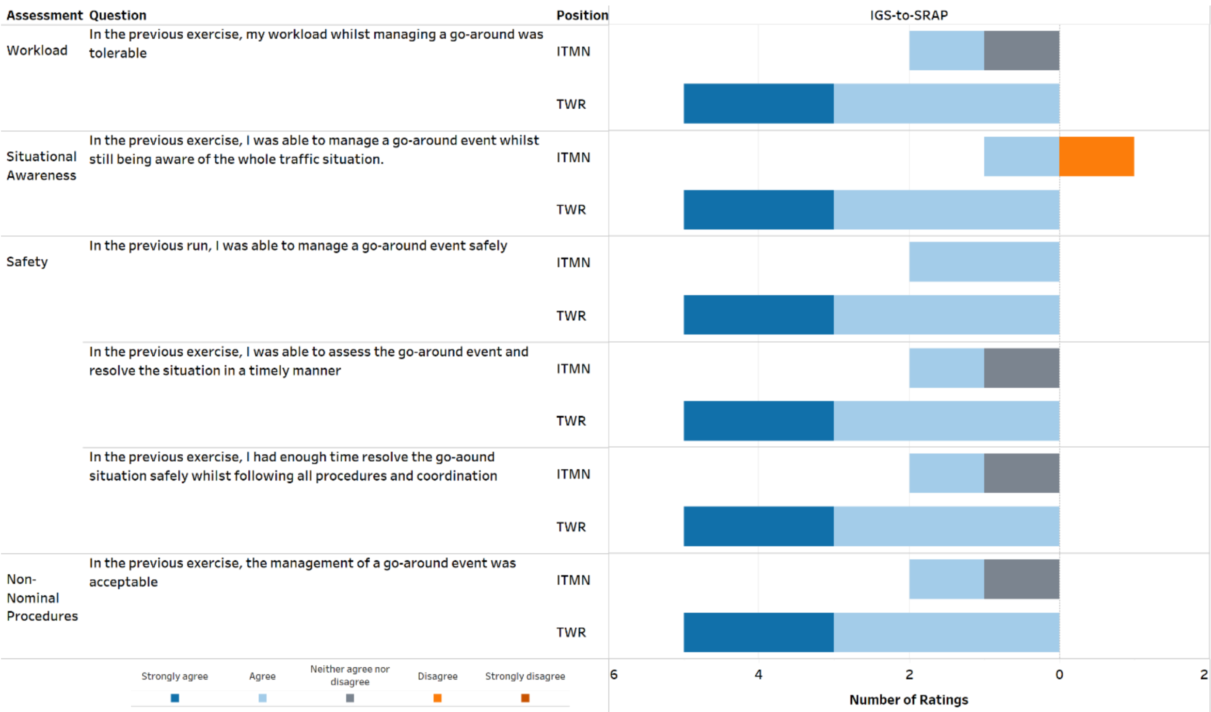

Figure 33: Subjective feedback from Post-Exercise Questionnaires on the Safety performance, Human Performance and User Acceptance of the Go-Around/Missed Approach Procedures

A participant disagreed that the go-around situation was manageable whilst maintaining full awareness of the whole traffic situation at the ITM sector, as it caused them to fall behind traffic according to the comments. It should be noted that this was impacted due to simulation limitation such as a technical error where the aircraft label was lost and the high traffic sample not allowing for any human error.

This procedure is more likely to affect the TWR ATCO as this is the time where the separation begins to reduce below RECAT-EU separations. Aircraft that are on the APP frequency may not be at reduced separation yet (compared to RECAT-EU) since they most probably have not started the descent on the glide slope at that stage. Nevertheless, this depends on the airport environment, for example, at CDG, flights are transferred to TWR quite early. No modifications to the procedures are required.

Overall, the participants stated that this procedure was very feasible. In particular at the TWR as ATCOs usually are already aware of the separation between a pair of aircraft as they send an initial message to pilot and it is easy to see the separation with the distance markers on the HMI.

However, it should be reinforced to pilots that they shall communicate to the controller about a missed approach as soon as practicable to avoid lost time in the go-around procedure where the following aircraft could risk flying into the wake of the leading aircraft that went around. Another requirement that is needed is that the crew shall pay particular attention to the transition of frequencies from APP to TWR and shall not delay it to avoid an aircraft being in between two frequencies where they are unable to communicate a missed approach or, conversely, the ATCO to not be able to communicate a go-around.

7.3.2.4.4.3 Separation Delivery Tool Failure Analysis

When there is a failure of the separation delivery tool, the procedure described in section 7.1.3.2.2 was used and assessed for IGS-to-SRAP arrival procedures.

Table 16 shows the number of go-arounds because of the separation delivery tool failure across all five exercises of IGS-to-SRAP arrival procedures. The separation delivery tool failure occurred at different times for each exercise in order to assess the feasibility and safety of the procedure under different circumstances.

Exercise Code	Number of Go-Arounds
T1IGS2SRAP_210615_121646	2
T1IGS2SRAP_210617_101439	3
T1IGS2SRAP_210617_163437	2
T1IGS2SRAP_210618_101927	0

Table 16: Number of Go-Arounds following the ORD Tool Failure

The data indicates that the result of the separation delivery tool failure is different each time depending on the situation. Table 16 shows that the number of go-arounds following the failure of the tool is between zero and three.

Figure 34 presents the participants assessment of the separation delivery tool failure procedure from the PEQ.

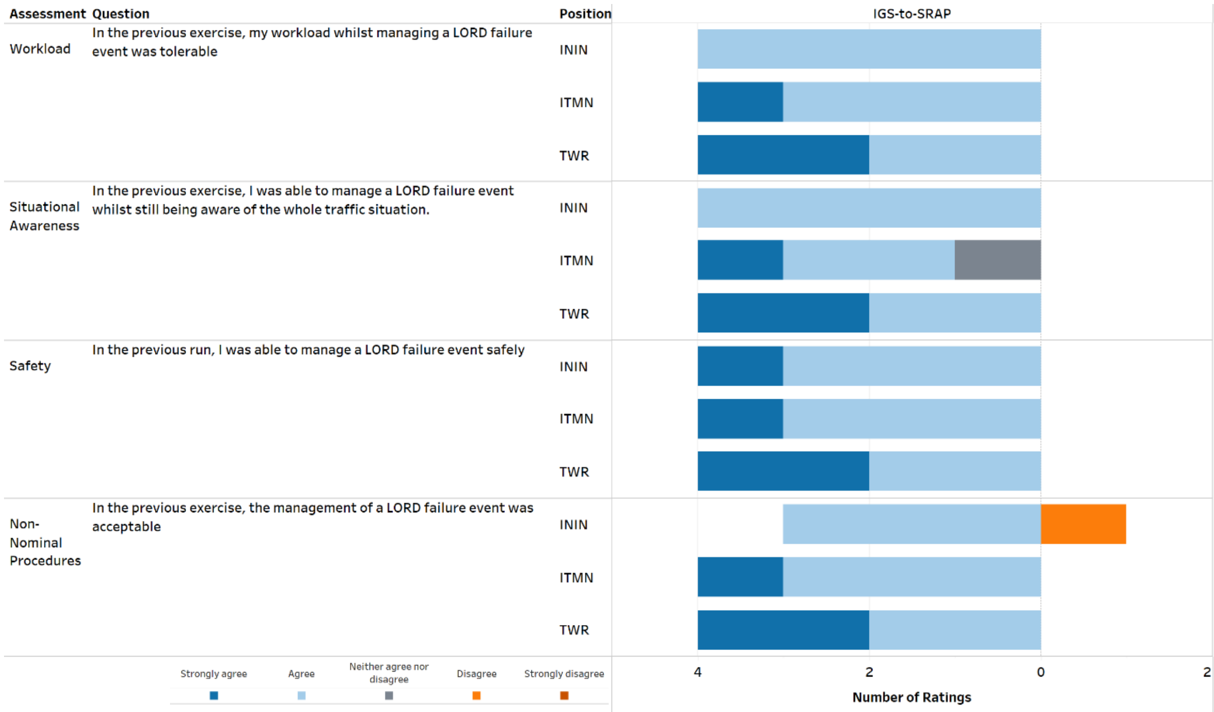

Figure 34: Subjective Feedback from Post-Exercise Questionnaires on the Safety Performance, Human Performance and User Acceptance of the Separation Delivery Tool Failure Procedures

The procedure for the separation tool failure during IGS-to-SRAP arrival procedures was deemed feasible, acceptable and can be resolved safely with a tolerable workload and sufficient situational awareness by the participants. One participant after one run disagreed with the statement "In the previous exercise, the LORD failure event was acceptable" commenting that it was difficult for the ITM sector as there was a lot of traffic on frequency at the time of the failure. However, the ITM sector found it acceptable. The participants agreed during debriefs that the separation delivery tool failure causes a sudden increase in workload. The participants acknowledged that this procedure is an emergency procedure, which is never easy to manage. The participants stated that this procedure is only feasible if an assistant is available to aid the ITM ATCO in order to avoid being late and behind traffic.

Overall, the participants were comfortable with the procedure and feel that no further modifications at this stage are required. However, some requirements and recommendations were suggested.

It is necessary that the ITM ATCO is aided by an assistant in the event of the separation delivery tool failure, otherwise the workload is too high and situational awareness is very low when the ATCO works alone. The exercise that resulted in three go-arounds was very complicated; the participant at the ITM sector had many tasks and communications; they had very low situational awareness and therefore, had to ask the assistant position to check the separations between pairs and indicate which aircraft should be sent around. The ITM participant relied on the assistant completely and the procedure would not have been manageable alone.

It was easier at the TWR position as there is less traffic than the other sectors and additionally, the TWR would also be managing the departures in the real CDG environment. Consequently, situational awareness was higher for TWR ATCOs as they had less workload than the other sectors and compared to reality. Therefore, they were often aware of the position of an aircraft against its indicators at the time of the separation delivery tool failure.

Additionally, in terms of teamwork and coordination, the participants stated that the ITM ATCO must communicate to the TWR ATCO the last aircraft in the sequence that is remaining on the upper glide so that the TWR ATCO is aware of the situation. This being the sequence immediately after the separation delivery tool failure and the last aircraft that will fly the upper glideslope until the tool and nominal operations return. There was a case during the simulation where the last aircraft flying IGS-to-SRAP arrival procedures on the upper glideslope arrived in the TWR sector quite a while after the previous aircraft on the upper glideslope; this led to confusion and low situational awareness for the TWR ATCO, which could lead to human errors with safety implication. Equally, when the separation delivery tool returns to operations, the INI ATCO must communicate to the ITM ATCO and the ITM ATCO must communicate to the TWR ATCO the first aircraft in the sequence that is performing IGS-to-SRAP arrival procedures on the upper glideslope. This is important for the TWR ATCO to know that the aircraft has changed their runway as it will increase their overall awareness, anticipation and aids their planning.

The rules of the separation delivery tool failure procedure were found to be easy enough to remember and apply during IGS-to-SRAP arrival procedures. The procedure should remain simple as it is an emergency procedure with no time for optimisation. The participants stated that applying RECAT-EU + 3NM for the upper-lower pairs is simple enough; however, they expressed the need to be able to easily access the RECAT-EU and RECAT-EU + 3NM separation tables in the event of a failure of the separation delivery tool.

7.3.2.5 Additional results outside R01 objectives

7.3.2.5.1 Additional comments linked to ORD tool

There were some specific comments linked to the use of the ORD tool that did not arose in Sesar 1, nor in W1 or during the test sessions in W2.

During post-exercise debriefs, there were mixed responses related to the separation delivery tool. Some participants found the toolkit "more relaxing" and others expressed concerns about how the separation delivery tool provided additional stress as the ATCOs require more focus and to be more precise. However, the participants changed their opinion by the end of the week having used the separation delivery tool more. One questionnaire comment included "[it was] a real pleasure working with the tool" and another participant mentioned that there was a noticeable increase in workload when the separation delivery tool failed in exercises and the participants had to return to current operations using RECAT-EU separations. It was also concluded that the additional stress could have also been related to the strip less simulation environment compared to current operations at CDG where they still use paper strips. Extensive training on the separation delivery tool is required for the ATCOs to be confident when using the separation delivery tool; the separation delivery tool may require the ATCO to adapt their working method such as not reducing speeds too early. The participants stated that the tool was particularly more useful and lowered stress at the tower position as the ATCOs did not have to check the distance between two aircraft.

The participants stated that on the Tower HMI, it was difficult to see the black chevrons against the black distance markers. This is not an issue for the concept as the Tower HMI used was not the CDG Tower HMI and rather a generic HMI for the purpose of the simulation. In real operations, an ANSP would be able to tailor the HMI to suit their needs. The participants also stated that they occasionally mistook between the speed indicator and the wake category on the aircraft's electronic label; this was due to lack of training and unfamiliarity when working with electronic labels as the participants are working with paper strips.

It should be noted that the participants recommended that for the separation delivery tool where the ROT indicator is shown, the wake/MRS indicator should always be shown, as these separations must be maintained to ensure safe operations.

Currently, the ORD only displays the MRS/Wake indicators when MRS/Wake separations are the most constraining or when ROT spacing is the most constraining and the MRS/Wake ITD is infringed in the background. ATCOs recommended to show the MRS/wake indicators always, even when ROT is the most constraining, because wake is a safety issue whereas ROT is useful but not as safety critical, i.e. ROT and MRS/Wake indicators should both be displayed when ROT is the most constraining.

These comments will lead to no new requirements as they are linked only to the ORD tool which is already deployed or being deployed at some airports.

7.3.2.5.2 Additional comments about IGS-to-SRAP HMI

An issue related to the HMI for IGS-to-SRAP procedures that was raised during debriefs was that when the final approach sector is busy (i.e. has a lot of traffic); the interception points can become confusing. For IGS-to-SRAP approach procedures, there are two interception points, one for ILS as current operations and another for the IGS-to-SRAP glideslope. This should be taken into consideration and further investigated locally and the OSED/SPR/Interop requirement REQ-14.5-SPRINTEROP-CTL.1109 will be rephrased to insist on the need that the two interception points shall be easy to identify and to distinguish.

7.3.2.5.3 Additional comments about phraseology

Even if the assessment of the phraseology from ATCO side was not an objective of R01 because the proposed phraseology from ATCO side was already validated during W1 (cf [38]), it was assessed using bespoke questions with an agreement scale rating as part of the PEQ after each run and as part of the PSQ at the end of the simulation, where participants rated their agreement with the statements. Figure 35 shows the questionnaire feedback related to phraseology from participants.

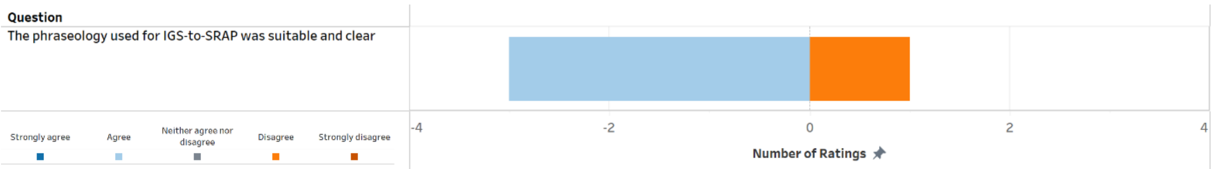

Figure 35: Subjective Feedback from Post-Simulation Questionnaires on Phraseology

During each exercise, the participants found the phraseology to be adequate.

In the PSQ, a participant disagreed with the statement: "The phraseology used for IGS-to-SRAP was suitable and clear", providing the explanation that there is a risk for confusion between ILS and GLS and the letters following the procedure (e.g. GLS V, RNAV W), especially when there is a lot of traffic and the instructions are spoken quickly. The participant felt that the letter could be easily misunderstood or incorrect. Whilst the other participants showed that they agreed with the statement in the PSQ, they expressed the same concerns for confusion between ILS and GLS and the letters behind the procedure, which occurred a few time during the simulation. This confusion should be further investigated.

The participants found the phraseology for the TWR ATCO to be too long and time consuming, especially if the ATCO also manages departures on the same frequency. The participants suggested that if two aircraft are expected to land using the same runway aiming point then the ATCO should not have to provide the runway in the message. Participants stated that TWR ATCOs usually provided the separation information to that aircraft and the preceding aircraft; however, with the separation delivery tool this may not be necessary, as the distance is always different. That last comment did not arise in previous simulations aiming at validating the use of the ORD tool. All these comments particular to CDG way of working and probably linked as well to Covid impact on controllers' ability to manage high density traffic will not lead to any recommendation.

In conclusion, as the phraseology specific to IGS-to-SRAP that was used in R01 was the one defined, evaluated and found acceptable in W1 ([38]), no additional requirements will be defined.

7.3.3 Unexpected Behaviours/Results

This validation was performed as planned with the exception of a few technical issues:

- If the controllers accidentally double clicked, it would transfer the flight to the next sector and the controllers could not change the aircraft to return to their sector;
- The rate of descent of certain aircraft was not realistic;
- The speeds of two aircraft types were not correct;
- Occasional technical and piloting errors;
- Changing frequencies is quite long.

These technical issues that led to higher workload and lower situational awareness ratings at times during the simulation.

The first exercise of the week was also lost due to a technical issue with the launching of the simulator platform; however, this does not affect the results.

The COVID-19 pandemic also influenced the validation as the participants were not used to working in high peak operations, which were required for the concept, therefore, the participants experience higher workloads and lower situational awareness.

7.3.4 Confidence in Results of Validation Exercise EXE-14.5-V3-VALP-R01

7.3.4.1 Level of significance/limitations of Validation Exercise Results

This section captures the potential limitations affecting the representativeness of the results obtained in the validation exercise. Numerous items that could have affected the controllers' performance include:

- The simulation was a strip less environment with CDG ATCOs that work in a paper strip environment;
- Labels on the HMI were big and overlapping often (related to strip less environment);
- Not all actors were available during the simulation: ACC and sequencer were missing;
- The approach colours in the label indicating which aircraft was performing and ILS or IGS-to-SRAP approaches were different in the APP and the TWR positions. Therefore, when the participants rotated position this was confusing;
- It was difficult to see the chevrons on the TWR HMI as the chevrons were black and blended with the black distance markers;
- The HMI was different to in their operations;
- The traffic mix is different and complex compared to the typical CDG traffic;

- Due to the COVID-19 pandemic, the controllers are no longer prepared for and used to high traffic loads as the current traffic has been significantly lower than the traffic before the pandemic (the simulation took place 15 months after the impacts of the COVID-19 pandemic;
- Aircraft performing go-arounds were "killed" and not reintroduced into the sequence. This was feasible for the assessment of the non-nominal procedures; however, the human performance assessment for the INI sector is not an accurate representation as they had less tasks than they would have in reality;
- On the final day, the participants reported that they were becoming familiar with the two traffic samples and had a few techniques prepared.

Despite these limitations due to Covid effect and to the simulator that could have affected the results, the results and feedback are positive. So the results of R01 can be considered as significant.

7.3.4.2 Quality of Validation Exercises Results

This section describes the issues concerning the quality of the results achieved in the validation exercise. The following issues affected the quality of the results:

- There were a few technical issues, which will have affected the human performance results. In particular, workload and situational awareness.
- The number of non-nominal situations that will occur within a short amount of time (50 minutes to 1 hour) were exaggerated in order to be able to complete the experimental design within a week and to test the non-nominal situations under different conditions. This could have had an impact on the human performance results.
- The traffic sample was adapted for the needs of the simulation and was not familiar to the ATCOs. It may have caused some confusion as flights and callsigns appeared from different directions to those that they are familiar. This was to balance the number of aircraft from both directions (North-East (LORNI) and North-West (MOPAR)).
- The procedure was tested in one airport environment based on a major European airport that is supposed to be representative of airports where the procedure could be implemented.

7.3.4.3 Significance of Validation Exercises Results

RTS are excellent validation techniques as they allow a human-in-the-loop experience of the concept and the proposed non-nominal procedures in a relatively controlled and repeatable environment. Moreover, addressing the objectives concerning procedures, safety, feasibility, technological improvements and Human Performance typically require direct involvement of users to provide subjective qualitative and quantitative feedback in controllers' operational environment, which can be undertaken during the RTS.

<u>**Statistical Significance**</u>

Five runs assessed the IGS-to-SRAP operations with seven non-nominal situations with four participants. Each participant was able to assess the concept from each sector position providing the maximum confidence in the feedback with the limited number of participants.

Whilst five runs does not provide high statistical significance, a further ten exercises using ISGS or SRAP procedures tested these same procedures where a lot of the feedback was very similar and applicable to all three Enhanced Arrival Operations, increasing the statistical significance.

In addition, 24 non-nominal situations occurred over the five runs (70 non-nominal situations over all 15 runs) and were tested at different points during the traffic sample, which provided a variation in the conditions, complexity and anticipation for the participants. These non-nominal situations were tested multiple times within one exercise (with the exception of the separation delivery tool failure, which was only possible to test once per exercise). Considering all of the feedback from all 15 runs and all 70 non-nominal situations, the statistical significance increases and can be considered high.

Considering the limited amount of time and number of participants, the confidence in the variation of the feedback provided was maximised and is sufficient to validate the concept.

Operational Significance

Whilst the participants were familiar with the airport environment, the traffic sample contained similar callsigns to their usual traffic; however, the traffic itself was different. Some traffic would arrive from different directions compared to their expectations and certain aircraft types were included in the traffic sample, which would not arrive at CDG in reality. This could have caused some confusion and surprise the participants. The traffic sample also did not include departures or runway crossings that the ATCOs would usually have to manage as well.

The system was paperless; however, the CDG environment uses paper strips. This would have increased the workload and lowered the situational awareness. The HMI was also different to their HMI in operations.

In addition, participants usually coordinate with more actors when performing these tasks, this ended up increasing their workload.

However, as the results and feedback are positive, R01 can be considered as operationally significant.

7.3.5 Conclusions

This section provides a summary of the conclusions developed from the analysis of the Validation exercise. The following conclusions concern only the management of the non-nominal situations which was the scope of R01.

7.3.5.1 Conclusions on concept clarification

7.3.5.1.1 Wrong Glideslope Alert Procedure

The following conclusions related to the management of a wrong glideslope alert were captured during the simulation:

- The procedure defined for the management of a Wrong Glideslope Alert (see 7.1.3.2.2.2) was found to be very feasible and no further modifications to the procedure rules are required at this current stage.
- Additional information is desired to visualise the vertical position of the aircraft on the glide would be helpful for ATCOs, such as Vertical Speed information or Approach Path Monitoring. This should be further investigated locally.
- APP must coordinate with TWR if an aircraft triggered the glide alert, in particular if the aircraft is finally not flying the procedure it would normally fly (for example if a Heavy aircraft is flying the IGS-to-SRAP Approach). It is important that the TWR ATCO is aware of the situation if the concerned aircraft will be transferred to TWR.
- A requirement must be derived stating that the wrong glideslope alert it must be sufficiently reliable. False alerts increase the ATCO's communication and hence, workload.

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- This procedure must have extensive training. It must be regularly briefed and included in the refresher training of the ATCOs.

7.3.5.1.2 Go-Arounds/Missed Approaches

The following conclusions related to the go-around/missed approach procedure were captured during the simulation:

- The procedure defined for the management of go-around/missed approach (see 7.1.3.2.2.1) was found to be very feasible and no further modifications to the procedure rules are required at this current stage.
- The pilot shall communicate to the ATCO about a missed approach as soon as practicably possible; conversely, a tool that plots the vertical position of the aircraft would be helpful for ATCOs such as Vertical Speed information or Approach Path Monitoring.
- A tool which alerts ATCOs immediately when an aircraft is performing a pilot initiated missed approach is strongly desired.
- The crew shall pay particular attention to the transition of frequencies from APP to TWR and shall not delay it.
- This procedure must have extensive training. It must be regularly briefed and included in the refresher training of the ATCOs.

7.3.5.1.3 Separation Delivery Tool Failure

The following conclusions related to the separation delivery tool procedure were captured during the simulation:

- The procedure defined for the management of a separation delivery tool failure (see 7.1.3.2.2.3) was found to be satisfactory and no further modifications to the procedure rules are required at this current stage.
- The ITM ATCO must be aided by an assistant to help with the procedures of the separation delivery tool failure
- The ITM ATCO must communicate to the TWR ATCO the last flight in the sequence remaining that will be performing an IGS-to-SRAP approach (intercepting the upper glide) in order for the TWR to monitor the RECAT-EU + 3NM separations if applicable.
- The ATCOs must be able to access the RECAT-EU and the RECAT-EU + 3NM separation tables easily in the event of a separation delivery tool failure.
- An alert / status indicator shall be shown on the TWR and APP controllers' HMI when the separation delivery tool fails.
- This procedure must have extensive training. It must be included in the regular non-nominal/emergency training.

7.3.5.2 Conclusions on technical feasibility

7.3.5.2.1 HMI

The following conclusions related to the HMI were captured during the simulation:

- Additional information is desired by the participants to visualise the vertical position of the aircraft, such as Vertical Speed information or Approach Path Monitoring. This will help the ATCOs to identify any aircraft that intercept the wrong glideslope and to identify any pilot initiated missed approaches. This should be further investigated locally.
- An alert / status indicator shall be shown on the TWR and APP controllers' HMI when the separation delivery tool fails.

7.3.5.2.2 Separation Delivery Tool

The following conclusions related to the separation delivery tool were captured during the simulation:

- The separation delivery tool is useful, acceptable, trusted and supports the IGS-to-SRAP approach procedures during non-nominal situations.
- IGS-to-SRAP arrival procedures <u>during high traffic density</u> would not be possible without the separation delivery tool.

7.3.5.2.3 Wrong Glideslope Alert

The following conclusions related to the wrong glideslope alert were captured during the simulation:

- The wrong glideslope alert is useful, necessary and suitable for IGS-to-SRAP approach procedures. The design of the wrong glideslope alert was clear, immediately noticeable and contained all the required information.
- A requirement must be derived stating that the wrong glideslope alert must be sufficiently reliable.

7.3.5.3 3. Conclusions on performance assessments

7.3.5.3.1 Safety

The following conclusions related to the safety performance for non-nominal situations with IGS-to-SRAP arrival procedures were captured during the simulation:

- The procedures for non-nominal situations during IGS-to-SRAP arrival procedures do not cause any safety concern provided that the safety requirements [39] derived from the simulation findings are met. Further details can be found within the Safety Assessment Report (SAR) [40].

7.3.5.3.2 Human Performance

The following conclusions related to the human performance for non-nominal situations with IGS-to-SRAP arrival procedures were captured during the simulation:

- Workload is high but tolerable. It was as expected for non-nominal situations with IGS-to-SRAP approach procedures.
- The situational awareness was sufficient for the procedures of non-nominal situations with IGS-to-SRAP approach procedures.
- Non-nominal situations will always increase the task load and are never easy to manage. Extensive training will be required for each procedure and for the separation delivery tool.
- Teamwork and coordination is essential. During the separation delivery tool failure, the workload for the ITM sector is too high. The ITM ATCO will require an assistant to help them with the procedures such as checking the separation between pairs and identifying which aircraft must be sent to go-around. The APP sector must also communicate to the TWR sector the last aircraft in the sequence that will perform a IGS-to-SRAP approach. This being the sequence immediately after the separation delivery tool failure and the final aircraft that will fly the upper glideslope until the tool and nominal operations return. During the wrong glideslope alert, the APP sector should communicate to the TWR whether an aircraft triggered a glide alert before it is transferred to TWR in case that aircraft is not flying on the normally-expected glide (for example if a Heavy aircraft is flying on IGS-to-SRAP).
- The following items are required for the transition of IGS-to-SRAP procedures into implementation:

- the procedure to manage an alert caused by an aircraft intercepting the wrong glideslope should be regularly briefed and included in the refresher training.
- the procedure to manage a go-around or missed approach should be regularly briefed and included in the refresher training.
- the procedure to manage the failure of the separation delivery tool should be included in the regular non-nominal/emergency training.
- Extensive training will be required to become confident with the IGS-to-SRAP concept for the management of non-nominal situations.

7.3.6 Recommendations

This section contains the recommendations following the validation exercise. The following actions are the recorded suggestions of the participants supported by findings of the data analysis.

The following recommendation is linked to the management of the non-nominal situations, which were the objectives of R01:

- ANSPs should locally consider the necessary tools and information required in order to best detect deviations from the glideslopes during deployment phases. These should help during the non-nominal situations: go-around/missed approach and wrong glideslope alert. The participants recommended that the APP and TWR sector have a tool to plot the vertical position of the aircraft, such as Vertical Speed information or Approach Path Monitoring. Equally, an alert when aircraft perform a pilot initiated missed approach would be desirable for all circumstances; this is an existing problem.
- For the wrong glideslope alert, the rule where aircraft with RECAT-EU wake turbulence categories CAT-A, CAT-B and CAT-C should be assessed and improved in terms of whether they should be able to intercept the upper glideslope for IGS-to-SRAP operations such that the rule is less penalising.

Some additional recommendations arose that were not linked to the objectives of R01, and are already covered by requirements:

- For the separation delivery tool, additional information has been recommended. The wake/MRS indicators to always be shown is desired by the participants. Therefore, when the ROT is the most constraining spacing, the wake/MRS indicators should also be shown because wake is a safety issue whereas ROT is useful but not as safety critical.
- The interception points for the two glideslopes on the HMI should be locally considered to ensure that they are clear and distinguishable.

8 Validation Exercise EXE-14.5-V3-VALP-R10 Report

8.1 Summary of the Validation Exercise EXE-14.5-V3-VALP-R10 Plan

8.1.1 Validation Exercise description, scope

The scope of the validation exercise R10 addresses IGS-to-SRAP (and SRAP) runway markings solutions from pilots' perspective via flight cockpit simulations using high level professional Level D/Type 7 flight crew training simulator. The simulator of the type Airbus A319 has full motion, control loading and a configurable visual system.

Figure 36: A319-100 Full Flight Simulator

The simulator is certified according to EASA CS-FTD Level D. The simulator is equipped with the following avionic components and systems:

<u>Aircraft Systems</u>

Engine	General Electric CFM56-5A5, 23500 lbs T/O Thrust
APU	APS 3200, Hamilton Sundstrand Corp (Software simulation)

<u>Autoflight System</u>

FMGS	S7AC13, Thales Avionics/Smiths (Full GPS, Orig. a/c boxes)
FCU	M11, Thales Avionics Sa (Orig. a/c box)

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FAC	CR102, Thales Avionics Sa (Software simulation)
MCDU	Thales Avionics/Smiths (Orig. a/c box)

Electronic Flight Control System

ELAC	L93, Thales Avionics Sa (Orig. a/c boxes)
SEC	L123, Thales Avionics Sa (Orig. a/c boxes)
FCDC	L53, LITEF GmbH (Software simulation)

Electronic Instrument System

DMC	V70, DIEHL AEROSPACE GmbH (Orig. a/c boxes)
FWC	H2F7, Airbus France (Orig. a/c boxes)
DU	FCD66, Thales Avionics Sa (Orig. a/c boxes)
SDAC	H1-D1, Airbus France (Software simulation)
TCAS II	7.1, Honeywell (Software simulation)
ACARS	AMU MK I, Honeywell International Inc. (Orig. a/c box)
EGPWS	MK V, Honeywell International Inc. (Orig. a/c box)

Figure 37: Flight Deck Airbus A319 FFS

The visual system is modified to simulate a second runway threshold and aiming point used for SRAP and IGS-to-SRAP operations including:

- one "normal" threshold with runway markings (incl. aiming point and touchdown zone markers), CAT II/III approach light system, PAPI, and Touchdown Zone (TDZ) Lights

- a second threshold located 1100m further beyond the normal threshold, with runway markings, a proposed specific CAT I approach light system (along the runway centreline), PAPI and Touchdown Zone Lights
- Centreline Lights
- Runway Edge and Runway End Lights.

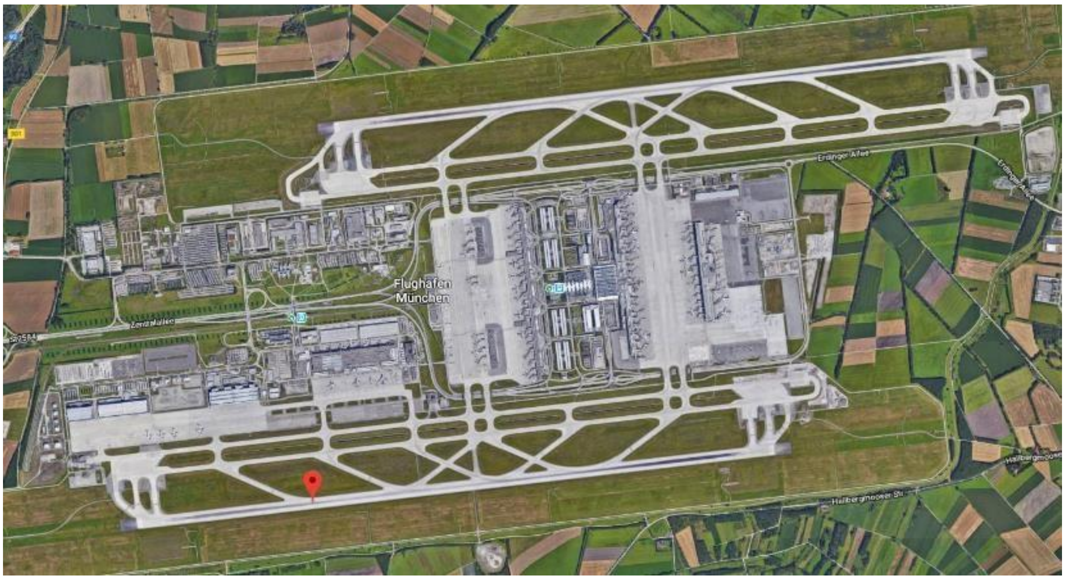

Figure 38: Position of the second threshold

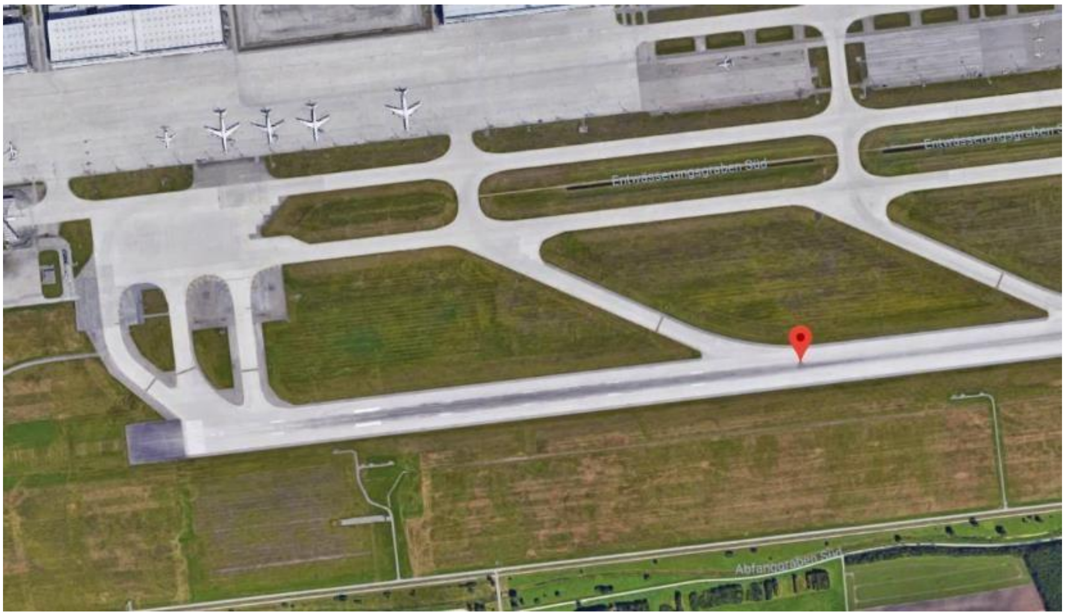

Figure 39: Position of the second threshold in detail

8.1.1.1 Lighting options

The environment used is Munich Airport with the added second threshold on runway 08R. The installed approach light system for this runway represents an ideal setup according to ICAO Annex 14 and EASA CS-ADR (certification specification for aerodrome design) requirements for a CAT II/III full approach light system. The runway has a length of 4000m and there is a possibility to switch between two configurations:

1. **steady** - all approach lights, except the TDZ lights, are illuminated at the same time for both thresholds, and
2. **switching** - approach lights are illuminated, with the touchdown zone lights and flashing approach lights along the runway centreline for one threshold only, or for the other, depending on the incoming landing traffic and intended threshold/aiming point.

Figure 40: Steady lighting configuration Rwy 08R/09R activated

2433 

2434 Figure 41: Switching lights with primary threshold Rwy 08R activated

2435 

2436 Figure 42: Switching lights with secondary threshold Rwy 09R (SRAP) activated

In case of switching mode, the simulator can activate the lights as if an aircraft was preceding the flown aircraft and approaching to the other threshold. Consequently, the pilot experienced during his approach several switches between the 08R and the 09R approach lights depending on the threshold used by the number one aircraft on final approach.

8.1.1.2 Charts

Charts for SRAP and IGS-to-SRAP approach are developed based on existing EDDM ones (Jeppesen). They include in particular:

- the vertical profile to the second threshold with the remaining runway length
- a note explaining that the procedure is a SRAP or IGS-to-SRAP one
- a note giving the type of marking
- a note giving the location of the PAPI for the SRAP or IGS-to-SRAP approach.

A set of paper charts are given to pilots. The charts are attached in the Annex of the report.

8.1.1.3 Phraseology

In addition of the 2 pilots, the scientific test flight instructor from Lufthansa Aviation Training plays the controllers' role, giving in particular the clearances for approach and landing. The phraseology used is the one developed in PJ02-02 in SESAR 2020 W1 and already evaluated by controllers in that project. It considers changes suggested during PJ02-02.

Approach clearance is given before releasing the simulator in order to give time to pilots for briefing

"ECTL021, Cleared ILS approach Runway 09R (or Cleared RNP approach Runway 09R), you are n°5 on final, preceding is B767 on lower glide"

The **landing clearance** is as follows:

"ECTL021, cleared to land RWY 09R, second threshold, wind xxx kts"

8.1.1.4 Scenarios

In each of the 12 flight simulation sessions, 16 runs were flown as follows:

- 2 landings to the nominal threshold (ILS08R) with a 3° glide slope
- 10 landings to the second threshold (ILS09R) with a 3° glide slope – SRAP procedure
- 4 landings to the second threshold (RNP09R) with a 3.5° glide slope – IGS-to-SRAP procedure.

The different conditions of each flight are given in Table 17 below.

The results, and in particular pilots' feedback from all 16 runs are considered as usable for solution PJ.02-W2-14.5 procedures.

The following table represents the sequence of the scenarios.

Run	ALS	Approach	THR	Wind	Visibility	weather
1	steady	ILS09R	09	calm	1500m	Light Rain

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2	steady	ILS08R	08	calm	1500m	Light Rain
3	steady	ILS09R	09	350/30	2500m	Light Rain
4	steady	ILS09R	09	350/30	2500m	Light Rain
5	steady	ILS09R	09	350/30	1500m	Heavy rain
6	steady	ILS09R	09	350/30	1500m	Heavy rain
7	steady	RNP09R	09	calm	1500m	Heavy rain
8	steady	RNP09R	09	calm	2500m	Light Rain
9	switching	ILS08R	08	calm	CAVOK	
10	switching	ILS09R	09	calm	CAVOK	
11	switching	ILS09R	09	350/30	2500m	Light Rain
12	switching	ILS09R	09	350/30	2500m	Light Rain
13	switching	ILS09R	09	350/30	1500m	Heavy rain
14	switching	ILS09R	09	350/30	1500m	Heavy rain
15	switching	RNP09R	09	calm	1500m	Heavy rain
16	switching	RNP09R	09	calm	2500m	Light Rain

Table 17: Sequence of flown scenarios in exercise R10

8.1.1.5 Scope of EXE-14.5-V3-VALP-R10

The aim of this exercise was:

- To evaluate the proposed solutions for runway lightings
- To confirm that the pilot tasks performance when flying a and IGS-SRAP approach is not negatively impacted
- To confirm that IGS-to-SRAP do not negatively affect safety from the perspective of the crew
- To confirm that IGS-to-SRAP are operationally feasible from flight crew perspective.

The simulator has data recording capabilities allowing extraction of the flown 4D trajectory and conversion to Excel (or CSV) format for each flown scenario. Video recordings was made of the aircraft windscreen (external visual view) during each scenario.

The approach to the normal threshold is an ILS approach. The approach to the second threshold is an ILS and RNP APCH. This means that the simulator allows programming of an ILS with touchdown aiming point beyond the normal threshold and a second ILS to land on the second touchdown aiming point beyond the second threshold.

An aircraft database was provided and loaded in the simulator containing the ILS approach to the normal threshold, the ILS approach to the second threshold and the RNP APCH to the second threshold. Both ILS approaches have a 3 degree glide slope while the RNP APCH has a 3.5 degree final approach path.

Within the exercise several stakeholders have been involved. The stakeholder's expectations are given in the table below.

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Stakeholder	Involvement	Why it matters to stakeholder
Airspace Users	Airspace Users (Airline Pilots) will be involved in the validation sessions	Airspace Users are interested in assessing the impact of SRAP and IGS-to-SRAP procedures on crew from safety and HP point of view.
ANSPs	No involvement in the validations.	ANSPs also need evidence to show that the SRAP and IGS-to-SRAP procedures are operationally feasible.
Airport Operators	No involvement in the validations.	Airport Operators are interested in the validation results of the exercise because SRAP concept could have a positive effect of noise reduction in the areas close to the airports. SRAP and IGS-to-SRAP may provide added value to alleviate any existing or future stringency on capacity due to noise and then improving quality of service to AUs.
Air Transport industry	Lufthansa Aviation Training is running the exercise.	Lufthansa need to assess the selected design solution to fly SRAP and IGS-to-SRAP approaches and in assessing the impact on the crew on safety and HP point of view. Expected positive effects of SRAP and IGS-to-SRAP concept on noise footprint, could give a competitive advantage to aircraft equipped with SRAP and IGS-to-SRAP capability.
European Commission	Direct participation through SJU.	EC is interested into improving the main KPA related the ATM. Regarding PJ02-02 EC is interested in Capacity and Environment KPA possible benefits coming from SRAP and IGS-to-SRAP concept.
EUROCONTROL	EUROCONTROL is leading PJ02-02.	EUROCONTROL is interested on the validation results of the exercise because they need evidence to show that safety will be maintained or improved. EUROCONTROL also needs evidence to show that the SRAP and IGS-to-SRAP procedures are operationally feasible from pilots' side.

Table 18: stakeholders' expectations of EXE-14.5-V3-VALP-R10

8.1.2 Summary of Validation Exercise EXE-14.5-V3-VALP-R10 Validation Objectives and success criteria

Section 8.3.1 contains a summary of the validation objectives and success criteria, with the achieved results. To avoid duplication, the table is not repeated here.

8.1.3 Summary of Validation Exercise EXE-14.5-V3-VALP-R10 Validation scenarios

EXE-14.5-V3-VALP-R10 addresses SRAP and IGS-to-SRAP runway lighting solutions from pilots' perspective. The exercise is performed using an Airbus A319-100 high level professional Level D/Type 7 flight crew training simulator without integration in a real ATM traffic environment.

In the reference scenario, the published standard ILS approach (conventional slope of 3 °) to the primary threshold Rwy 08R was flown (primary). In the solution runs, SRAP and IGS-to-SRAP approaches were flown. SRAP approaches have been guided by an ILS to Rwy 09R, IGS-to-SRAP by RNAV procedures to Rwy 09R.

Twelve sessions involving two airline pilots have been take place. Each session encompassed:

- A briefing session where the concepts to be evaluated be explained to the pilots
- 16 runs described in the table below, each followed by a questionnaire
- 1 post session questionnaire followed by a post session debriefing

Run	ALS	Approach	THR	ILS	Wind	Visibility	weather
1	steady	ILS09R	09	IMSF / 110.75 / 3°	calm	1500m	Light Rain
2	steady	ILS08R	08	IMSF / 110.75 / 3°	calm	1500m	Light Rain
3	steady	ILS09R	09	IMSF / 110.75 / 3°	350/30	2500m	Light Rain
4	steady	ILS09R	09	IMSF / 110.75 / 3°	350/30	2500m	Light Rain
5	steady	ILS09R	09	IMSF / 110.75 / 3°	350/30	1500m	Heavy rain
6	steady	ILS09R	09	IMSF / 110.75 / 3°	350/30	1500m	Heavy rain
7	steady	RNP09R	09	IMSF / 110.75 / 3.5°	calm	1500m	Heavy rain
8	steady	RNP09R	09	IMSF / 110.75 / 3.5°	calm	2500m	Light Rain
9	switching	ILS08R	08	IMSF / 110.75 / 3°	calm	CAVOK	
10	switching	ILS09R	09	IMSF / 110.75 / 3°	calm	CAVOK	
11	switching	ILS09R	09	IMSF / 110.75 / 3°	350/30	2500m	Light Rain
12	switching	ILS09R	09	IMSF / 110.75 / 3°	350/30	2500m	Light Rain
13	switching	ILS09R	09	IMSF / 110.75 / 3°	350/30	1500m	Heavy rain
14	switching	ILS09R	09	IMSF / 110.75 / 3°	350/30	1500m	Heavy rain

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15	switching	RNP09R	09	IMSF / 110.75 / 3.5°	calm	1500m	Heavy rain
16	switching	RNP09R	09	IMSF / 110.75 / 3.5°	calm	2500m	Light Rain

Table 19: Scenario List (in blue, IGS-to-SRAP runs)

During the runs, pilot-flying and pilot-non-flying was switching after each run between the two crewmembers. For switching configuration runs, at the beginning of the run, the simulator will be number 5 in the landing sequence. The four aircraft in front of it will land alternatively on second and first threshold as shown in the figure below.

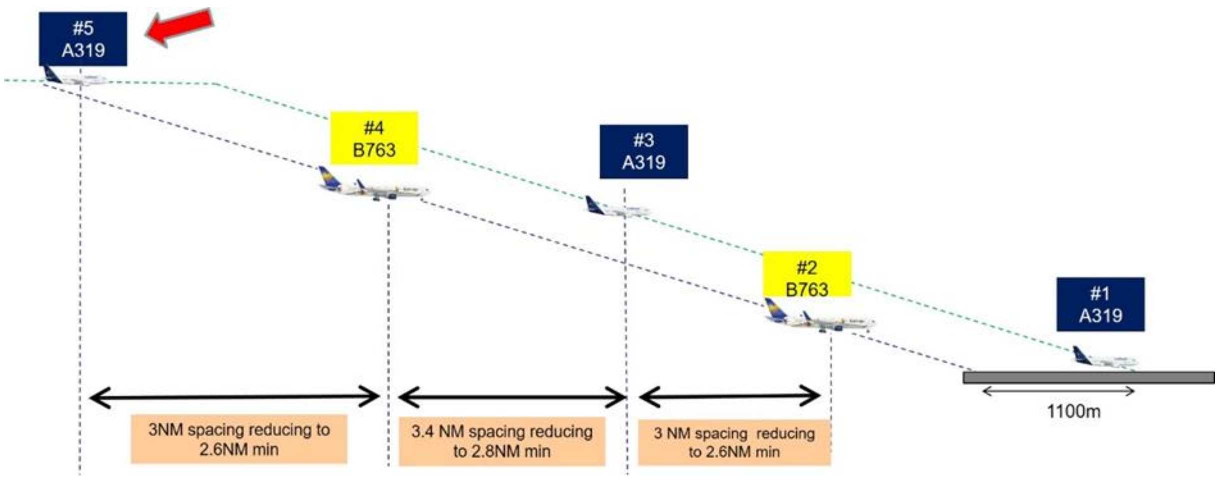

Figure 43: Landing sequence in switching configuration

8.1.4 Summary of Validation Exercise EXE-14.5-V3-VALP-R10 Validation Assumptions

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
R10-ASS1	IGS-to-SRAP landing minima	Procedure in place	Pilots are expected to use the landing minima from the charts (no increase to be applied by pilots).	As per IGS-to-SRAP concept definition, if there is an impact on landing minima for IGS-to-SRAP, it should be transparent for the pilots.	Approach	Interoperability	OSED	n/a	PJ02-W2-14.5	MEDIUM

Table 20: R10 Validation Assumptions overview

8.2 Deviation from the planned activities

There were no deviations from the planned activities.

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8.3 Validation Exercise EXE-14.5-V3-VALP-R10 Results

8.3.1 Summary of Validation Exercise EXE-14.5-V3-VALP-R10 Results

The table below provides an overview of the Validation Objectives and the Success Criteria as mentioned in the EXE-14.5-V3-VALP-R10 (EUROCONTROL) Validation Plan. For each objective the table provides the paragraph numbers in which the results for each objective are discussed. Finally, the table indicates for each objective whether the validation objective analysis status is OK, partially OK or NOK.

Validation Exercise #05 Validation Objective ID	Validation Exercise #05 Validation Objective Title	Validation Exercise #05 Success Criterion ID	Validation Exercise #05 Success Criterion	Sub-operating environment	Exercise #05 Validation Results	Validation Exercise #05 Validation Objective Status
OBJ-14.5-V3-VALP-0203	To confirm that IGS-to-SRAP does not negatively affect safety from the perspective of the crew	CRT-14.5-V3-VALP-0203-001	There is evidence that the level of operational safety is maintained and not negatively impacted under IGS-to-SRAP procedures compared to the reference scenario, from the perspective of the crew	Aircraft, Crew	See A 3.2.1	OK
OBJ-14.5-V3-VALP-0204	To confirm that the Second Runway Aiming Point (SRAP) is operationally feasible from crew perspective	CRT-14.5-V3-VALP-0204-001	Pilot succeeds to manage IGS-to-SRAP operation by applying existing SOPs.	Aircraft, Crew	See A 3.2.2	Ok
		CRT-14.5-V3-VALP-S0204-002	Pilots are confident when flying IGS-to-SRAP operation			
OBJ-14.5-V3-VALP-0301	To confirm that the phraseology used by ATCO and Flight Crew for IGS-to-SRAP is clearly understandable	CRT-14.5-V3-VALP-0301-002	Proposed phraseology does not lead to errors related to perception & interpretation of	Aircraft, Crew	See A.3.2.3	OK

Validation Exercise #05 Validation Objective ID	Validation Exercise #05 Validation Objective Title	Validation Exercise #05 Success Criterion ID	Validation Exercise #05 Success Criterion	Sub-operating environment	Exercise #05 Validation Results	Validation Exercise #05 Validation Objective Status
			auditory information.			
		CRT-14.5-V3-VALP-0301-003	Pilots accept and judge the proposed phraseology as being appropriate for all encountered operating			

Table 21: Validation Results for Exercise R10

8.3.2 Analysis of Exercise EXE-14.5-V3-VALP-R10 Results per Validation objective

The sections below provide the results per validation objective.

8.3.2.1 OBJ-14.5-V3-VALP-0203 Results

This chapter presents the results on the subjective feeling of safety recorded after each flight. The pilots were asked to rate if they think that their perceived level of safety decreased, stayed the same or increased compared to today's operation.

The following graphs indicate the perception of safety after all runs for the pilot flying and the pilot non-flying respectively.

Overall, it can be summarized that a very little decrease of safety was recorded. There is no specific tendency identifiable for the solution with steady lighting or switching lighting.

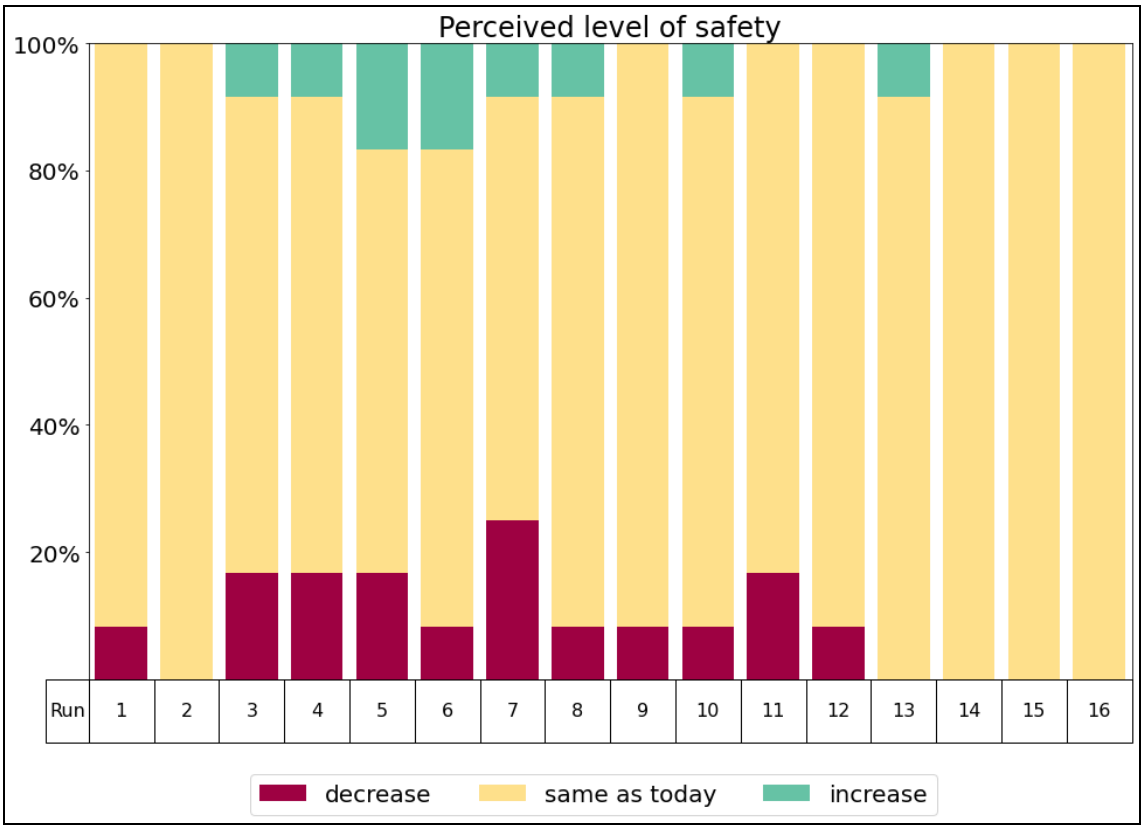

Figure 44: Perceived level of safety after all runs Pilot flying

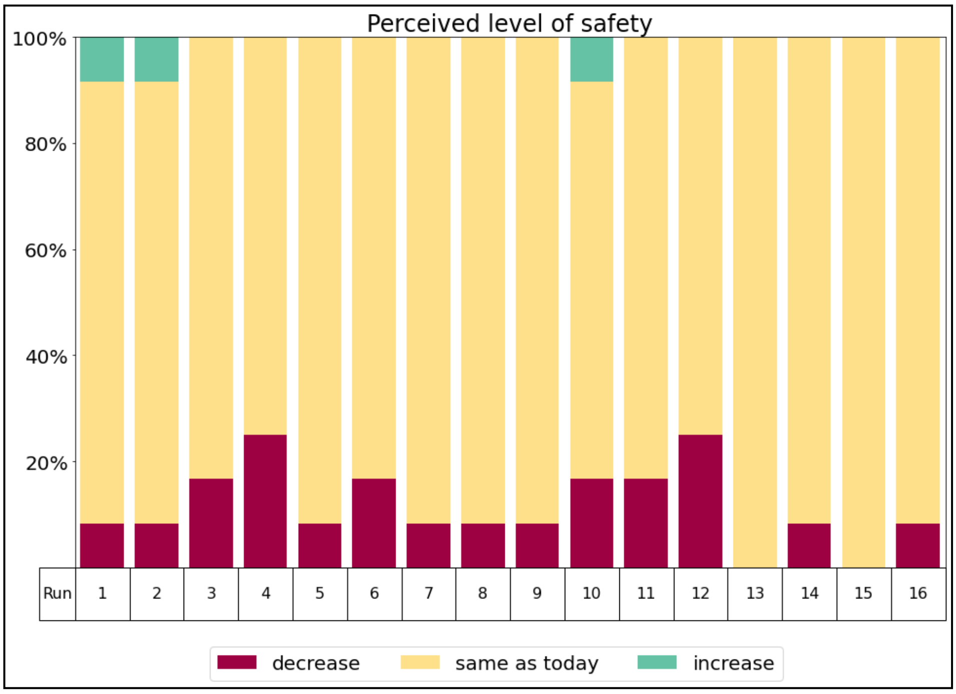

Figure 45: Perceived level of safety after all runs Pilot flying

Figure 46 provides a comparison between all scenarios with calm wind and heavy crosswind conditions. Pilot 1 and pilot 2 indicates the pilot flying (1) and it can be determined that overall crosswind has an influence on the perceived level of safety. However, there is no difference between the steady or the switching solution.

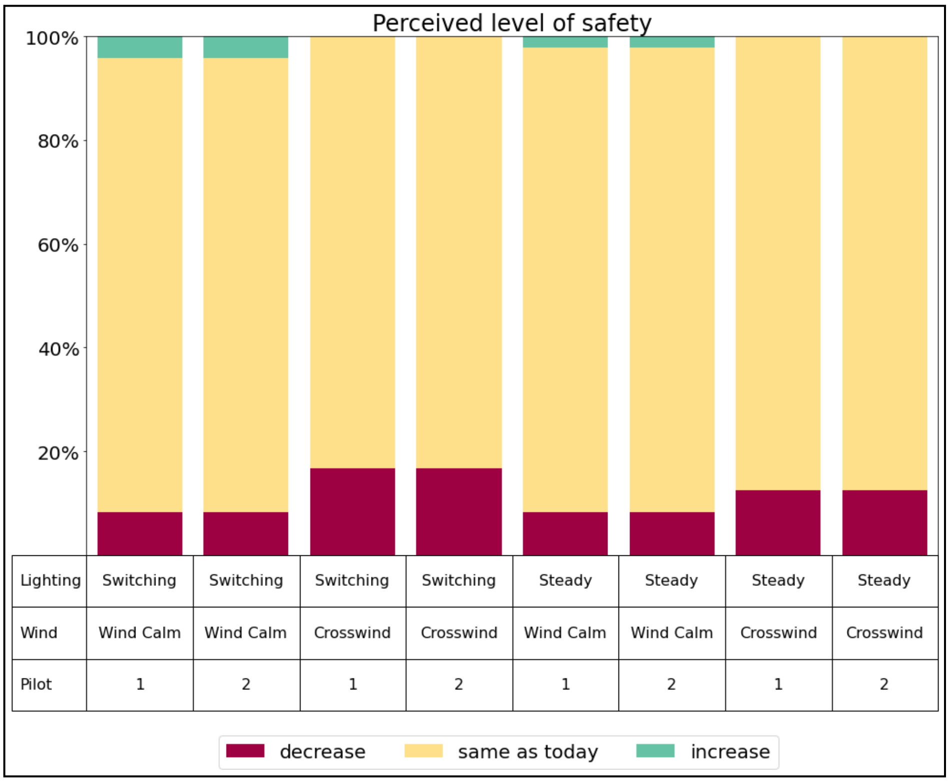

Figure 46: Perceived Level of Safety comparing Wind Conditions

Figure 47 provides an overview about the flown scenarios comparing the type of approach – an ILS approach with 3° and a RNP approach with 3.5° slope. Again, pilot 1 represents pilot flying, pilot 2 represents pilot-non-flying. No statistically significant result can be perceived – neither for any of the two types of approach nor the type of lighting (steady – switching).

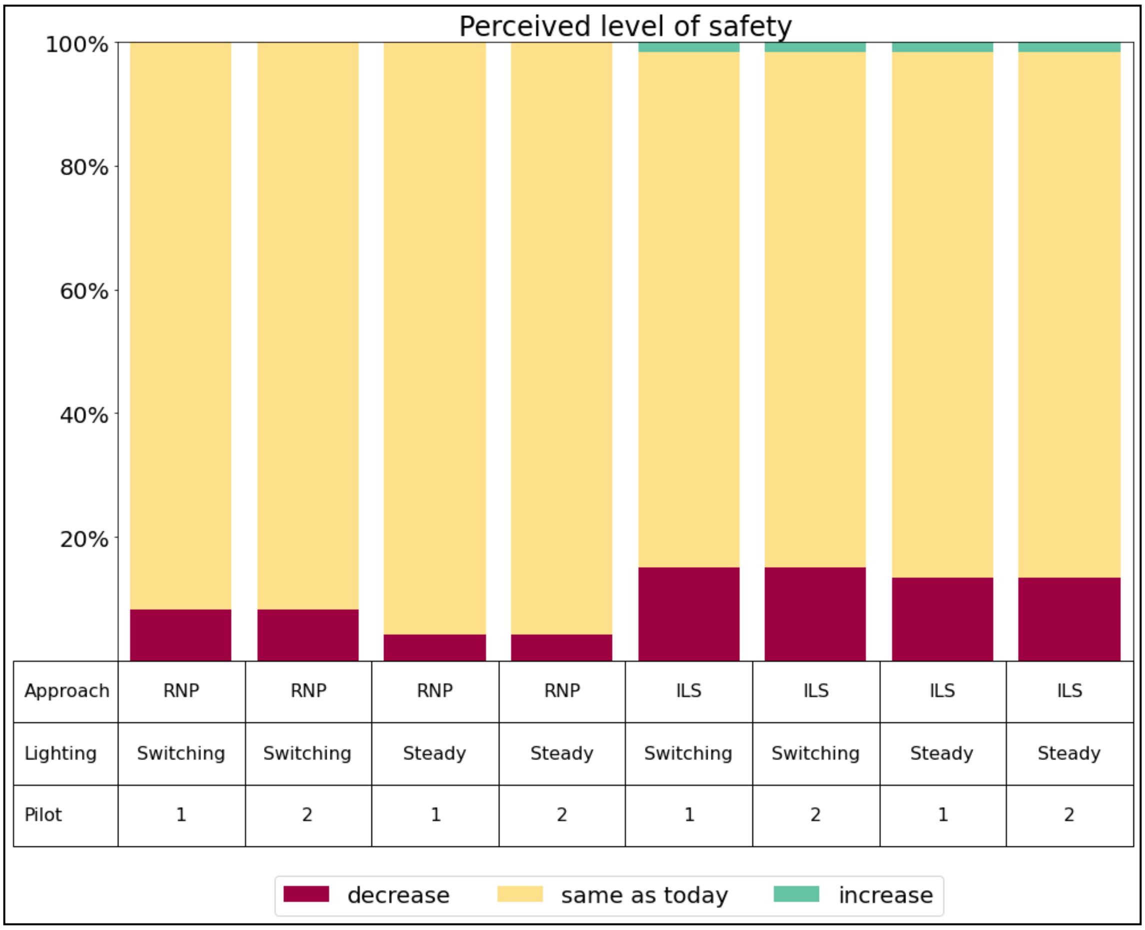

Figure 47: Perceived Level of Safety comparing Type of Approach

8.3.2.2 OBJ-14.5-V3-VALP-0204 Results

This section outlines the results on the question of operational feasibility.

The pilots filled a questionnaire after the simulation where they were asked questions regarding the standard operating procedures (SOPs), and the acceptability of the different concepts.

More than 95% of the pilots indicated that they executed all tasks in line with the SOPs and that they can imagine using the concept of Secondary Runway Aiming Point in an every-day operation. Some pilots stated that there already some airports using displaced threshold which is causing no operational problems. Consequently, it can be preliminary concluded that the concept is operational feasible.

The visual indications are one of the factors contributing to operational feasibility and are therefore reported hereafter.

PAPI

The pilots were asked several questions about the visual indications like PAPI, runway marking and the approach light configuration.

8.3.2.2.1 PAPI

The graph below indicates the answer to the question whether the PAPI is acceptable to the pilots. Pilots were asked to answer to the question "The PAPI indications were acceptable to me" with a rating from 1 "strongly disagree" to 5 "strongly agree".

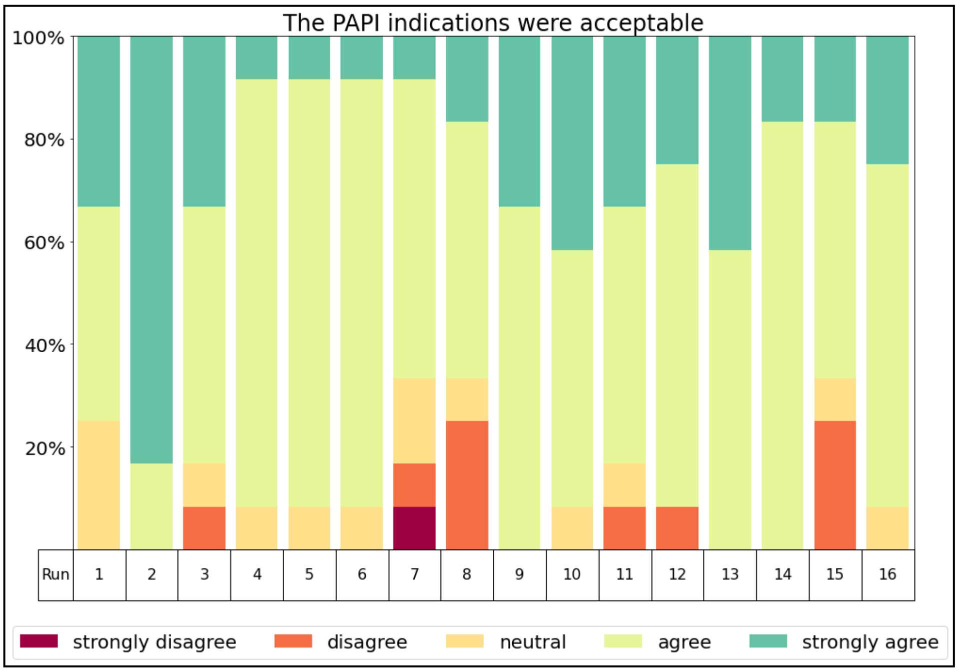

Figure 48: Acceptability of different PAPI settings for the pilot flying

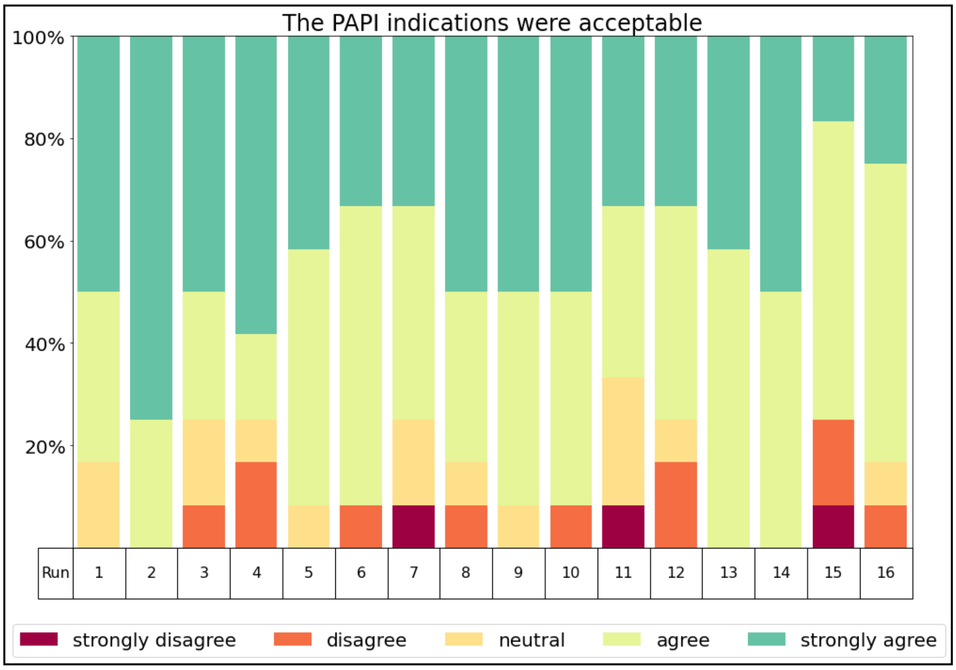

Figure 49: Acceptability of different PAPI settings for the pilot-non-flying

Based on the overall result the PAPI was acceptable – at least 80% of the pilots stated for all scenarios 80% "strongly agree" and "agree". Only a few pilots stated the PAPI indications were not acceptable.

Looking in more detail to the scenarios, Figure 50 provides a comparison between the ILS approach with 3° and the RNP approach with 3.5° degree. Pilot 1 represents pilot flying, pilot 2 represents pilot-non-flying. A slightly tendency to the 3° approach can be identified. However, for the 3.5° approach slope during the RNP procedure the PAPI on the right side was aligned with the 3.5° slope.

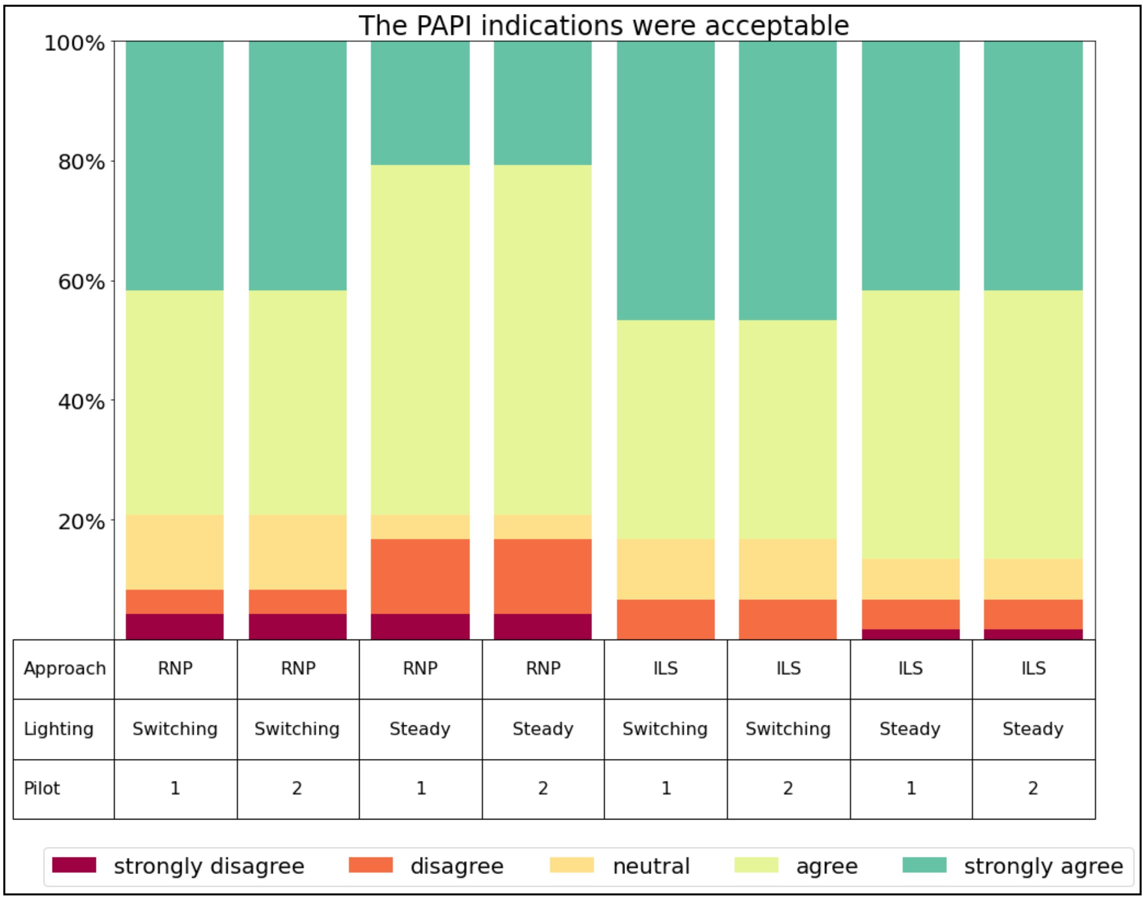

Figure 50: Acceptability of different PAPI settings comparing different approach-types

8.3.2.2.2 Threshold identification

The graph below indicates the answer to the question if the threshold identification were acceptable to the pilots. They were asked to answer to the question "The threshold identification was acceptable to me" with a rating from 1 "strongly disagree" to 5 "strongly agree".

Overall, at least 80% of the pilots during all scenarios stated that the threshold identification was acceptable using "agree" or "strongly agree". A slightly tendency can be identified for "strongly disagree" statements with respect of the scenarios using the steady solution.

However, having a more in-depth view comparing the type of approach (ILS 3° or RNP 3.5°) in Figure 53 the tendency of less acceptability can be identified during the switching scenarios.

Figure 54 provides a comparison between the scenarios with strong crosswind or calm wind. The influence of strong crosswind to the proper identification of the threshold is evident. Pilots stated due to the crap-angle the field of vison of the pilot can be limited. Furthermore, during the switching scenarios the wind-conditions had a stronger influence on the acceptability due to the fact that the respective threshold could be focused only during the short final after the last switch.

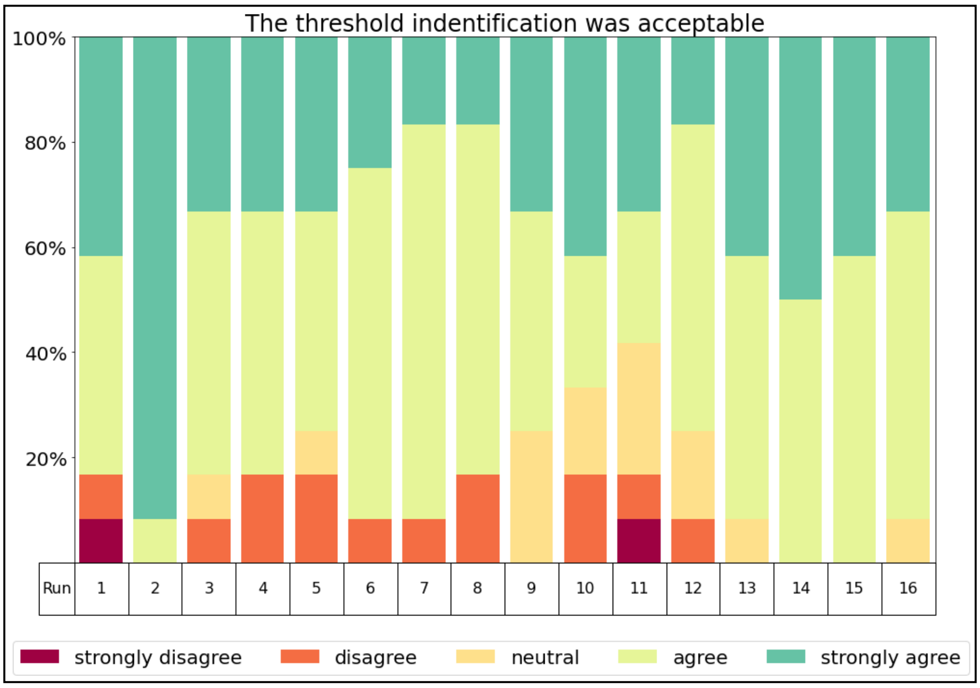

Figure 51: Acceptability of the threshold identification for the pilot flying

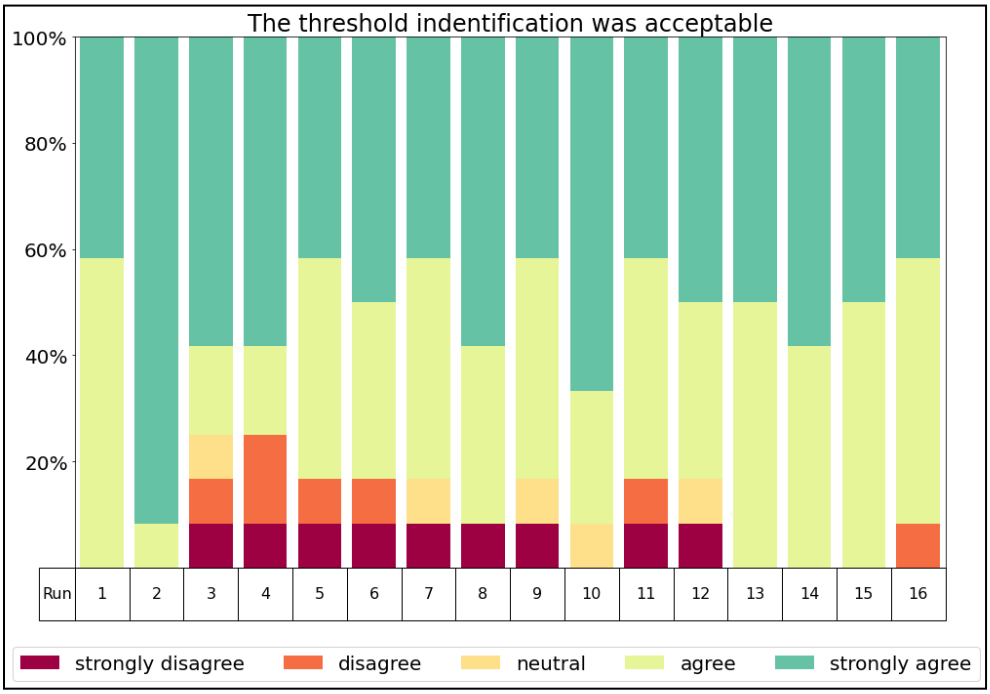

Figure 52: Acceptability of the threshold identification for the pilot-non-flying

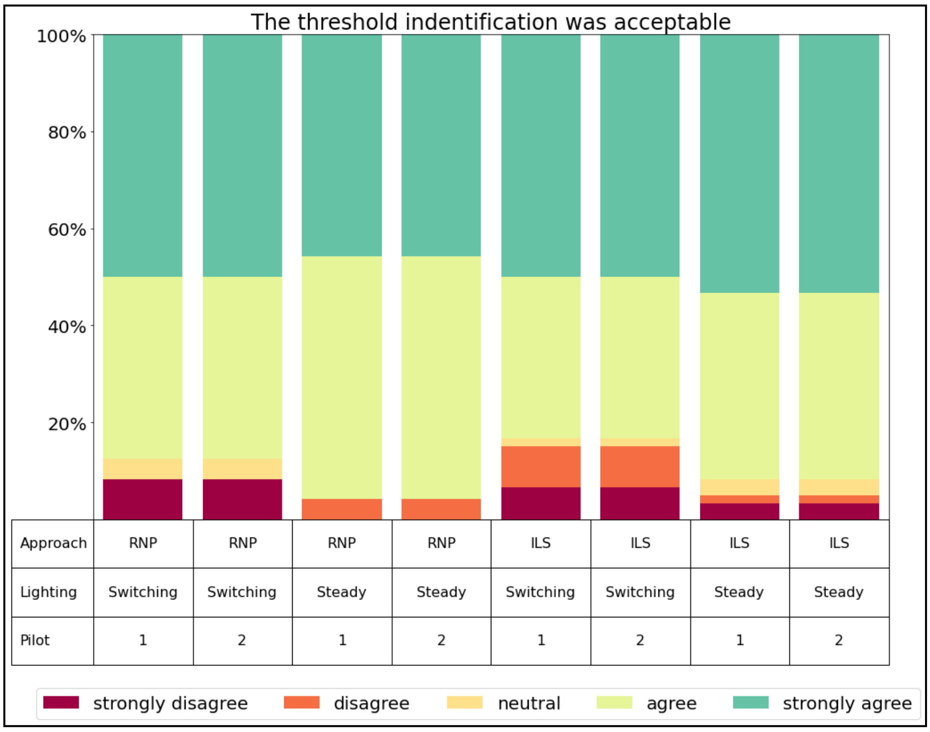

Figure 53: Acceptability of the threshold identification with respect of the type of approach

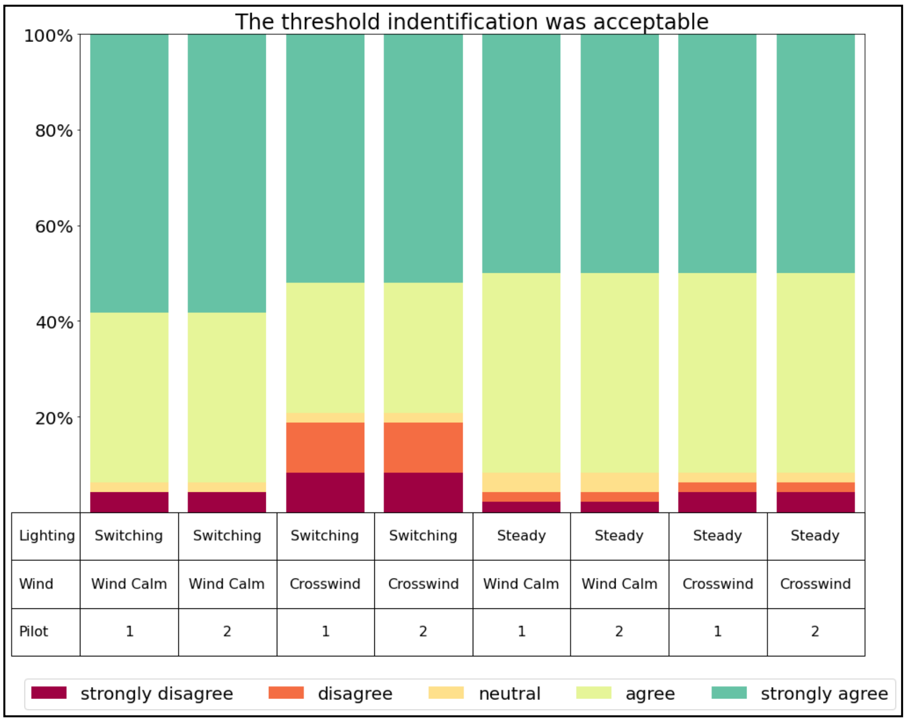

Figure 54: Acceptability of the threshold identification with respect of the wind condition

8.3.2.2.3 Aiming Point

The graphs below indicate the answer to the question if the aiming point identification was acceptable to the pilots. They were asked to answer to the question "The aiming point identification was acceptable to me" with a rating from 1 "strongly disagree" to 5 "strongly agree". The two figures show all scenarios according to the scenario list in Table 17 for pilot flying and pilot-non-flying.

Again, the results show at least 80% of the pilots could accept the threshold identification during all scenarios flown. Overall, it can be noted that the aiming point identification for both options – steady and switching approach lights – is acceptable to the pilots.

Comparing the calm wind and strong crosswind scenarios in Figure 57, no clear tendency could be identified. A slightly less acceptability is markable for the switching configuration in heavy crosswind conditions. However, the difference is not significant compared to the other scenarios.

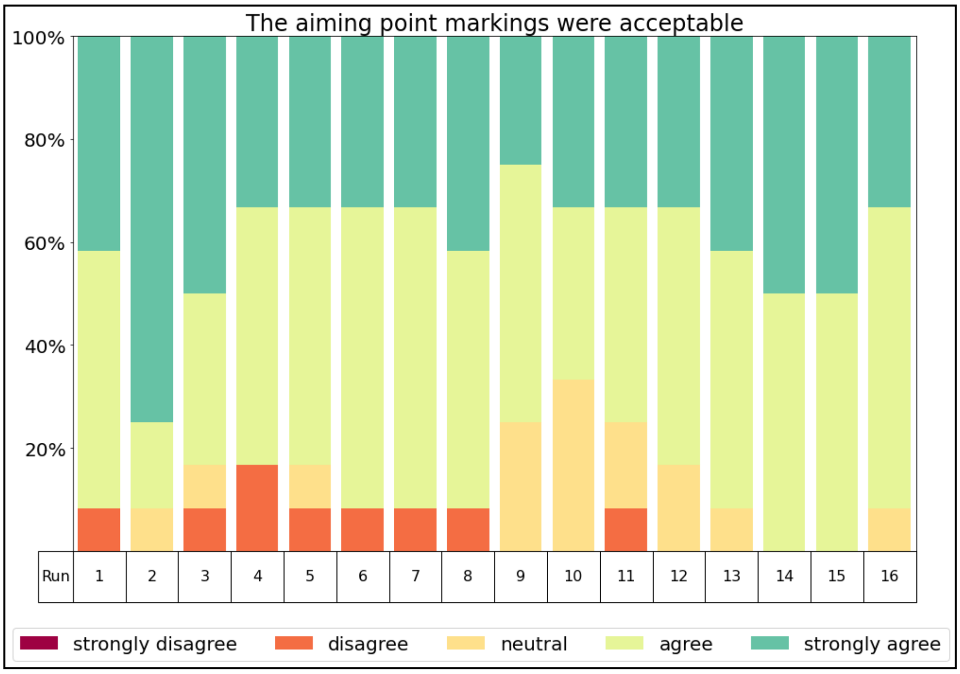

Figure 55: Acceptability of different aiming identification for the pilot flying

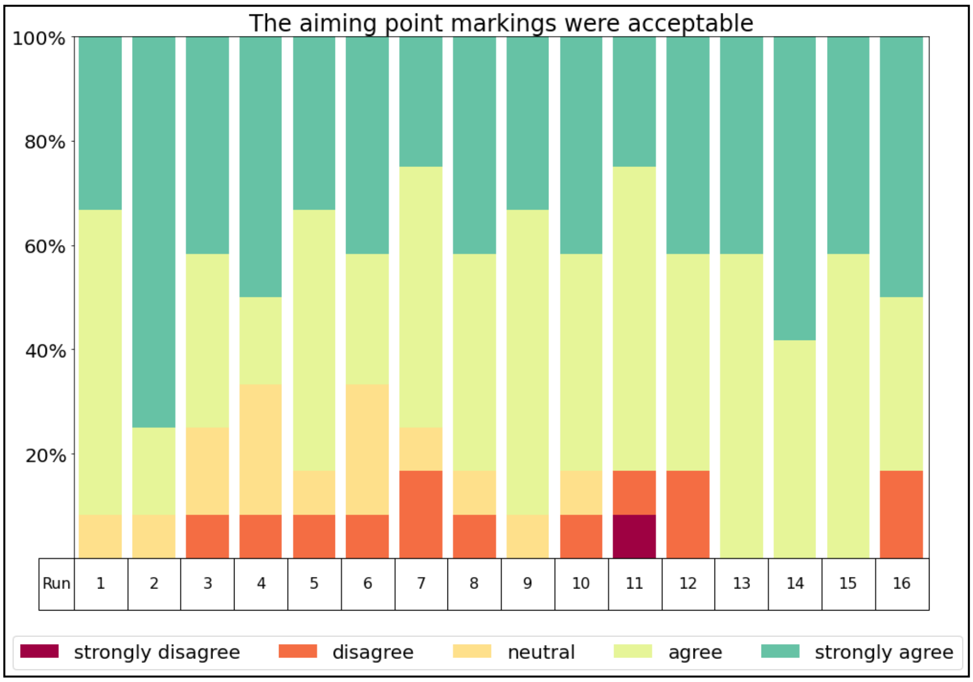

Figure 56: Acceptability of different aiming identification for the pilot non-flying

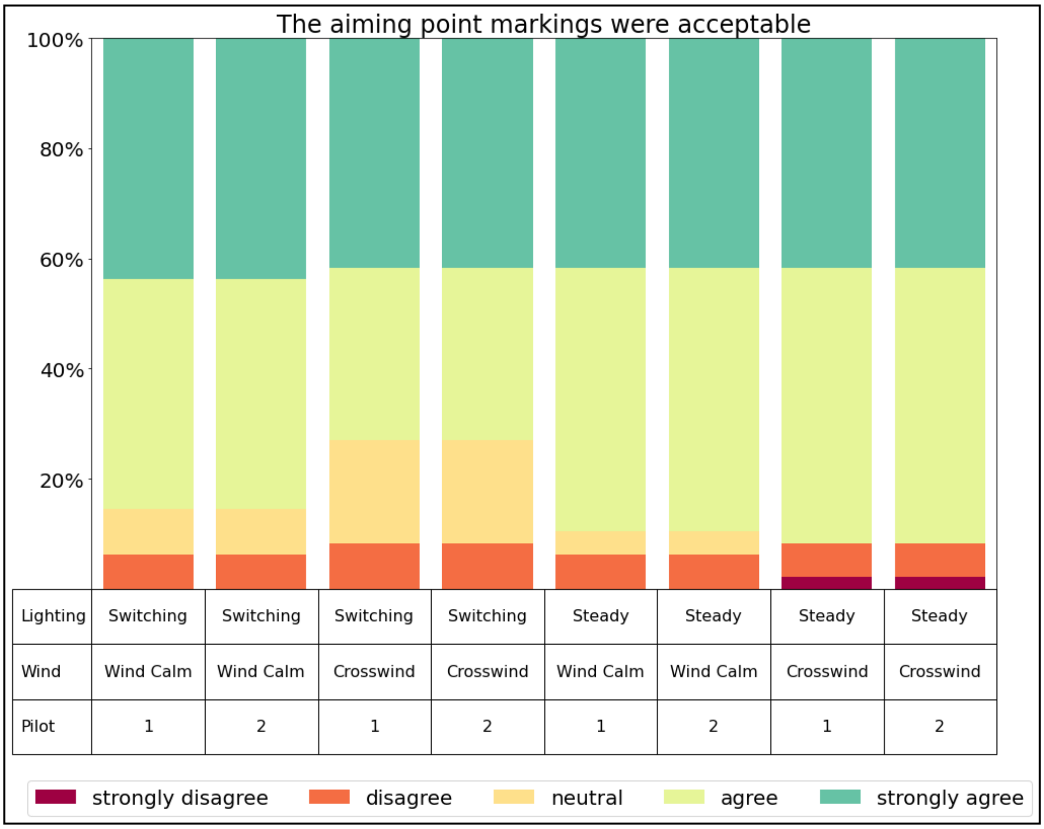

Figure 57: Acceptability of different aiming identification for different wind conditions

After the simulation, the pilots were asked their general feeling on the different marking options. Figure 58 provides the results from the debriefing questionnaire. Both concepts – switching and steady approach lightings – have been accepted as good as the other. However, there is a small tendency to the steady lighting concept.

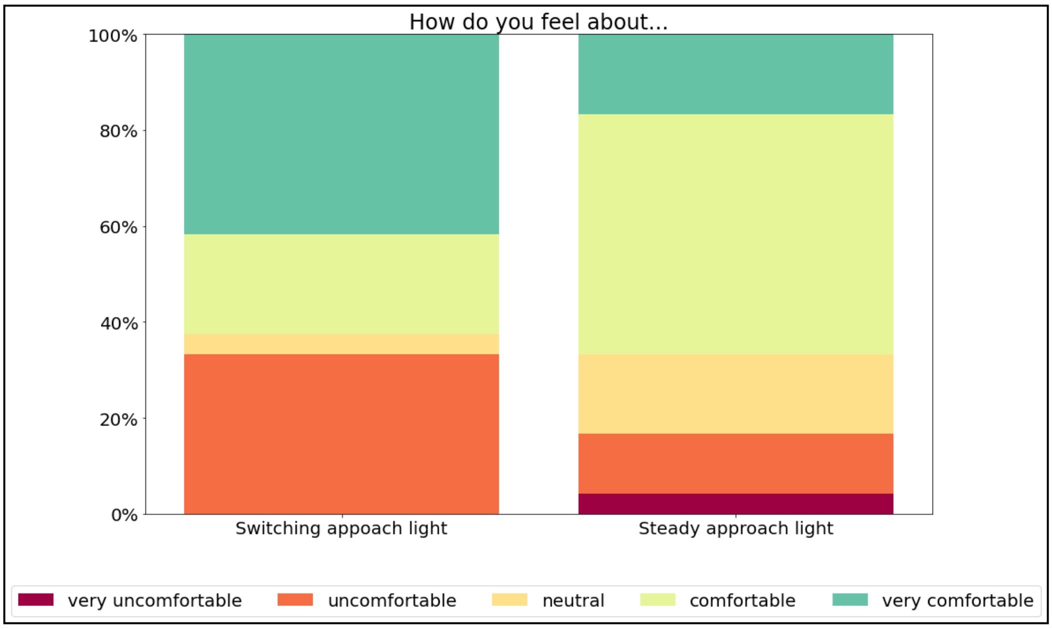

Figure 58: Overall acceptability of Lighting Concept

Furthermore, after the simulations the pilots have been asked which option for the approach lighting configuration they would prefer more – the switching light configuration or the steady light configuration. Figure 59 provides the results from the debriefing questionnaires – the results show a clear tendency to the switching light configuration.

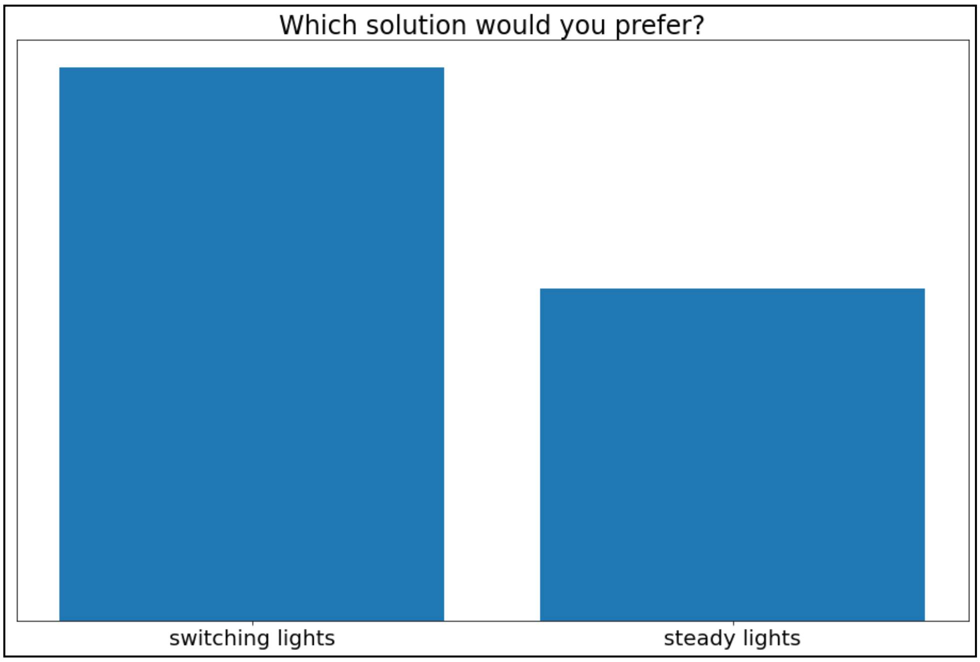

Figure 59: Pilots preference regarding different Approach Light Configurations

These two figures built on the answers from the final questionnaire give the impression of opposite results. From Figure 58, it seems that the steady option is preferred and Figure 59 shows a preference for the switching solution. However, based as well on the discussions during the debriefing sessions, no clear statement favouring one of the options was made. Both options were rated as acceptable and operational feasible during daily operations – even in strong crosswind conditions.

8.3.2.3 OBJ-14.5-V3-VALP-0301 Results

The phraseology used is described in section 8.1.1.3.

The pilots found the phraseology well adapted and giving them useful and necessary information. In particular, all pilots stated that the information from ATC about the preceding aircraft and the flown glide raised their situational awareness regarding the intended approach and related threshold.

No changes were suggested by the pilots.

8.3.3 Unexpected Behaviours/Results

There are no unexpected behaviours to be reported.

8.3.4 Confidence in Results of Validation Exercise EXE-14.5-V3-VALP-R10

8.3.4.1 Level of significance/limitations of Validation Exercise Results

There are no limitations identified, the standard SOP have been applied including ATC, communication, adapted charts and a Level D simulator.

8.3.4.2 Quality of Validation Exercises Results

The simulations were run in a professional Level D certified flight simulator of type Airbus A319. The approaches were flown by certified type rated airline pilots.

8.3.4.3 Significance of Validation Exercises Results

The results of the simulations are operationally significant as they were run using the highest level of realism concerning the cockpit environment and visual system and operated by certified airline pilots.

8.3.5 Conclusions

The aim of this simulation campaign to assess the influence of adverse weather situation with reduced visibility and challenging crosswind conditions.

Overall, the conclusion can be drawn that the pilots found most approaches acceptable and feasible to fly. The general concept for the usage of a second runway aiming point was accepted and the benefits with respect of capacity and improved separation clearly understood. The influence of adverse weather could not be clearly identified. Moreover, most of the pilots stated that they can imagine having the SRAP and IGS-to-SRAP solution in daily operation available.

There was no clear decision for one of the two options. However, according to the first simulation campaign in 2019, there was a transition in acceptability from the steady option in good visibility to the switching option in less visibility.

In good visibility, the pilot can focus longer to the two approach lighting systems and is able to clearly identify his intended threshold. In good visibility, the switching configuration may cause some confusion, especially if the last switch is very late due to preceding traffic. If the visibility becomes shorter the switching configuration becomes more accepted due to the fact, that the steady configuration may cause confusion approaching to the second runway aiming point, overflying the first approach lighting systems. Pilots stated it could be possible to intend to “dive” towards the first threshold because the IGS-to-SRAP approach light system is not visible yet.

8.3.6 Recommendations

The tests were overall positively acknowledged by most pilots. The tests allowed to make a few recommendations:

- (recurrent) Training on different approach types IGS-to-SRAP has to be ensured
- In the cockpit, special focus has to be put on the briefing :
    - Briefing has to include the expected lighting configuration
    - Special briefing is needed in case of 3.5°approach
- It remains undecided what the best lighting configuration would be: switching versus steady; pilot opinions were very diverse on this topic

- In the switching scenario, at the time of the landing clearance the "correct" runway has to be illuminated and switching should be finished latest at around 1000ft. This is the "gate" at which also in the cockpit everything must be stable (aircraft fully configured, at the correct approach speed and approach path and with stable thrust settings)
- ATC should communicate the approach type of the previous aircraft
- The approach naming shall be indicated by a different runway number (e.g. xLS 08R & xLS 09R).

9 Validation Exercise EXE-14.5-V3-VALP-R15 Report

9.1 Summary of the Validation Exercise EXE-14.5-V3-VALP-R15 Plan

9.1.1 Validation Exercise description, scope

The scope of the validation exercise R15 addresses SRAP and IGS-to-SRAP runway markings solutions from pilots' perspective via flight cockpit simulations using high level professional Level D/Type 7 flight crew training simulator. The simulator of the type Airbus A319 has full motion, control loading and a configurable visual system.

Figure 60: A319-100 Full Flight Simulator

The simulator is certified according to EASA CS-FTD Level D. The simulator is equipped with the following avionic components and systems:

<u>Aircraft Systems</u>

Engine	General Electric CFM56-5A5, 23500 lbs T/O Thrust
APU	APS 3200, Hamilton Sundstrand Corp (Software simulation)

<u>Autoflight System</u>

FMGS	S7AC13, Thales Avionics/Smiths (Full GPS, Orig. a/c boxes)

FCU	M11, Thales Avionics Sa (Orig. a/c box)
FAC	CR102, Thales Avionics Sa (Software simulation)
MCDU	Thales Avionics/Smiths (Orig. a/c box)

Electronic Flight Control System

ELAC	L93, Thales Avionics Sa (Orig. a/c boxes)
SEC	L123, Thales Avionics Sa (Orig. a/c boxes)
FCDC	L53, LITEF GmbH (Software simulation)

Electronic Instrument System

DMC	V70, DIEHL AEROSPACE GmbH (Orig. a/c boxes)
FWC	H2F7, Airbus France (Orig. a/c boxes)
DU	FCD66, Thales Avionics Sa (Orig. a/c boxes)
SDAC	H1-D1, Airbus France (Software simulation)
TCAS II	7.1, Honeywell (Software simulation)
ACARS	AMU MK I, Honeywell International Inc. (Orig. a/c box)
EGPWS	MK V, Honeywell International Inc. (Orig. a/c box)

Figure 61: Flight Deck Airbus A319 FFS

The visual system is modified to simulate a second runway threshold and aiming point used for SRAP and IGS-to-SRAP operations including:

- one "normal" threshold with runway markings (incl. aiming point and touchdown zone markers) and PAPI
- a second threshold located 1100m further beyond the normal threshold, with different switchable possibilities for runway markings (aiming point, touchdown zone markings) and a second PAPI
- no lighting system (approach lighting system, centreline lights, runway edge lights, touchdown zone lights), consequently all scenarios are in daylight conditions

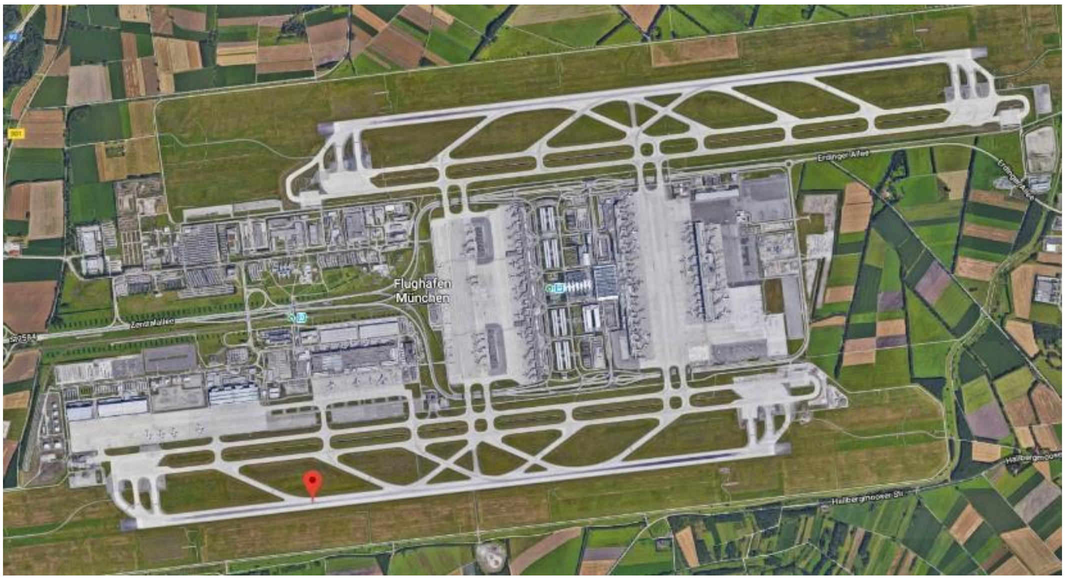

Figure 62: Position of the second threshold

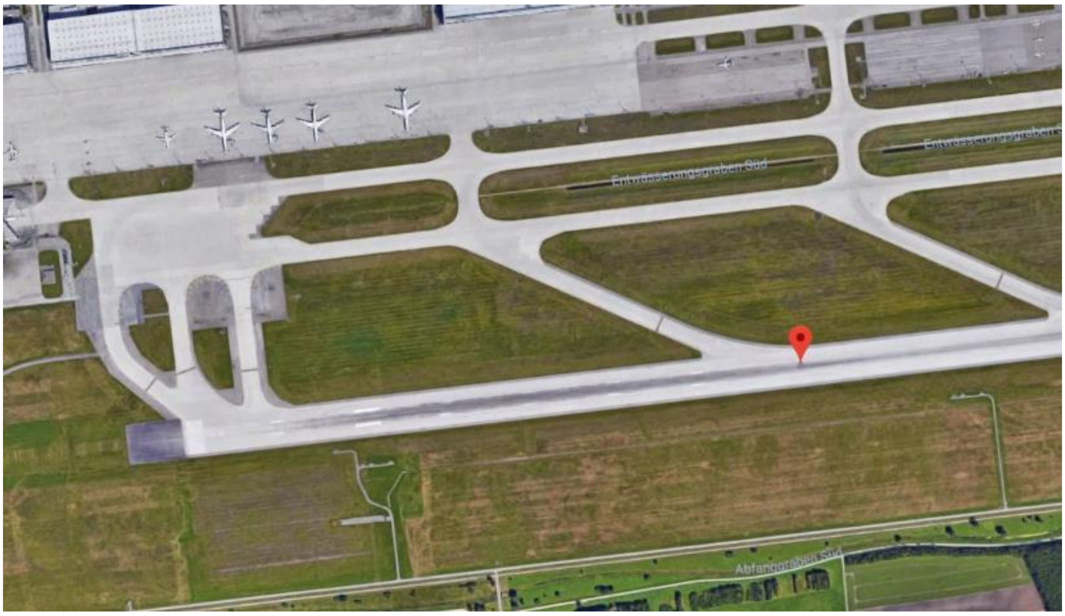

Figure 63: Position of the second threshold in detail

The environment used is Munich Airport with the added second threshold on runway 08R. With the view to add a safety net and to improve the situational awareness of both flight crew and ATCOs, the additional threshold on runway 08R is named 09R.

The SRAP approach procedure is an ILS procedure with a 3.0° final approach glideslope. Due to the simulator configuration limitations preventing to change the marking and the PAPI at the same time, there have been two options:

- either fly IGS-to-SRAP approaches without PAPI
- or to fly only SRAP procedures, and to use the results about marking for IGS-to-SRAP as well.

The second option was chosen.

In the solution runs, SRAP approaches guided by an ILS have been flown.

9.1.1.1 Marking options

Several options for the runway marking of the second threshold are provided. They are displayed below. Please note these are only drawing. In all options, markings are symmetrical around the runway centreline.

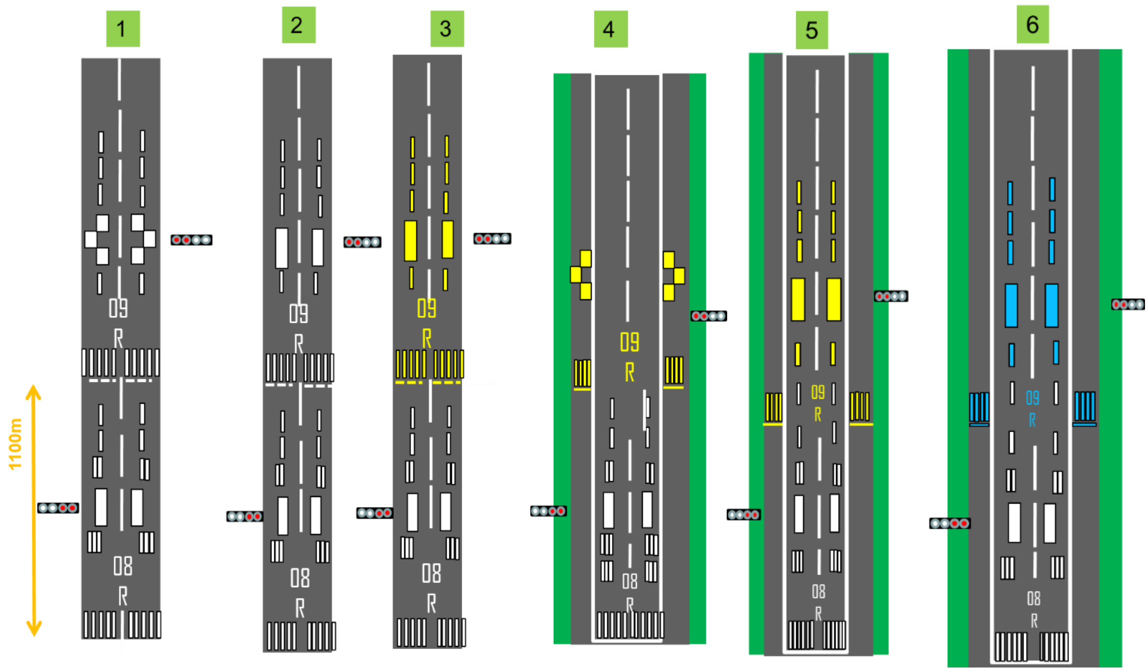

Figure 64: Marking options

Options 1, 2 and 3 could be used only with a threshold displacement of at least 1100m. Options 4,5 and 6 could be used with any value of displacement. Options 1 to 4 come from the pilot survey that was run in 2020. Option 6 using blue colour corresponds to what was implemented in Toulouse airport, for Airbus steep approaches tests, and was the solution ENAV was planning to use for VLD1-W2 flight trials in Malpensa. That explains why that option was added to the flight simulation campaign.

To ease the simulator reconfiguration between two runs, a displacement of 1100m was used with all cases, as shown in Figure 64. All configurations could be activated instantaneously on a special page on the instructor operation station.

Not all options were considered in one flight simulation session (= 16 runs). In the first six sessions, only options 1, 2, 3 and 4 were evaluated. After the first six sessions, pilots' opinions on the four options assessed were evaluated to keep the three options most acceptable and run in the last six sessions, together with options 5 and 6.

9.1.1.2 Charts

Charts for SRAP and IGS-to-SRAP approaches were developed based on existing EDDM ones (Jeppesen). They included in particular:

- the vertical profile to the second threshold with the remaining runway length
- a note explaining that the procedure is a SRAP or IGS-to-SRAP one
- a note giving the location of the PAPI for the SRAP or IGS-to-SRAP approach.

A set of paper charts was given to pilots. They are available in Appendix F.

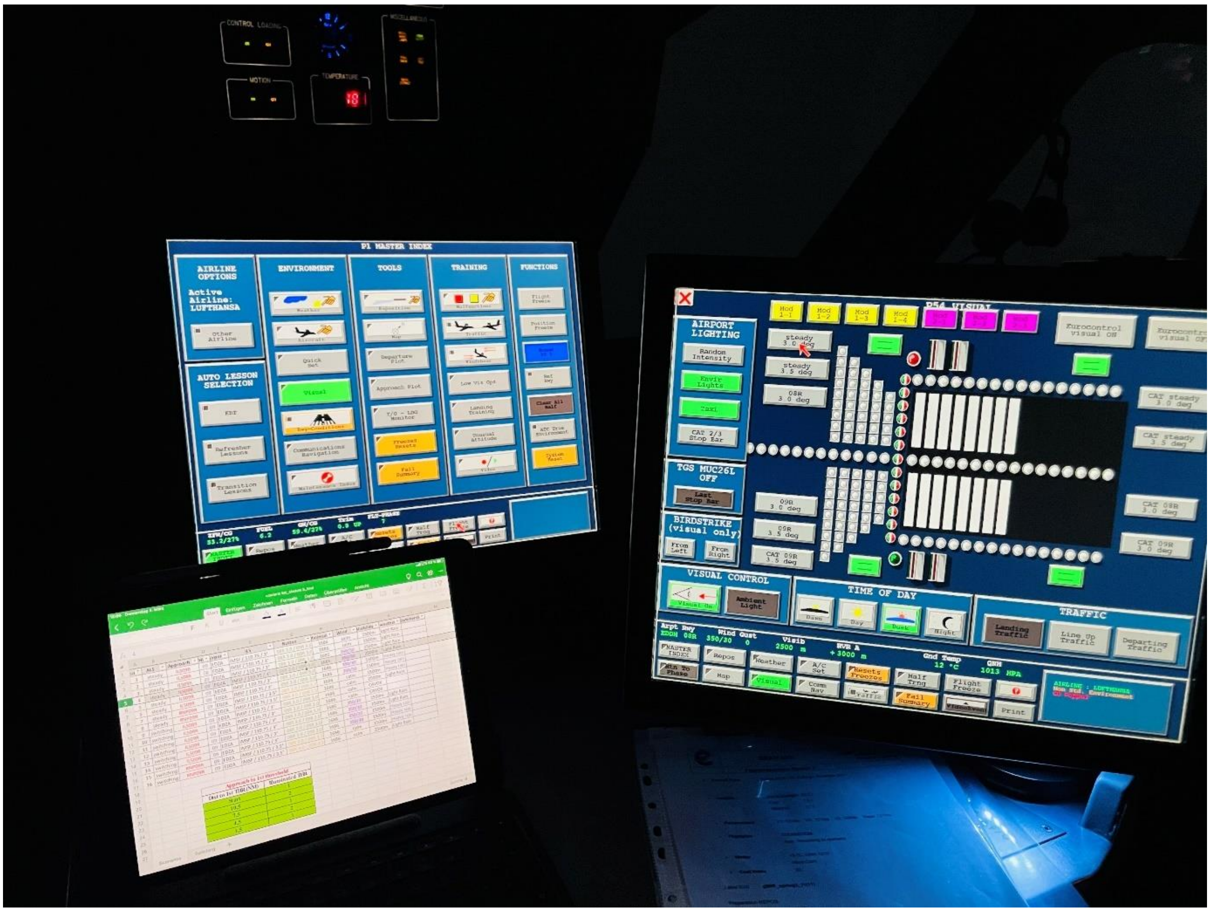

Figure 65: Instructor Operation Station Full Flight Simulator

9.1.1.3 Phraseology

In addition of the 2 pilots, the scientific test flight instructor from Lufthansa Aviation Training played the controllers' role, giving in particular the clearances for approach and landing. The phraseology used was the same as in R10.

Approach clearance was given before releasing the simulator in order to give time to pilots for briefing:

"ECTL021, Cleared ILS approach Runway 09R (or Cleared RNP approach Runway 09R), you are n°5 on final, preceding is B767 on lower glide"

The **landing clearance** was as follows:

"ECTL021, cleared to land RWY 09R, second threshold, wind xxx kts"

9.1.1.4 Scope of EXE-14.5-V3-VALP-R15

The aim of this exercise was:

- To evaluate the different solutions for runway markings. The solutions evaluated are those considered most acceptable by the pilots that answered the survey organised by EUROCONTROL at the end of 2019.
- To confirm that the pilot tasks performance when flying a SRAP or IGS-to-SRAP approach is not negatively impacted
- To confirm that IGS-to-SRAP does not negatively affect safety from the perspective of the crew
- To confirm that IGS-to-SRAP is operationally feasible from flight crew perspective.

The simulator had data recording capabilities allowing extraction of the flown 4D trajectory and conversion to Excel (or CSV) format for each flown scenario. Video recordings were made of the aircraft windscreen (external visual view) during each scenario.

The approach to the normal threshold was an ILS approach. The approach to the second threshold was an ILS (SRAP) or RNP APCH (IGS-to-SRAP). This means that the simulator allowed programming of an ILS with touchdown aiming point beyond the normal threshold and a second ILS to land on the second touchdown aiming point beyond the second threshold.

An aircraft database was provided and loaded in the simulator containing the ILS approach to the normal threshold, the ILS approach to the second threshold and the RNP APCH to the second threshold. Both ILS approaches had a 3 degree glide slope while the RNP APCH has a 3.5 degree final approach path.

Within the exercise several stakeholders have been involved. The stakeholder's expectations are given in the table below.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Stakeholder	Involvement	Why it matters to stakeholder
Airspace Users	Airspace Users (Airline Pilots) will be involved in the validation sessions	Airspace Users are interested in assessing the impact of SRAP and IGS-to-SRAP procedures on crew from safety and HP point of view.
ANSPs	No involvement in the validations.	ANSPs also need evidence to show that the SRAP and IGS-to-SRAP procedures are operationally feasible.
Airport Operators	No involvement in the validations.	Airport Operators are interested in the validation results of the exercise because SRAP concept could have a positive effect of noise reduction in the areas close to the airports. SRAP and IGS-to-SRAP may provide added value to alleviate any existing or future stringency on capacity due to noise and then improving quality of service to AUs.
Air Transport industry	Lufthansa Aviation Training is running the exercise.	Lufthansa need to assess the selected design solution to fly SRAP and IGS-to-SRAP approaches and in assessing the impact on the crew on safety and HP point of view. Expected positive effects of SRAP and IGS-to-SRAP concept on noise footprint, could give a competitive advantage to aircraft equipped with SRAP and IGS-to-SRAP capability.
European Commission	Direct participation through SJU.	EC is interested into improving the main KPA related the ATM. Regarding PJ02-02 EC is interested in Capacity and Environment KPA possible benefits coming from SRAP and IGS-to-SRAP concept.
EUROCONTROL	EUROCONTROL is leading PJ02-02.	EUROCONTROL is interested on the validation results of the exercise because they need evidence to show that safety will be maintained or improved. EUROCONTROL also needs evidence to show that the SRAP and IGS-to-SRAP procedures are operationally feasible from pilots' side.

Table 22: stakeholders' expectations of EXE-14.5-V3-VALP-R15

9.1.2 Summary of Validation Exercise EXE-14.5-V3-VALP-R15 Validation Objectives and success criteria

Section 9.3.1 contains a summary of the validation objectives and success criteria, with the achieved results. To avoid duplication, the table is not repeated here.

9.1.3 Summary of Validation Exercise EXE-14.5-V3-VALP-R15 Validation scenarios

EXE-14.5-V3-VALP-R15 addressed IGS-to-SRAP runway markings solutions from pilots' perspective. The exercise was performed using an Airbus A319-100 high level professional Level D/Type 7 flight crew training simulator without integration in a real ATM traffic environment.

In the reference scenario, the published ILS approach (conventional slope of 3°) was flown.

Twelve sessions involving two airline pilots have taken place. Each session encompassed:

- A briefing session where the concepts to be evaluated be explained to the pilots
- 16 runs (session 1-6) and 17 runs (session 7-12) described in the tables below, each followed by a questionnaire
- 1 post session questionnaire followed by a post session debriefing

During the runs, pilot-flying and pilot-non-flying were switching after each run between the two crewmembers.

RUN	Marking Option	Aiming Point	RWY	AP	TDZ	Meteo (Visibility)
1	2	2nd	ILS09R	AP ICAO	(TDZ 1st multiple 2nd single)	CAVOK (Day)
2	2	2nd	ILS09R	AP ICAO	(TDZ 1st multiple 2nd single)	CAVOK (Day)
3	1	2nd	ILS09R	AP Chequered	(TDZ 1st multiple 2nd single)	CAVOK (Day)
4	1	1st	ILS08R	AP Chequered	(TDZ 1st multiple 2nd single)	CAVOK (Day)
5	1	2nd	ILS09R	AP Chequered	(TDZ 1st multiple 2nd single)	Heavy rain
6	1	2nd	ILS09R	AP Chequered	(TDZ 1st multiple 2nd single)	CAVOK (Day)
7	1	1st	ILS08R	AP Chequered	(TDZ 1st multiple 2nd single)	CAVOK (Day)
8	1	2nd	ILS09R	AP Chequered	(TDZ 1st multiple 2nd single)	Heavy rain
9	3	2nd	ILS09R	AP Duplication (yellow)	(TDZ 1st multiple 2nd single)	CAVOK (Day)
10	3	2nd	ILS09R	AP Duplication (yellow)	(TDZ 1st multiple 2nd single)	CAVOK (Day)

11	3	2nd	ILS09R	AP Duplication (yellow)	(TDZ 1^{st} multiple 2^{nd} single)	Heavy rain
12	3	2nd	ILS09R	AP Duplication (yellow)	(TDZ 1^{st} multiple 2^{nd} single)	Heavy rain
13	4	2nd	ILS09R	Side runway AP Chequered (yellow)	No	CAVOK (Day)
14	4	2nd	ILS09R	Side runway AP Chequered (yellow)	No	CAVOK (Day)
15	4	2nd	ILS09R	Side runway AP Chequered (yellow)	No	Heavy rain
16	4	2nd	ILS09R	Side runway AP Chequered (yellow)	No	Heavy rain

Table 23: Scenario List Session 1-6

RUN	Marking Option	Aiming Point	RWY	AP	TDZ	Meteo (Visibility)
1	2	2nd	ILS 09R	AP ICAO	(TDZ 1^{st} multiple 2^{nd} single)	CAVOK (Day)
2	2	2nd	ILS 09R	AP ICAO	(TDZ 1^{st} multiple 2^{nd} single)	CAVOK (Day)
3	2	2nd	ILS 09R	AP ICAO	(TDZ 1^{st} multiple 2^{nd} single)	Heavy rain
4	2	2nd	ILS 09R	AP ICAO	(TDZ 1^{st} multiple 2^{nd} single)	Heavy rain
5	1	2nd	ILS 09R	AP Chequered	(TDZ 1^{st} multiple 2^{nd} single)	CAVOK (Day)
6	1	2nd	ILS 09R	AP Chequered	(TDZ 1^{st} multiple 2^{nd} single)	CAVOK (Day)
7	2	2nd	ILS 09R	AP Chequered	(TDZ 1^{st} multiple 2^{nd} single)	Heavy rain

8	2	2nd	ILS 09R	AP Chequered	(TDZ 1^{st} multiple 2^{nd} single)	Heavy rain
9	3	2nd	ILS 09R	Side runway AP Chequered (yellow)	No	CAVOK (Day)
10	3	2nd	ILS 09R	Side runway AP Chequered (yellow)	No	CAVOK (Day)
11	3	2nd	ILS 09R	Side runway AP Chequered (yellow)	No	Heavy rain
12	3	2nd	ILS 09R	Side runway AP Chequered (yellow)	No	Heavy rain
13	4	2nd	ILS 09R	Side runway AP Chequered (blue)	No	CAVOK (Day)
14	4	2nd	ILS 09R	Side runway AP Chequered (blue)	No	CAVOK (Day)
15	4	2nd	ILS 09R	Side runway AP Chequered (blue)	No	Heavy rain
16	4	2nd	ILS 09R	Side runway AP Chequered (blue)	No	Heavy rain
17	2	1st	ILS 08R	AP ICAO	(TDZ 1^{st} multiple 2^{nd} single)	CAVOK (Day)

Table 24: Scenario List Session 7-12

9.1.4 Summary of Validation Exercise EXE-14.5-V3-VALP-R15 Validation Assumptions

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
R15-ASS1	IGS-to-SRAP landing minima	Procedure in place	Pilots are expected to use the landing minima from the charts (no increase to be applied by pilots).	As per IGS-to-SRAP concept definition, if there is an impact on landing minima for IGS-to-SRAP, it should be transparent for the pilots.	Approach	Interoperability	OSED	n/a	PJ.02-W2-14.5	MEDIUM

Table 25: R15 Validation Assumptions overview

9.2 Deviation from the planned activities

There were no deviations from the planned activities

9.3 Validation Exercise EXE-14.5-V3-VALP-R15 Results

9.3.1 Summary of Validation Exercise EXE-14.5-V3-VALP-R15 Results

The table below provides an overview of the Validation Objectives and the Success Criteria. For each objective the table provides the paragraph numbers in which the results for each objective are discussed. Finally, the table indicates for each objective whether the validation objective analysis status is OK, partially OK or NOK.

As already mentioned, within the exercise SRAP and IGS-to-SRAP objectives have been assessed. However, no IGS-to-SRAP approaches have been flown. Consequently, findings from SRAP approaches have been transferred to verify IGS-to-SRAP validation objectives.

Validation Exercise R15 Validation Objective ID	Validation Exercise #05 Validation Objective Title	Validation Exercise #05 Success Criterion ID	Validation Exercise #05 Success Criterion	Sub-operating environment	Exercise #05 Validation Results	Validation Exercise #05 Validation Objective Status
OBJ-14.5-V3-VALP.0203	To confirm that IGS-to-SRAP does not negatively affect safety from the perspective of the crew	CRT-14.5-V3-VALP-0203-001	There is evidence that the level of operational safety is maintained and not negatively impacted under IGS-to-SRAP procedures compared to the reference scenario, from the perspective of the crew	Aircraft, Crew	See 9.3.2.1	Partially OK, due to reduction in perceived level of safety for Option 3 and 4 (yellow markings)
OBJ-14.5-V3-VALP-0204	To confirm that the IGS-to-SRAP is operationally feasible from crew perspective	CRT-14.5-V3-VALP-0204-001	Pilot succeeds to manage IGS-to-SRAP operation by applying existing SOPs.	Aircraft, Crew	See 9.3.2.2	OK
		CRT-14.5-V3-VALP-0204-002	Pilots are confident when flying a IGS-to-SRAP operation			
OBJ-14.5-V3-VALP.0301	To confirm that the phraseology used by ATCO and Flight Crew for IGS-to-	CRT-14.5-V3-VALP-0301-002	Proposed phraseology does not lead to errors related to perception &	Aircraft, Crew	See 9.3.2.3	OK

Validation Exercise R15 Validation Objective ID	Validation Exercise #05 Validation Objective Title	Validation Exercise #05 Success Criterion ID	Validation Exercise #05 Success Criterion	Sub-operating environment	Exercise #05 Validation Results	Validation Exercise #05 Validation Objective Status
	SRAP is clearly understandable		interpretation of auditory information.			
		CRT-14.5-V3-VALP.0301-003	Pilots accept and judge the proposed phraseology as being appropriate for all encountered operating			

Table 26: Validation Objectives for Exercise 15 (IGS-to-SRAP)

9.3.2 Analysis of Exercise EXE-14.5-V3-VALP-R15 Results per Validation objective

The sections below provide the results per validation objective. Note that the validation objectives for SRAP and IGS to SRAP were partly grouped to increase readability of the report and also to be able to better compare the results. Furthermore, as already mentioned, there have been no IGS-to-SRAP procedures flown within the marking scenarios. Consequently, the results for the SRAP validation objectives have been used as well for the IGS-to-SRAP validation objectives

9.3.2.1 OBJ-14.5-V3-VALP-SRAP.0203 Results

This chapter presents the results on the subjective feeling of safety recorded after each flight. The pilots were asked to rate if they think that their perceived level of safety decreased, stayed the same or increased compared to today's operation. The analysis took into account if the pilot was flying the scenario or not. There is a figure for the pilot flying and one for the pilot non-flying.

The following two graphs show the results recorded after all scenarios for session 1-6 for pilot flying and pilot non-flying. The results always comparing a marking option with good visibility and low visibility using heavy rain. Furthermore, the last column represents the reference scenario flown to the primary threshold.

The results show clear tendency to an increase of safety using the options 3 and 4 with yellow markings. Most of the pilots' state that the yellow marking was not very good visible. Furthermore, a possibility to confuse the yellow marking with taxiway marking or even construction work marking was mentioned. Consequently, for the session 7-12 a new colour (blue) was introduced.

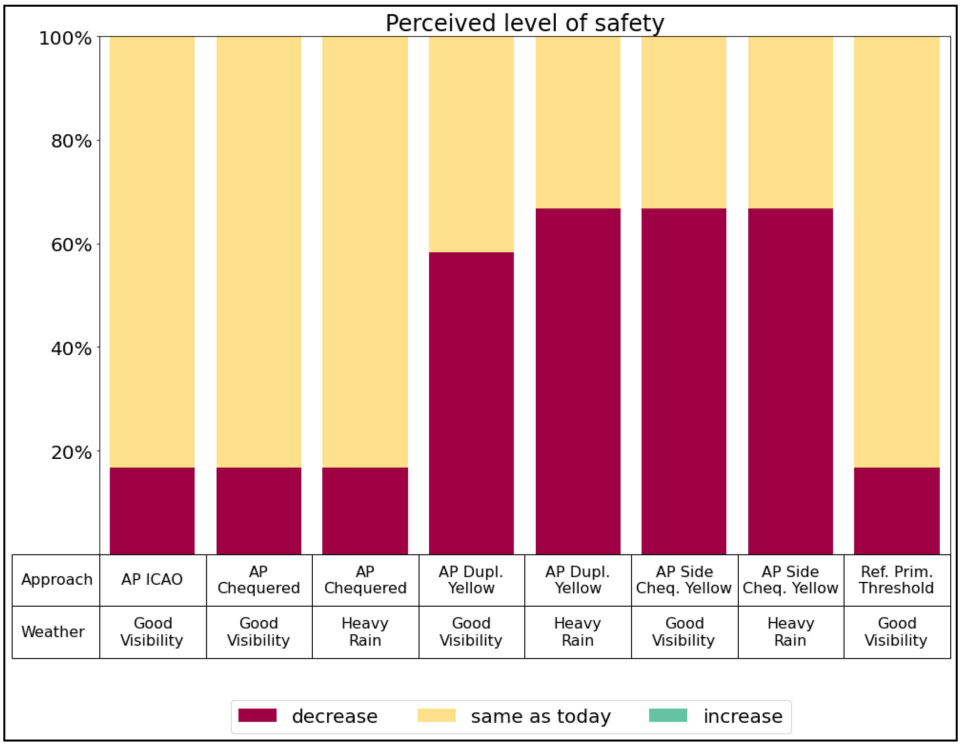

Figure 66: Perceived Level of Safety Session 1-6 Pilot Flying

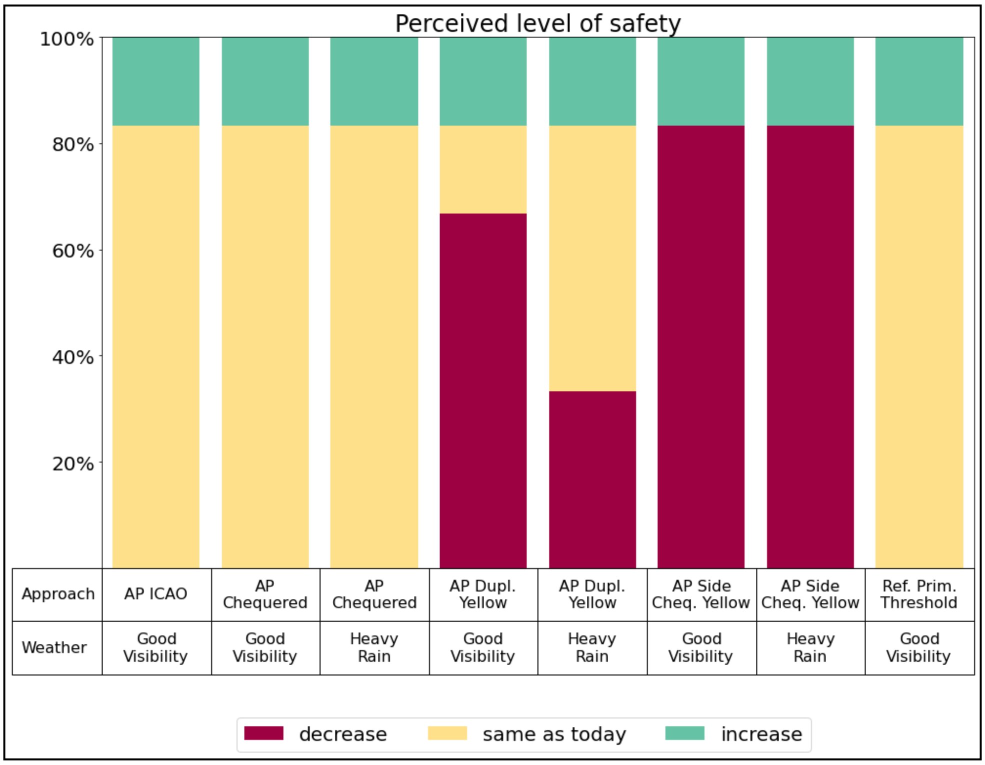

Figure 67: Perceived Level of Safety Session 1-6 Pilot Non-Flying

The following two graphs show the results recorded after all scenarios session 7-12 with revised options based on the results of session 1-6. The results always comparing a marking option with good visibility and low visibility using heavy rain. Furthermore, the last column represents the reference scenario flown to the primary threshold.

Especially for the pilot flying, again the yellow marking leads to a reduction of safety. The blue marking (Option 5) was comparable to the first two options and resulted not in a reduction of safety.

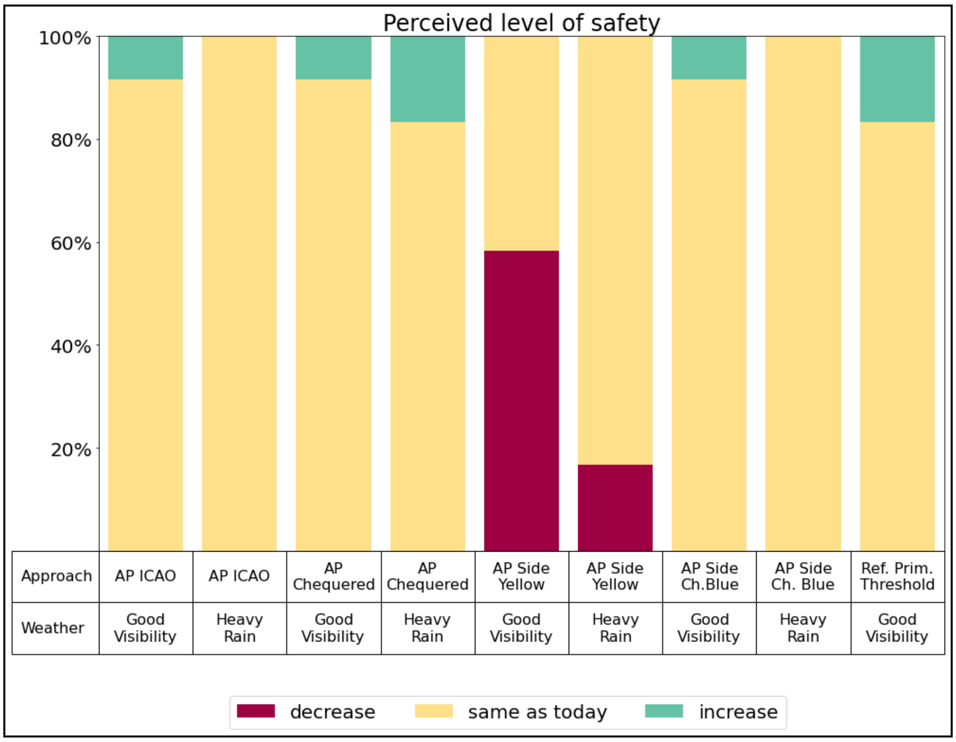

Figure 68: Perceived Level of Safety Session 7-12 Pilot Flying

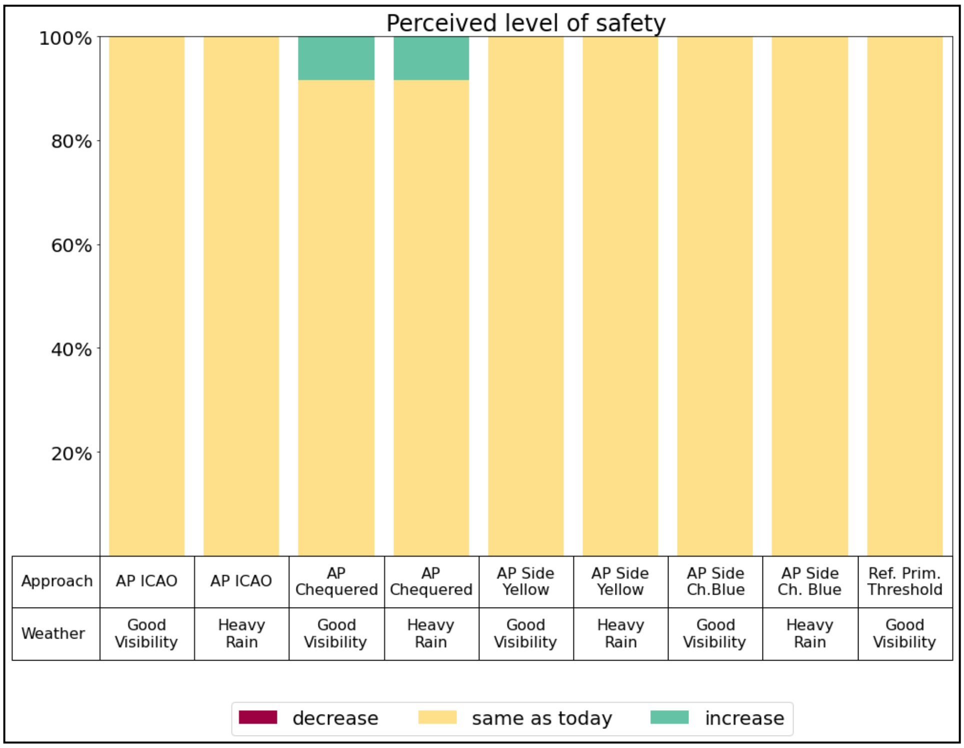

Figure 69: Perceived Level of Safety Session 7-12 Pilot Non-Flying

9.3.2.2 OBJ-14.5-V3-VALP-SRAP.0204 Results

To be in line with the objective the chapter outlines the results on the question of operational feasibility. The pilots filled a questionnaire after the simulation where they were asked questions regarding the standard operating procedures (SOPs), and the acceptability of the different concepts.

More than 95% of the pilots indicated that they executed all tasks in line with the SOPs and that they can imagine using the concept of Secondary Runway Aiming Point in an every-day operation. Therefore, it can be preliminary concluded that the concept is operational feasible.

The visual indications are one of the factors contributing to operational feasibility and are therefore reported hereafter.

9.3.2.2.1 PAPI

The pilots were asked several questions about the visual indications like PAPI and runway marking.

The graph below indicates the answer to the question whether the PAPI is acceptable to the pilots for Session 1-6. Pilots were asked to answer to the question “The PAPI indications were acceptable to me” with a rating from 1 “strongly disagree” to 5 “strongly agree”. The results comparing a marking option with good visibility and low visibility using heavy rain. Furthermore, the last column represents the reference scenario flown to the primary threshold.

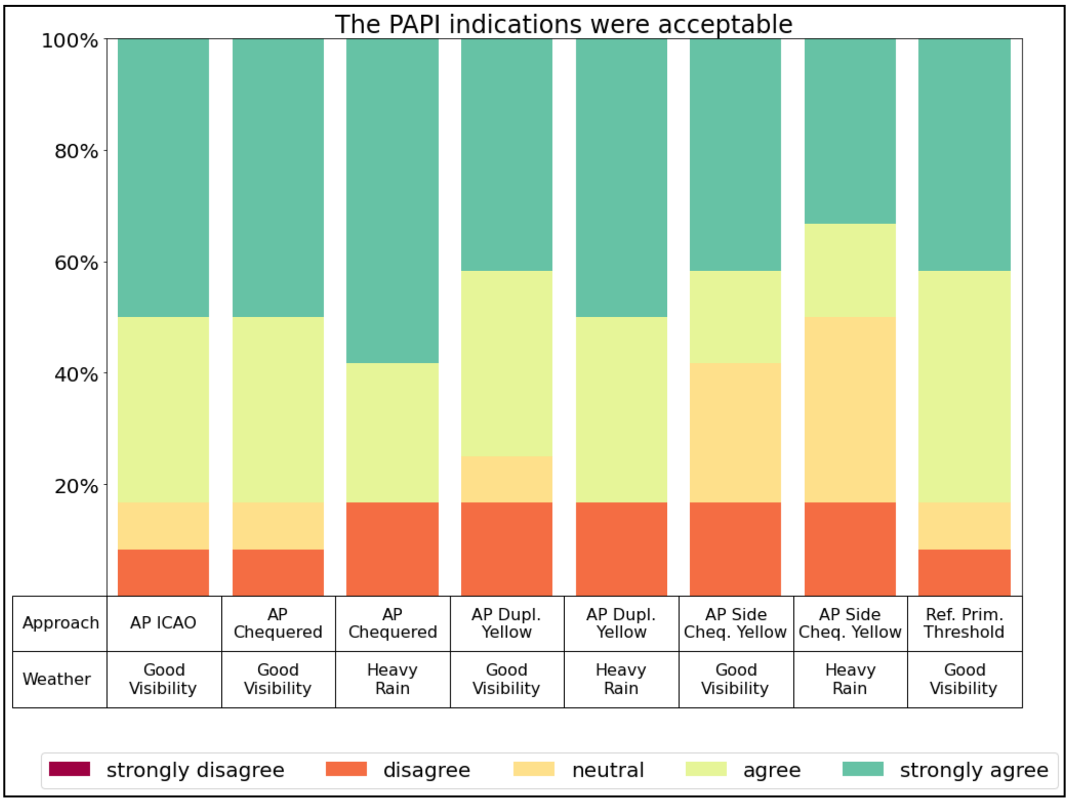

Figure 70: Acceptability of different PAPI settings for the pilot flying (session 1-6)

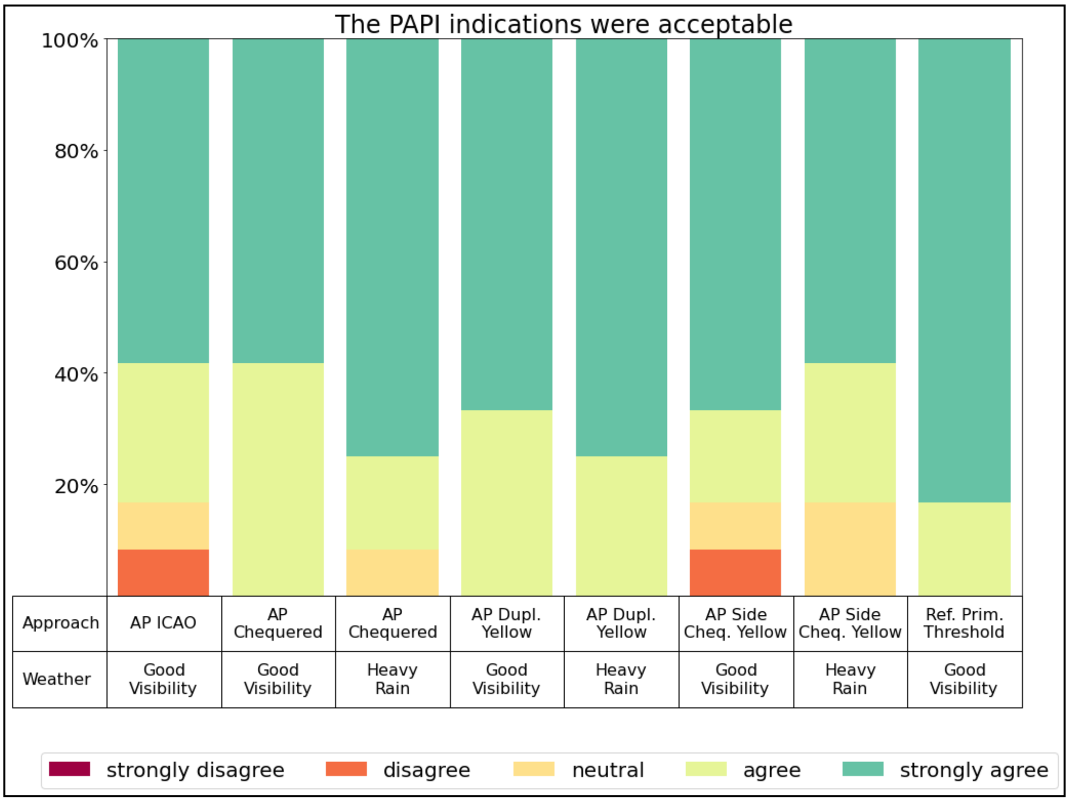

Figure 71: Acceptability of different PAPI settings for the pilot non-flying (session 1-6)

The answers – especially from Pilot-Non-Flying represents a very good to good acceptance of the proposed PAPI solution. Only option 4 (AP side cheq. yellow) was not that much accepted as the other options. Consequently, for session 7-12 an additional option – based on pilots' feedback – with blue colour was added.

The graph below indicates the answer to the question whether the PAPI is acceptable to the pilots for Session 7-12. Pilots were asked to answer to the question "The PAPI indications were acceptable to me" with a rating from 1 "strongly disagree" to 5 "strongly agree".

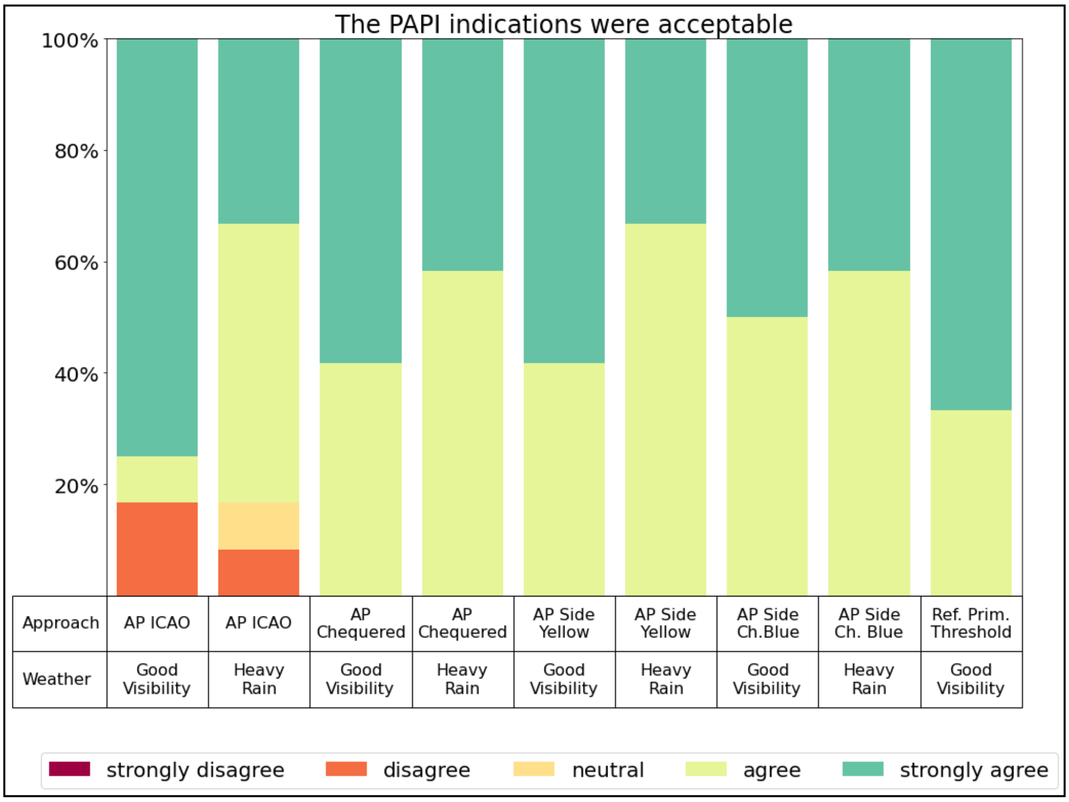

Figure 72: Acceptability of different PAPI settings for the pilot flying (session 7-12)

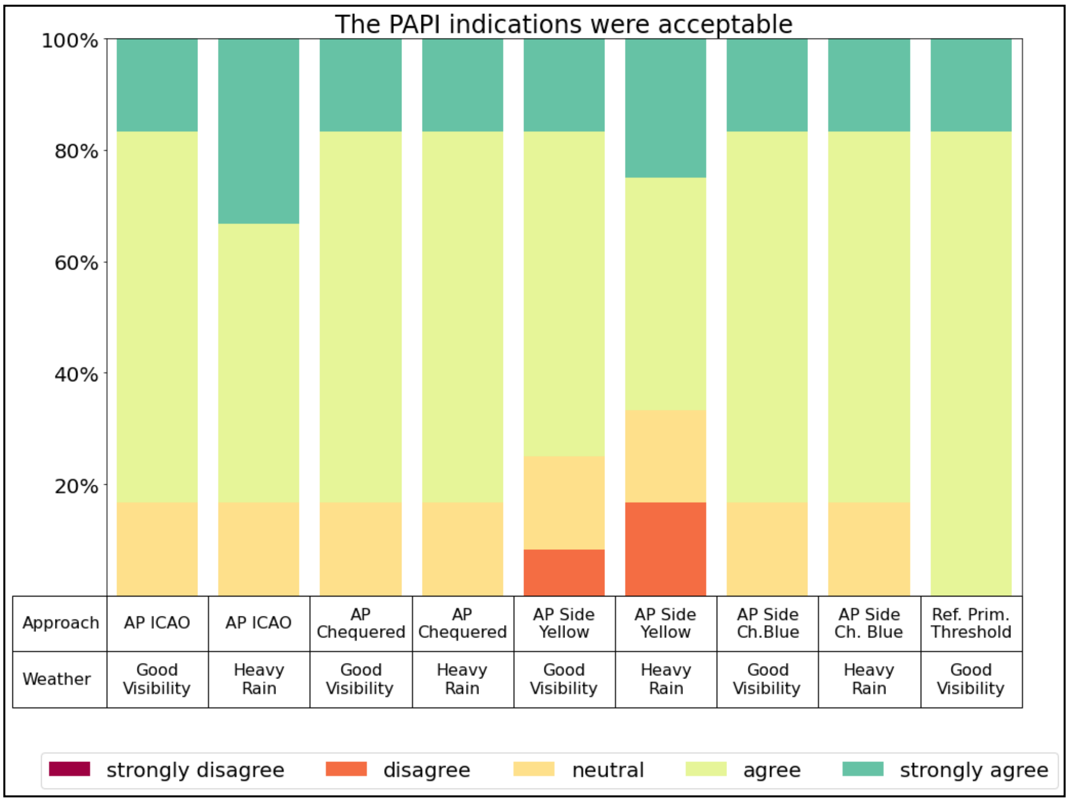

Figure 73: Acceptability of different PAPI settings for the pilot non-flying (session 7-12)

For session 7-12 with a revised list of proposed marking options, all options show a good acceptability for pilot flying and pilot-non-flying.

9.3.2.2.2 Threshold

The graphs below indicate the answer to the question if the threshold identification were acceptable to the pilots for session 1-6. They were asked to answer to the question "The threshold identification was acceptable to me" with a rating from 1 "strongly disagree" to 5 "strongly agree". The results comparing a marking option with good visibility and low visibility using heavy rain. Furthermore, the last column represents the reference scenario flown to the primary threshold.

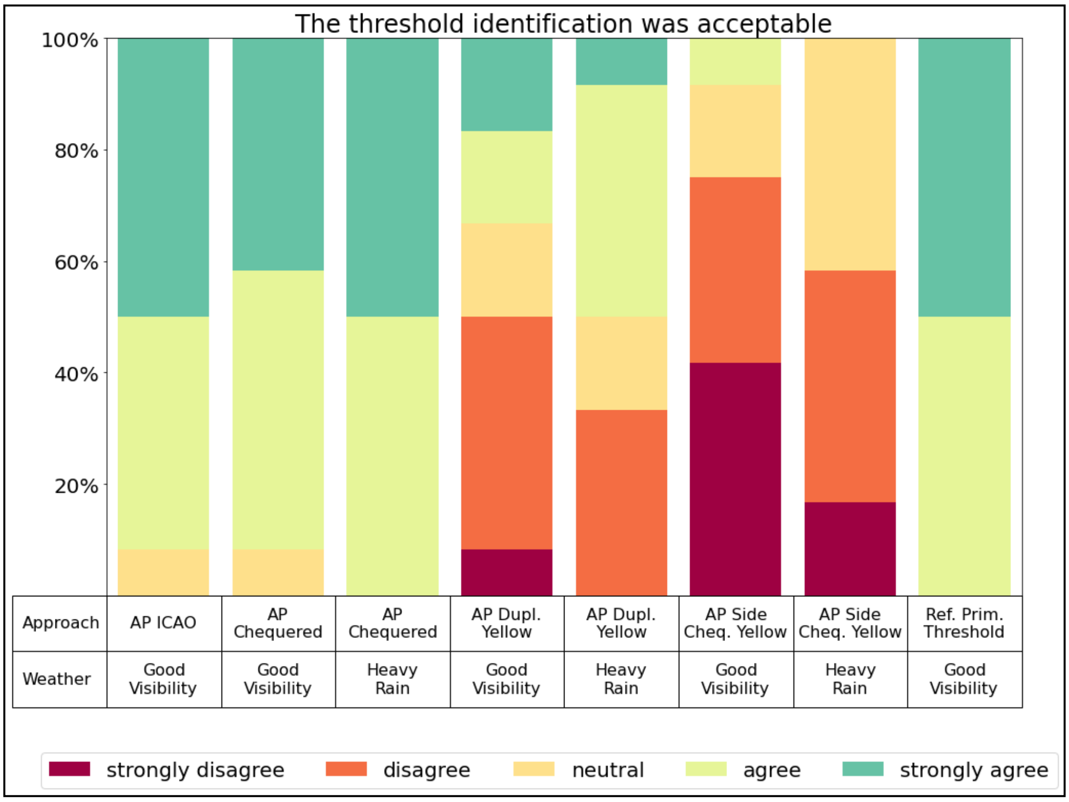

Figure 74: Acceptability of different threshold identification for the pilot flying (session 1-6)

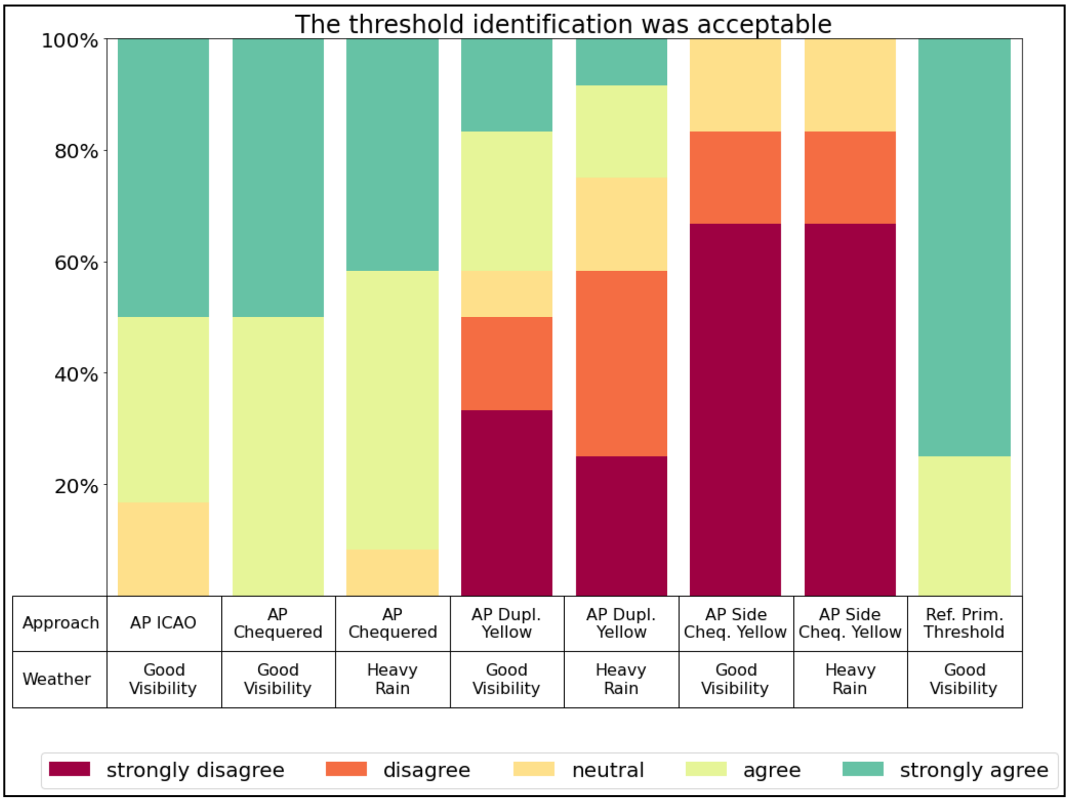

Figure 75: Acceptability of different threshold identification for the pilot non-flying (session 1-6)

The graph indicates that the acceptability of the first two option using white colour was very high. However, using yellow for the threshold marking lowered the acceptability significantly. Poor visibility during the scenarios with heavy rain had no influence on the results.

The graphs below indicate the answer to the question if the threshold identification were acceptable to the pilots for session 7-12 with revised options, removing the AP duplication yellow with a blue side marking. They were asked to answer to the question “The threshold identification was acceptable to me” with a rating from 1 “strongly disagree” to 5 “strongly agree”.

Again, the yellow marking option represents the lowest acceptability comparing to the other options. However, Option 5 with blue marking indicates an increase in acceptability compared to the yellow option. The pilots stated the blue markings have been better to be identified, especially in good visibility.

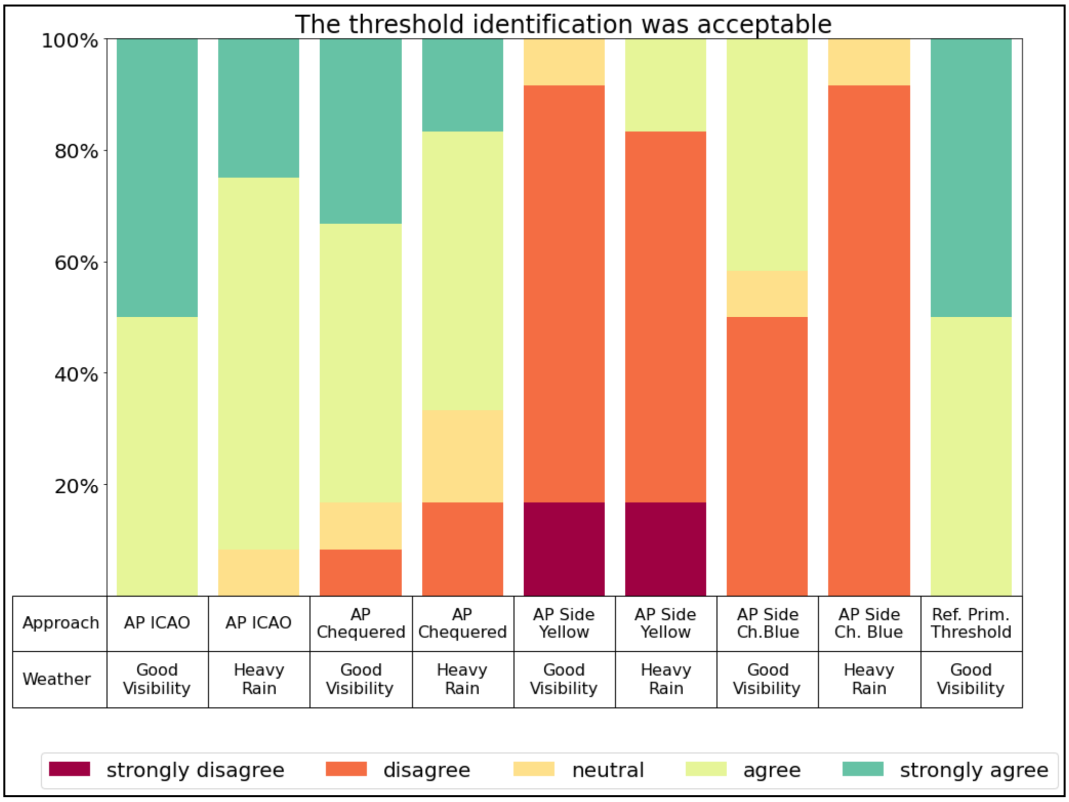

Figure 76: Acceptability of different threshold identification for the pilot flying (session 7-12)

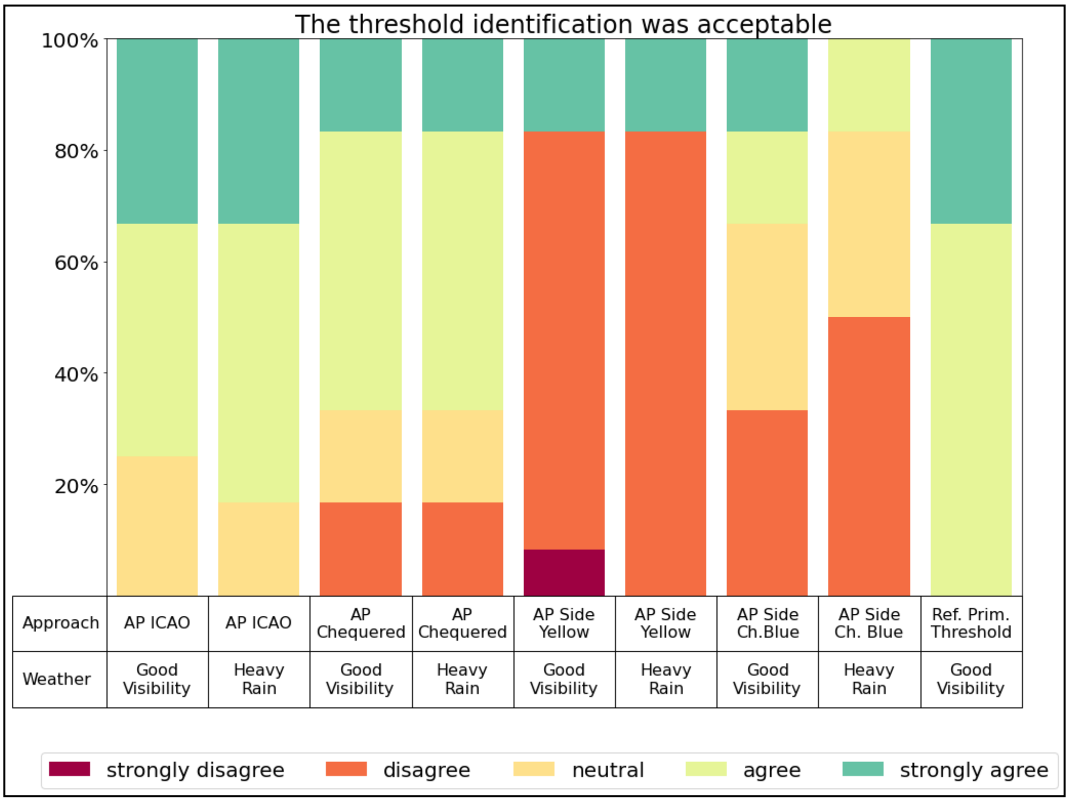

Figure 77: Acceptability of different threshold identification for the pilot non-flying (session 7-12)

9.3.2.2.3 Aiming Point

The graphs below indicate the answer to the question if the aiming point identification was acceptable to the pilots for session 1-6. They were asked to answer to the question “The aiming point identification was acceptable to me” with a rating from 1 “strongly disagree” to 5 “strongly agree”. The results comparing a marking option with good visibility and low visibility using heavy rain. Furthermore, the last column represents the reference scenario flown to the primary threshold.

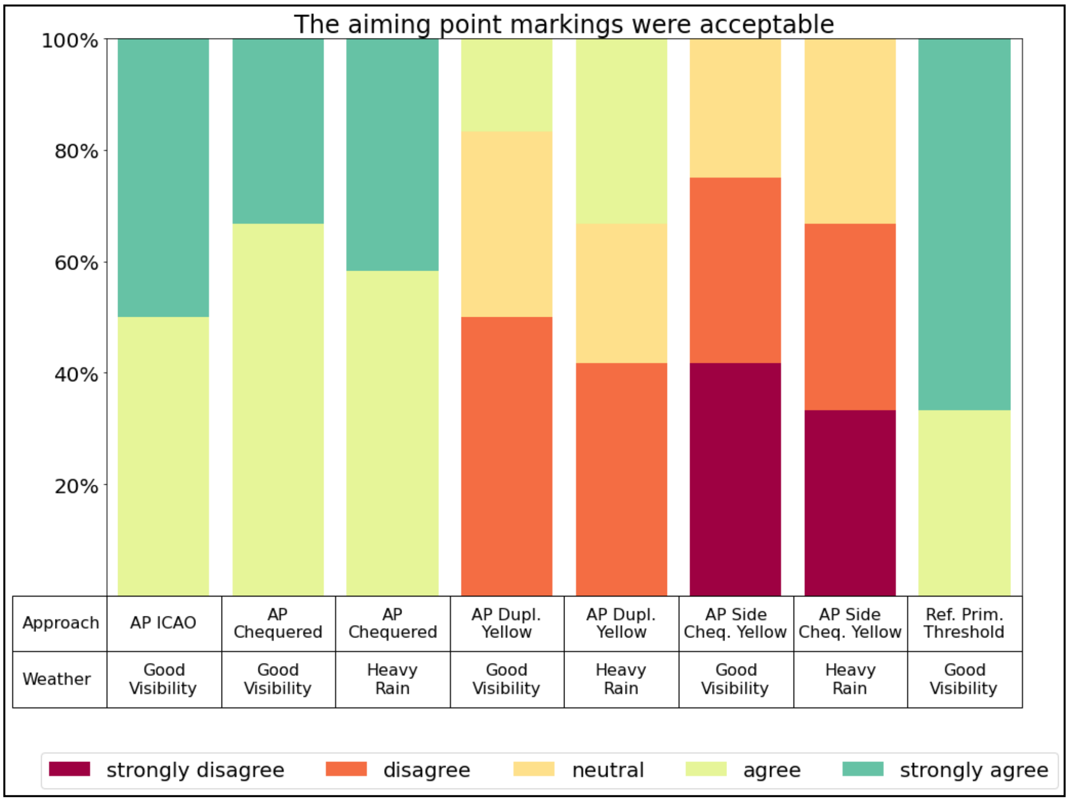

Figure 78: Acceptability of different aiming identification for the pilot flying (session 1-6)

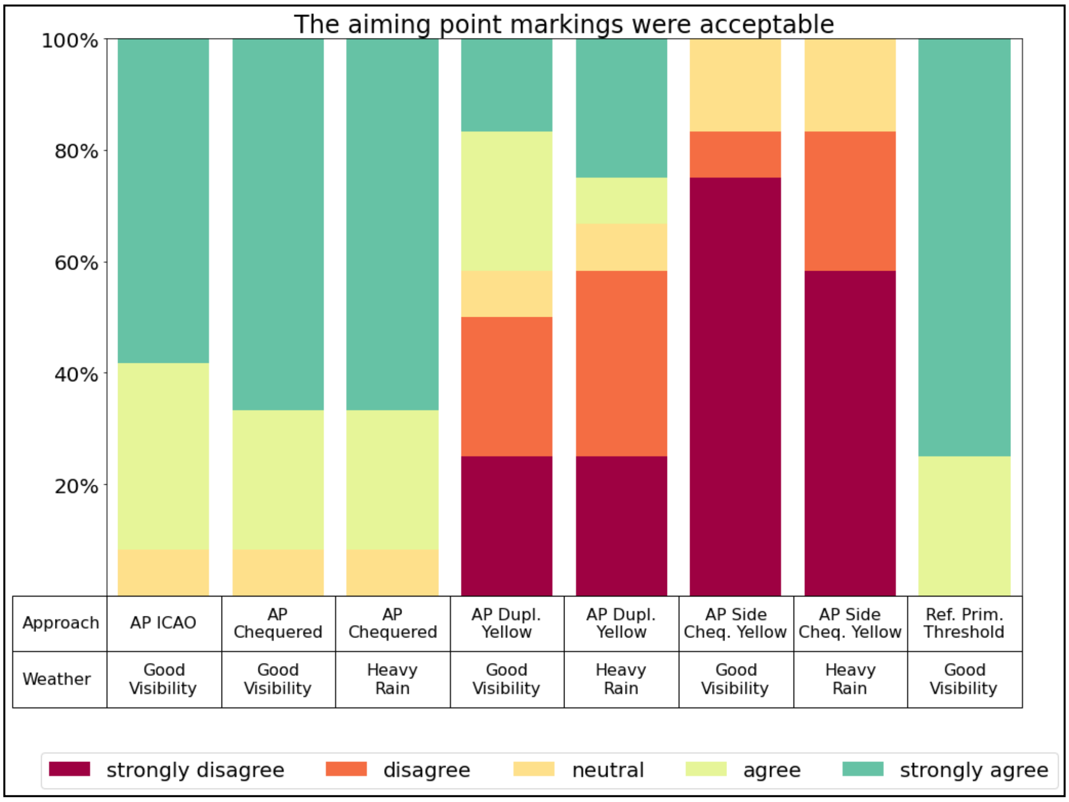

Figure 79: Acceptability of different aiming identification for the pilot non-flying (session 1-6)

Similar results as for the threshold identification could be recognized. Again, the standard white colour was highly acceptable – comparable to the results of the reference scenario using the primary threshold with standard markings. The two options using yellow colours were not acceptable for pilot flying and pilot flying. Introducing the fifth option with blue colours of the marking provided a slightly increase for the acceptability.

However, compared to option one and two using white colours, the blue colour is not as acceptable as white colour.

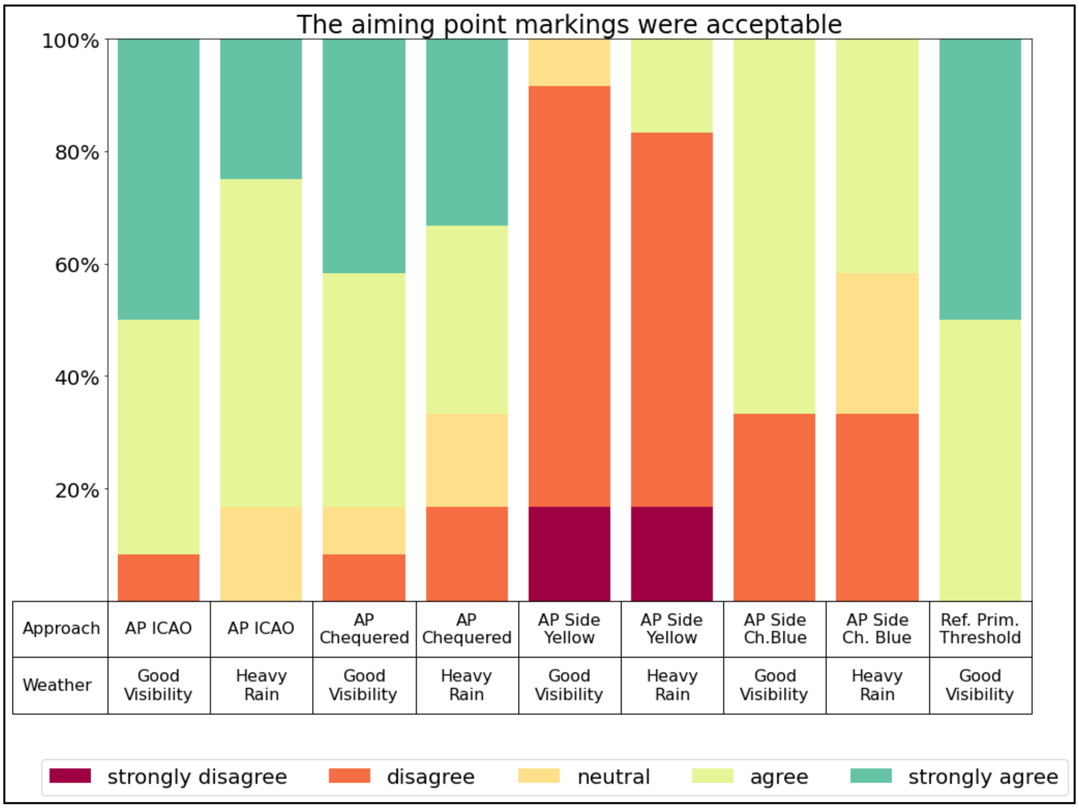

Figure 80: Acceptability of different aiming identification for the pilot flying (session 7-12)

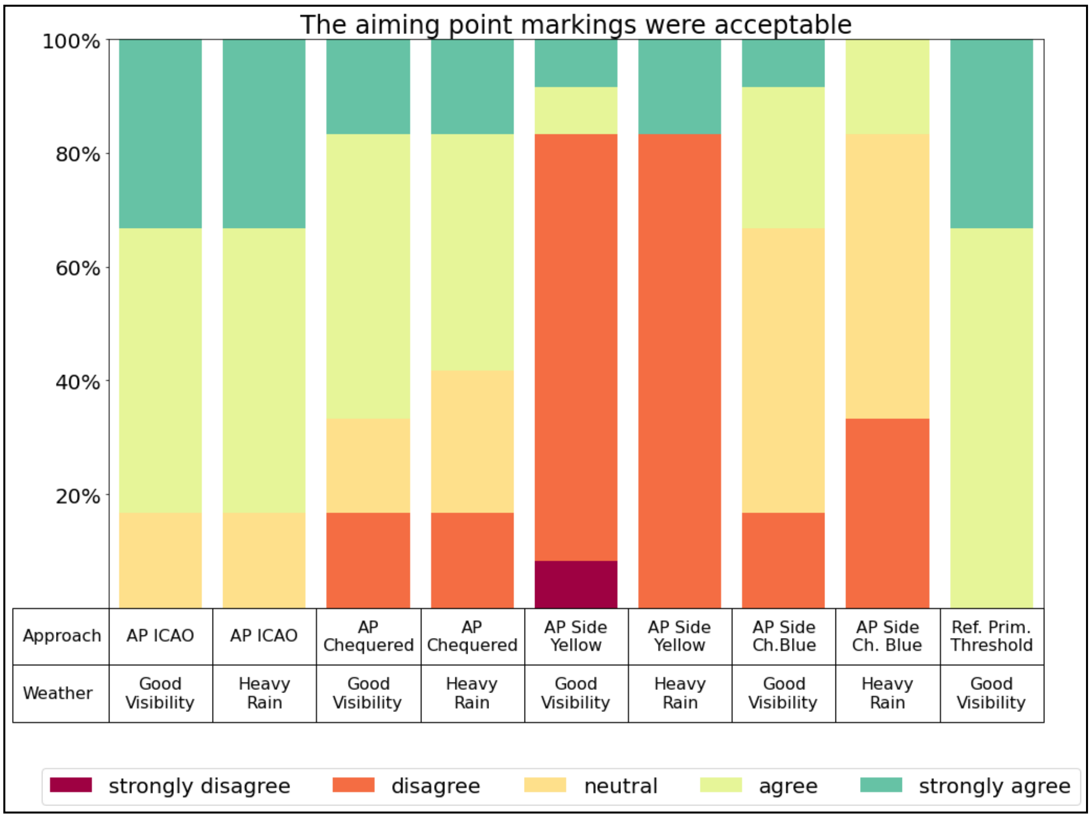

Figure 81: Acceptability of different aiming identification for the pilot non-flying (session 7-12)

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9.3.2.2.4 Touchdown Zone Marking

The last element of the adapted markings for the second runway aiming point were the touchdown zone markings. The graphs below indicate the answer to the question if the touchdown zone markings were acceptable to the pilots for session 1-6. They were asked to answer to the question "The threshold identification was acceptable to me" with a rating from 1 "strongly disagree" to 5 "strongly agree". The results comparing a marking option with good visibility and low visibility using heavy rain. Furthermore, the last column represents the reference scenario flown to the primary threshold.

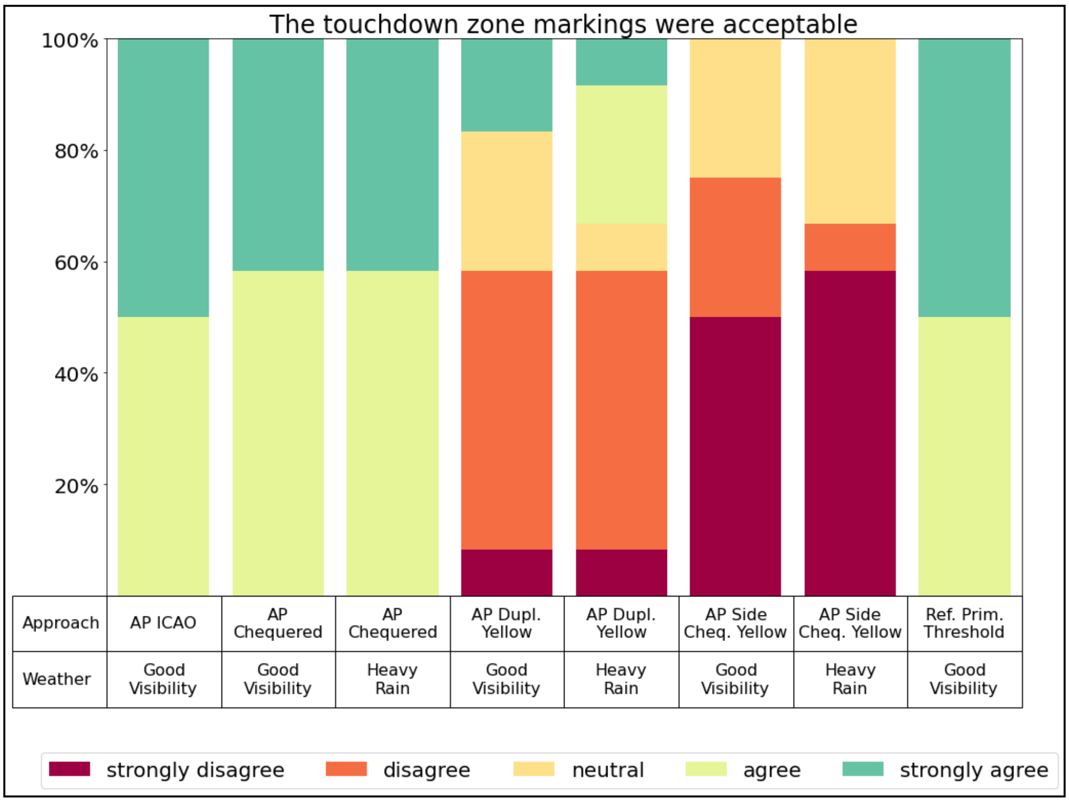

Figure 82: Acceptability of different touchdown zone markings identification for the pilot flying (session 1-6)

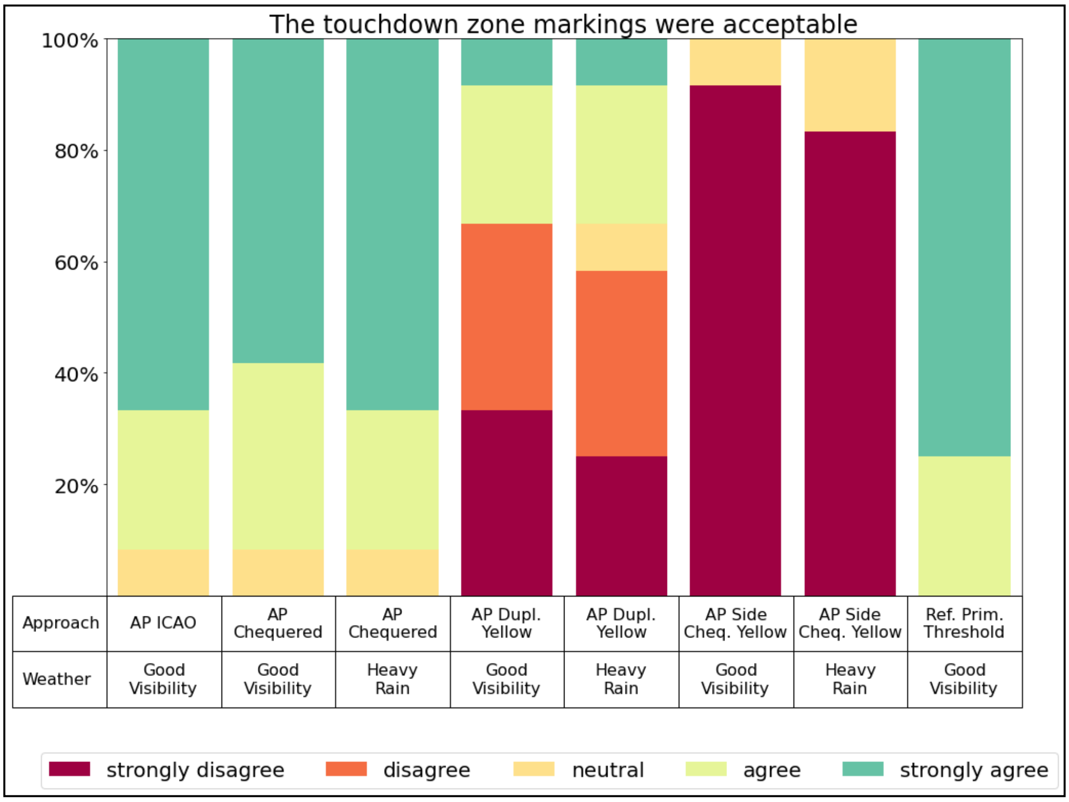

Figure 83: Acceptability of different touchdown zone markings identification for the pilot non-flying (session 1-6)

As well the results for the last element of the marking show the same tendency – white colour his highly more acceptable then yellow. Between option 1 and 2 a difference for the acceptance can't be identified. Introducing blue instead of yellow as colour for the markings improves the acceptability. However, white is still the mostly liked option.

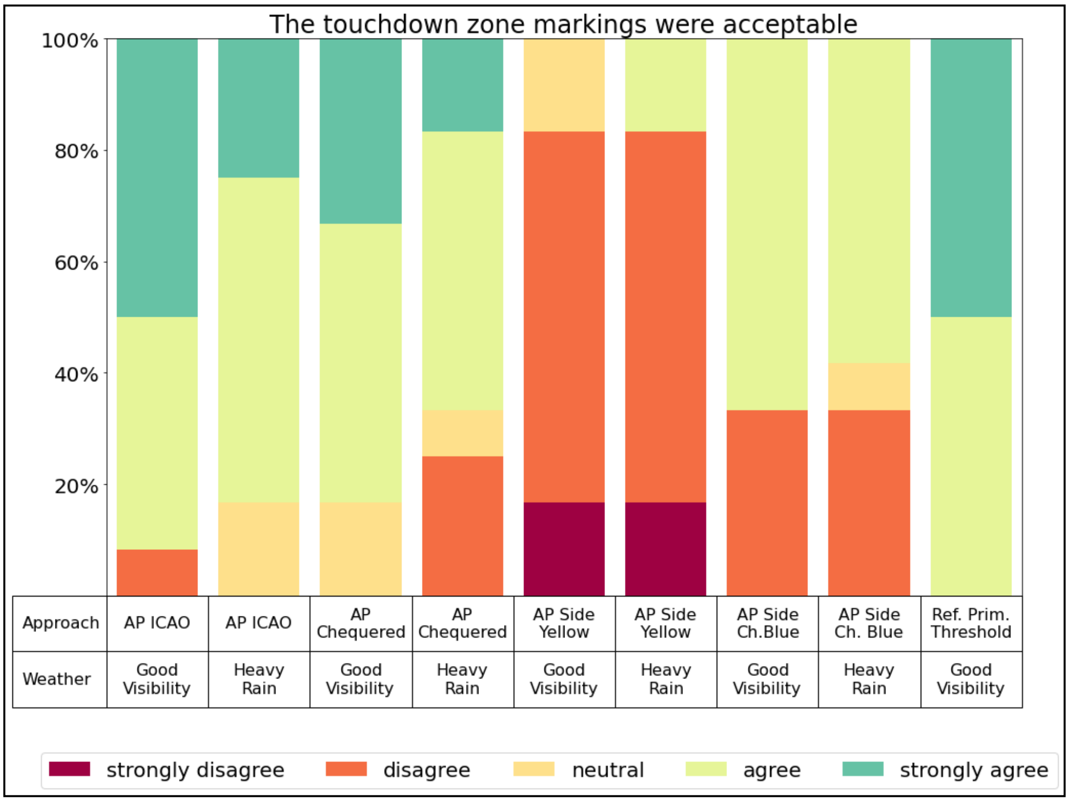

Figure 84: Acceptability of different touchdown zone markings identification for the pilot flying (session 7-12)

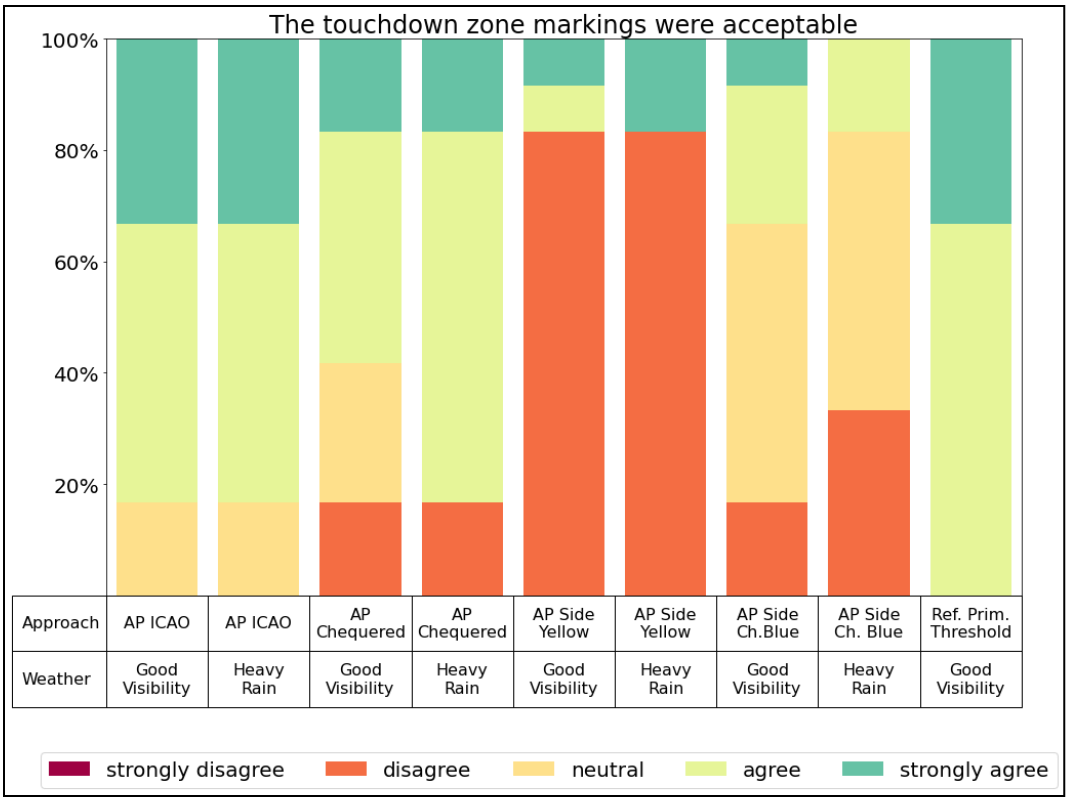

Figure 85: Acceptability of different touchdown zone markings identification for the pilot non-flying (session 7-12)

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After the simulation, the pilots were asked their general feeling on the different marking options.

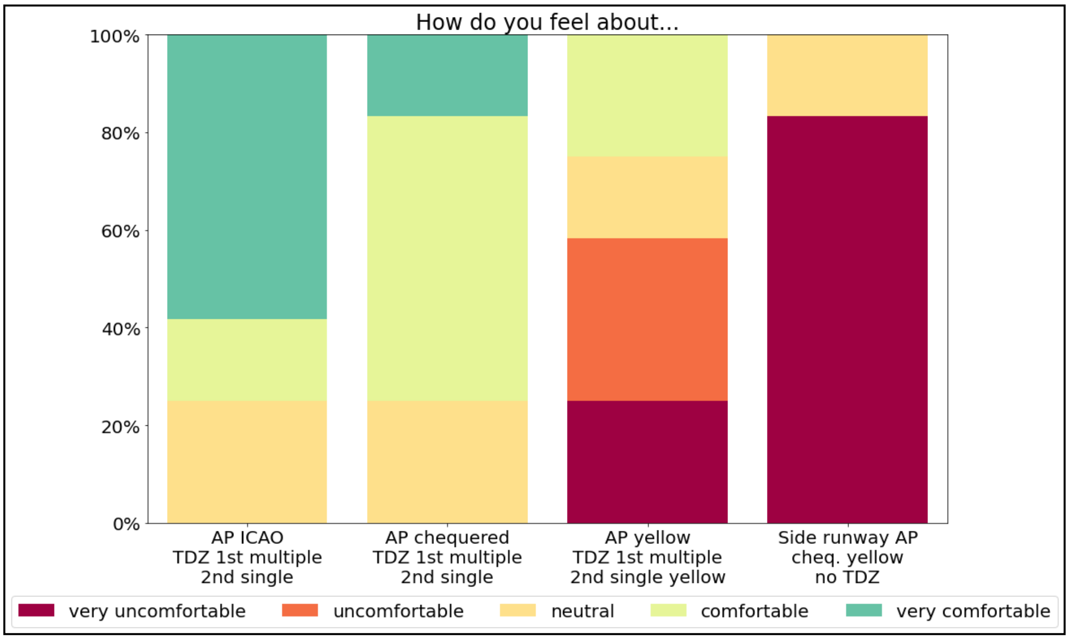

Figure 86: Overall acceptability of marking concepts Session 1-6

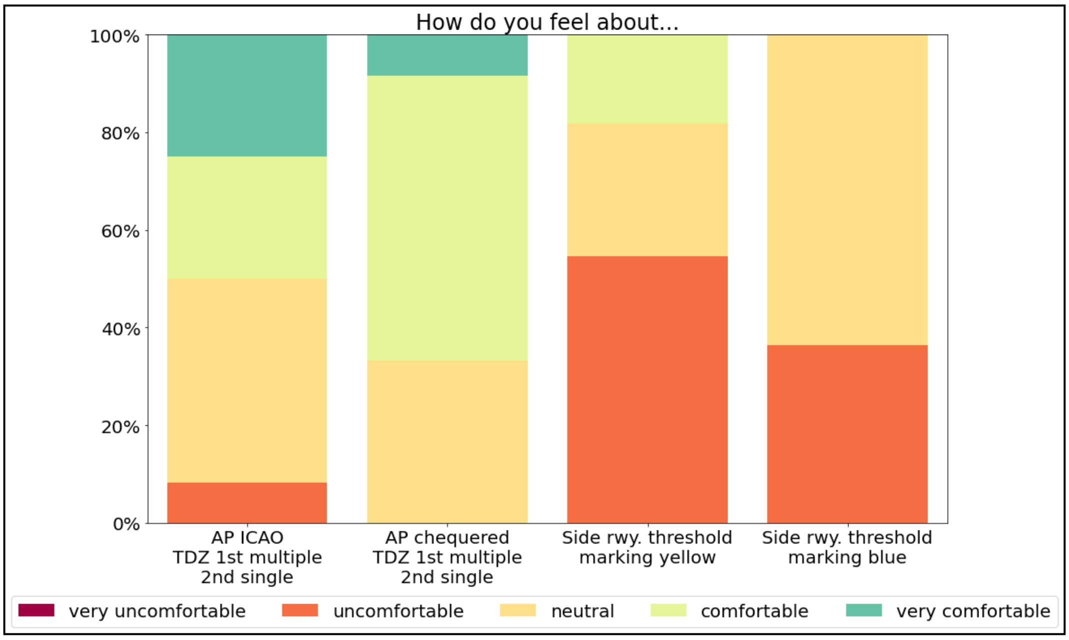

Figure 87: Overall acceptability of marking concepts Session 7-12

The results show a clear tendency towards option 1 and option 2 using white colour. Option 1 indicates the highest overall acceptability. The pilots stated using the standard ICAO marking concept feel most comfortable comparing to the other options. However, using yellow colour for the marking (option 3 and option 4 within session 1-6) was very uncomfortable for the pilots. As already mentioned before, introducing blue as a new colour providing a difference to the standard white colour was more acceptable.

Furthermore, after the simulations the pilots have been asked which option they would prefer most. The results from the previous question were confirmed – option 1 was preferred most by the pilots during session 1-6 and session 7-12, followed by option 2.

However, looking into session 7-12, comparing the options with different colours as side markings (option 3 and option 4), option 3 with yellow colour was preferred more than option 4 with blue colour. During the sessions the pilots stated that the blue colour was better apparent. However, the results of the questionnaires show a tendency to option 3 (session 7-12) with the yellow side markings.

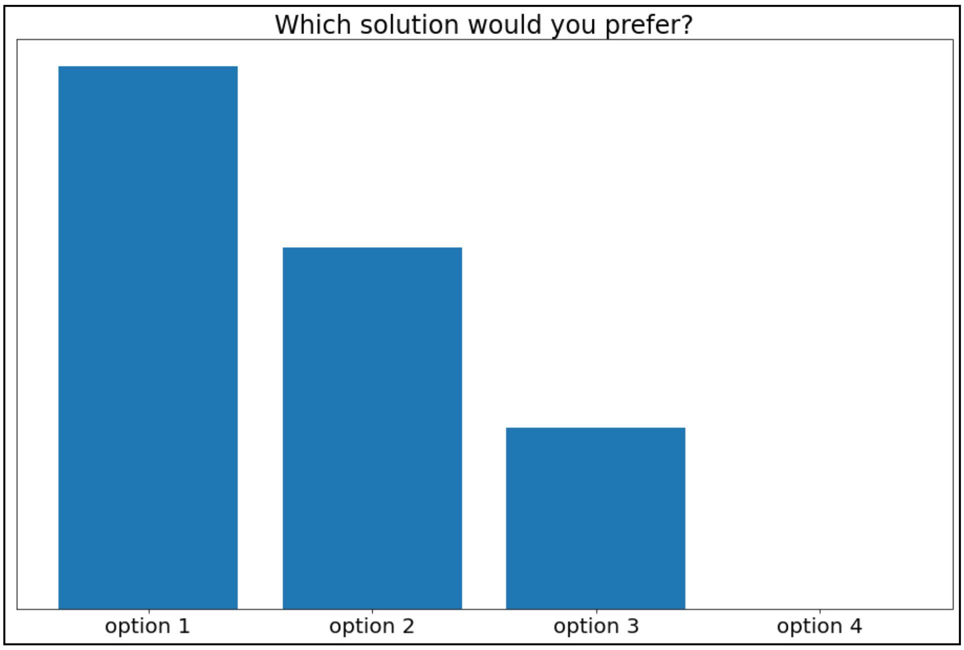

Figure 88: Pilots preference regarding Option 1-4 for session 1-6

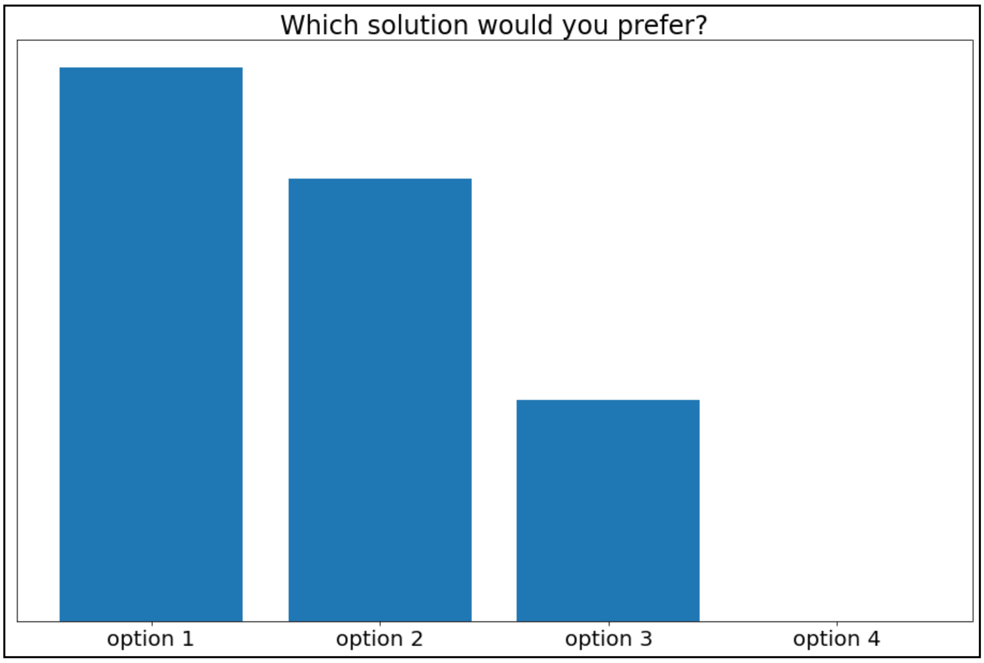

Figure 89: Pilots preference regarding Option 1-4 for session 7-12

9.3.2.3 OBJ-14.5-V3-VALP-00301 Results

The phraseology used is described in section 9.1.1.3.

The pilots found the phraseology well adapted and giving them useful and necessary information. In particular, all pilots stated that the information from ATC about the preceding aircraft and the flown glide raised their situational awareness regarding the intended approach and related threshold.

No changes were suggested by the pilots.

9.3.2.4 Additional results on workload

This section presents the level of perceived workload as experienced by the pilots in all scenarios. The pilots were presented with a questionnaire that contained a question with regard to their workload after each scenario. They were asked to rate their perceived level of workload from 1 being "very low" to 5 being "very high". The analysis took into account if the pilot was flying the scenario or not. There is a figure for the pilot flying and one for the pilot non-flying.

The following two graphs show the workload results recorded after all scenarios for session 1-6 for pilot flying and pilot non-flying. The results always comparing a marking option with good visibility and low visibility using heavy rain. Furthermore, the last column represents the reference scenario flown to the primary threshold.

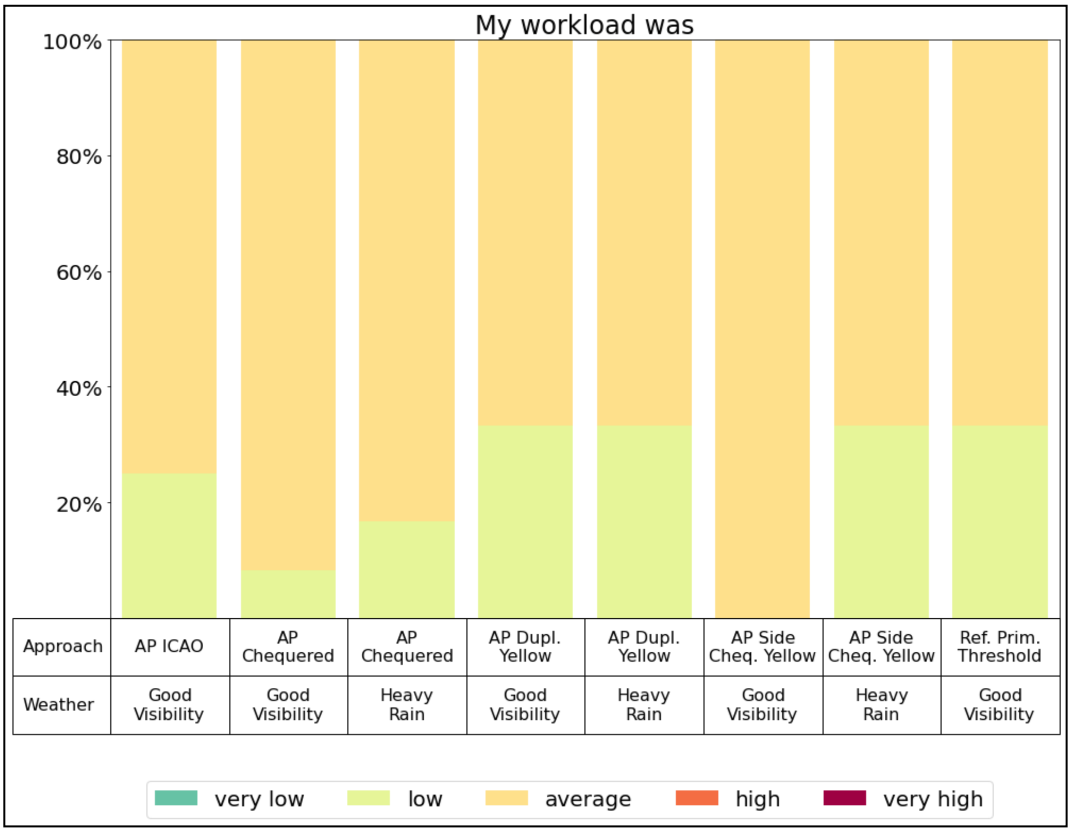

Figure 90: Workload Session 1-6 Pilot Flying

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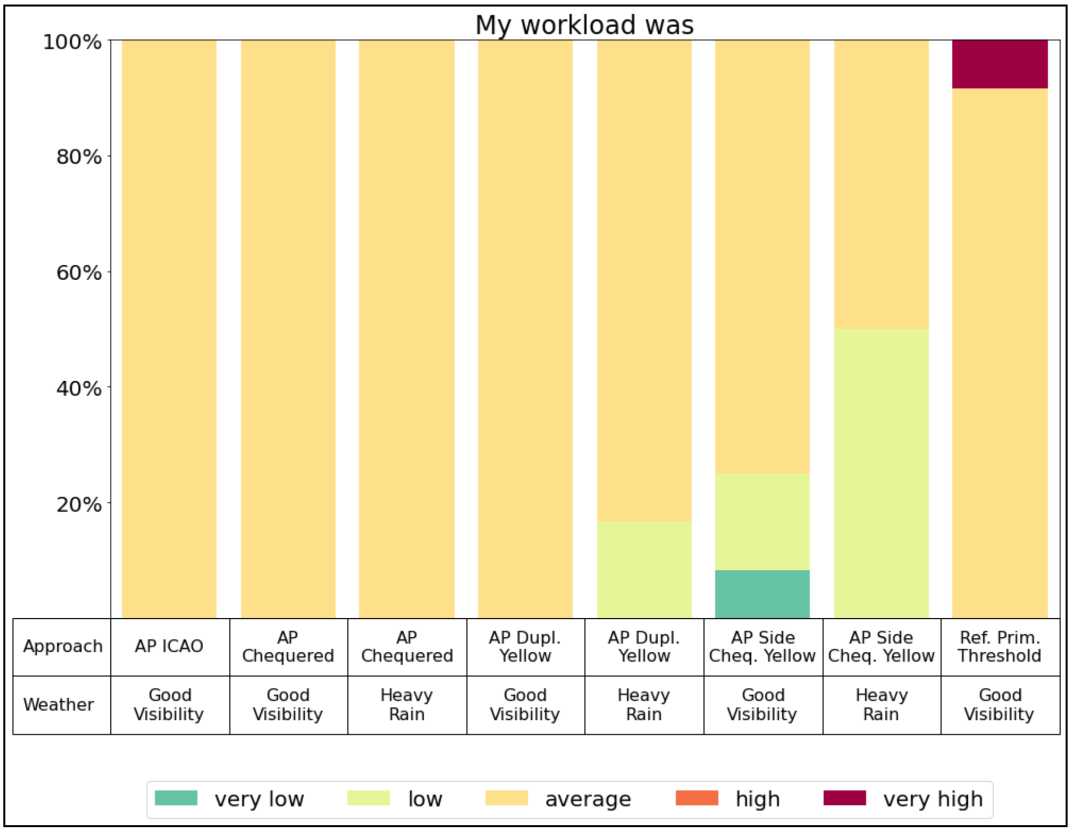

Figure 91: Workload Session 1-6 Pilot Non-Flying

None of the scenarios resulted in a high or very high workload. The "very high" workload in the reference scenario "Pilot-Non-Flying" was based on a misunderstanding of one pilot within the questionnaires. That issue could be clarified during the debriefing.

The following two graphs show the workload results recorded after all scenarios session 7-12 with revised options based on the results of session 1-6. The results always comparing a marking option with good visibility and low visibility using heavy rain. Furthermore, the last column represents the reference scenario flown to the primary threshold.

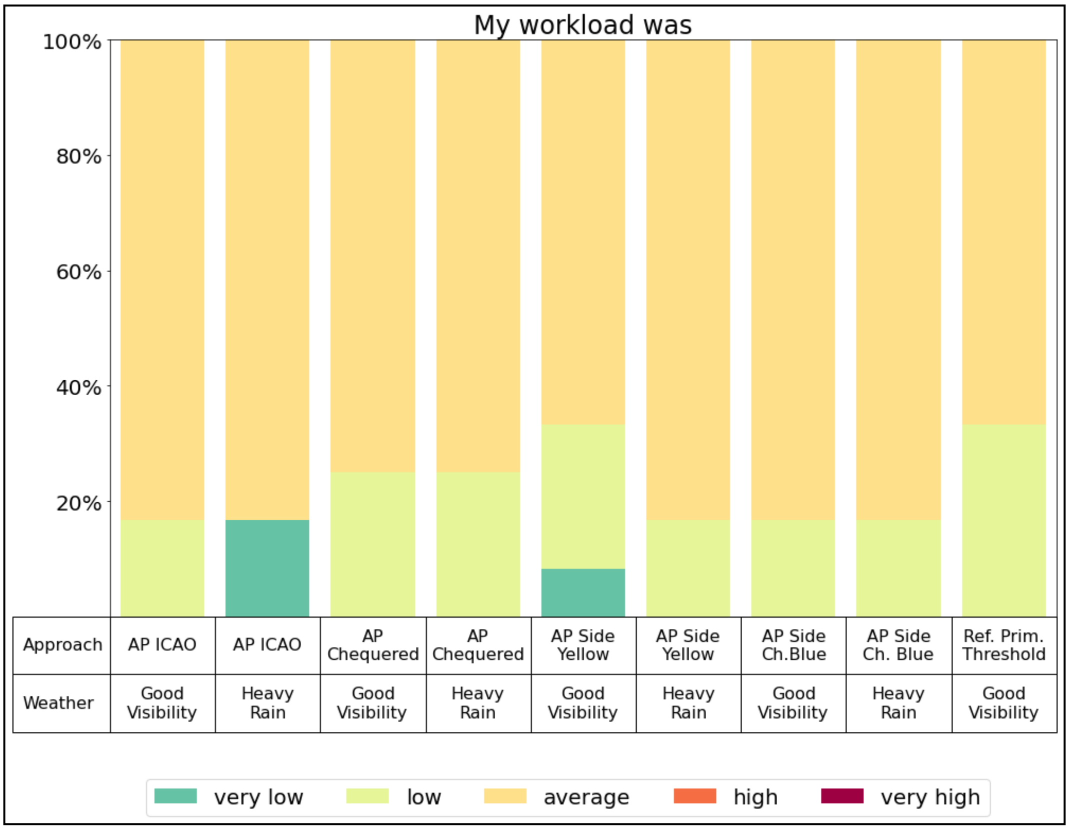

Figure 92: Workload Session 7-12 Pilot Flying

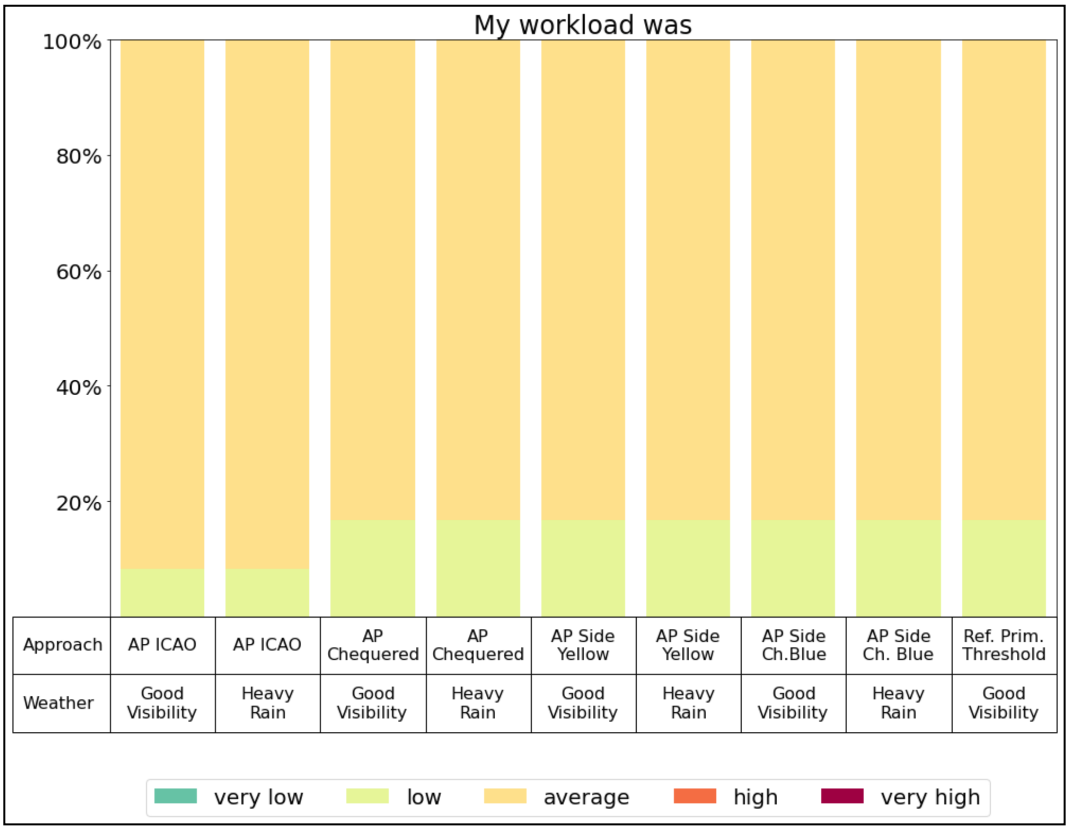

Figure 93: Workload Session 7-12 Pilot Non-Flying

Again, none of the scenarios resulted in a high or very high workload. Furthermore, no difference can be identified between the different marking options with different visibilities.

9.3.3 Unexpected Behaviours/Results

There are no unexpected behaviours to be reported.

9.3.4 Confidence in Results of Validation Exercise EXE-14.5-V3-VALP-R15

9.3.4.1 Level of significance/limitations of Validation Exercise Results

There are no limitations identified, the standard SOP have been applied including ATC, communication, adapted charts and a Level D simulator.

9.3.4.2 Quality of Validation Exercises Results

The simulations were run in a professional Level D certified flight simulator of type Airbus A319. The approaches were flown by certified type rated airline pilots.

9.3.4.3 Significance of Validation Exercises Results

The results of the simulations are operationally significant as they were run using the highest level of realism concerning the cockpit environment and visual system and operated by certified airline pilots.

9.3.5 Conclusions

Overall, the conclusion can be drawn that the pilots found most approaches acceptable and feasible to fly. The general concept for the usage of a second runway aiming point was accepted and the benefits with respect of capacity and improved separation clearly understood.

From the perspective of the usage of different markings to clearly identify the second runway aiming point/threshold overall a highly acceptance was provided. The duplication of ICAO marking using the standard colours caused no confusion, the landing could be performed as usual. A tendency to option 1 (ICAO duplication) was identifiable based on the questionnaires as well during the debriefing discussions. However, option 2 with the chequered aiming point was acceptable too.

Some concerns were expressed though on the operational feasibility of using different colours for the marking instead of standard white. The pilot stated yellow could cause confusion due to a mix-up with taxiway marking which uses yellow as well. Even a statement was made with respect of construction work which uses yellow colours. Additionally, the lower contrast to the concrete of the runway was mentioned, especially for the touchdown zone and aiming point markings. Blue colour was discussed as well but the acceptability was higher due to the fact that there is no possibility of confusion with taxiway marking.

Furthermore, for the side marking options used for a second runway aiming point configuration with less distance of 1000m between the two thresholds was not favoured by the pilots. They stated a possible safety issue with missing touchdown zone markings during session 1-6 with option 4. That intermediate conclusion was implemented in session 7-12 using standard marking for the touchdown zone and the aiming point on the runway but using yellow or blue colour for the whole markings. That option was better accepted. However, most of the pilots indicated using a different colour than the standard white needed to be briefed well to maintain situation awareness and protect the pilot flying from confusion during flare.

Though, it should be mentioned the majority of the pilots stated the markings are visible only in the very last segment of the approach short before commencing the during the flare phase. Consequently, the influence on overall approach with respect of workload, safety and feasibility can be assessed as comparatively lower then e.g. the approach lighting system.

9.3.6 Recommendations

The tests were overall positively acknowledged by most pilots, however some minor issues were reported. Still the tests allowed to make a few preliminary recommendations:

- (recurrent) Training on different approach types to SRAP and IGS to SRAP has to be ensured
- In the cockpit, special focus has to be put on the briefing:
  - Which threshold is used (standard or SRAP)
  - Special briefing is needed in case of 3.5°approach
  - Landing distance available (especially for SRAP)
- ATC should communicate the approach type of the previous aircraft
- The approach naming shall be indicated by a different runway number (e.g. xLS 08R & xLS 09R)
- The marking should be as close to existing marking as possible
- Touchdown zone marking should be on the runway.

10 Validation Exercise EXE-14.5-V3-VALP-R25 Report

10.1Summary of the Validation Exercise EXE-14.5-V3-VALP-R25 Plan

10.1.1Validation Exercise description, scope

The scope of the validation exercise R25 addressed SRAP and IGS-to-SRAP runway lighting steady solution from pilots' perspective via flight cockpit simulations using high level professional Level D/Type 7 flight crew training simulator. The simulator of the type Airbus A319 had full motion, control loading and a configurable visual system.

Figure 94: A319-100 Full Flight Simulator

The simulator is certified according to EASA CS-FTD Level D. The simulator is equipped with the following avionic components and systems:

<u>Aircraft Systems</u>	
Engine	General Electric CFM56-5A5, 23500 lbs T/O Thrust
APU	APS 3200, Hamilton Sundstrand Corp (Software simulation)
<u>Autoflight System</u>	
FMGS	S7AC13, Thales Avionics/Smiths (Full GPS, Orig. a/c boxes)
FCU	M11, Thales Avionics Sa (Orig. a/c box)
FAC	CR102, Thales Avionics Sa (Software simulation)
MCDU	Thales Avionics/Smiths (Orig. a/c box)
<u>Electronic Flight Control System</u>	
ELAC	L93, Thales Avionics Sa (Orig. a/c boxes)
SEC	L123, Thales Avionics Sa (Orig. a/c boxes)

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FCDC	L53, LITEF GmbH (Software simulation)

<u>Electronic Instrument System</u>

DMC	V70, DIEHL AEROSPACE GmbH (Orig. a/c boxes)
FWC	H2F7, Airbus France (Orig. a/c boxes)
DU	FCD66, Thales Avionics Sa (Orig. a/c boxes)
SDAC	H1-D1, Airbus France (Software simulation)
TCAS II	7.1, Honeywell (Software simulation)
ACARS	AMU MK I, Honeywell International Inc. (Orig. a/c box)
EGPWS	MK V, Honeywell International Inc. (Orig. a/c box)

Figure 95: Flight Deck Airbus A319 FFS

The visual system was modified to simulate a second runway threshold and aiming point used for SRAP and IGS-to-SRAP operations including:

- one “normal” threshold with runway markings (incl. aiming point and touchdown zone markers), CAT II/III approach light system, PAPI, and Touchdown Zone (TDZ) Lights
- a second threshold located 1100m further beyond the normal threshold, with runway markings, a proposed specific CAT I approach light system (along the runway centreline), PAPI and Touchdown Zone Lights
- Centreline Lights
- Runway Edge and Runway End Lights

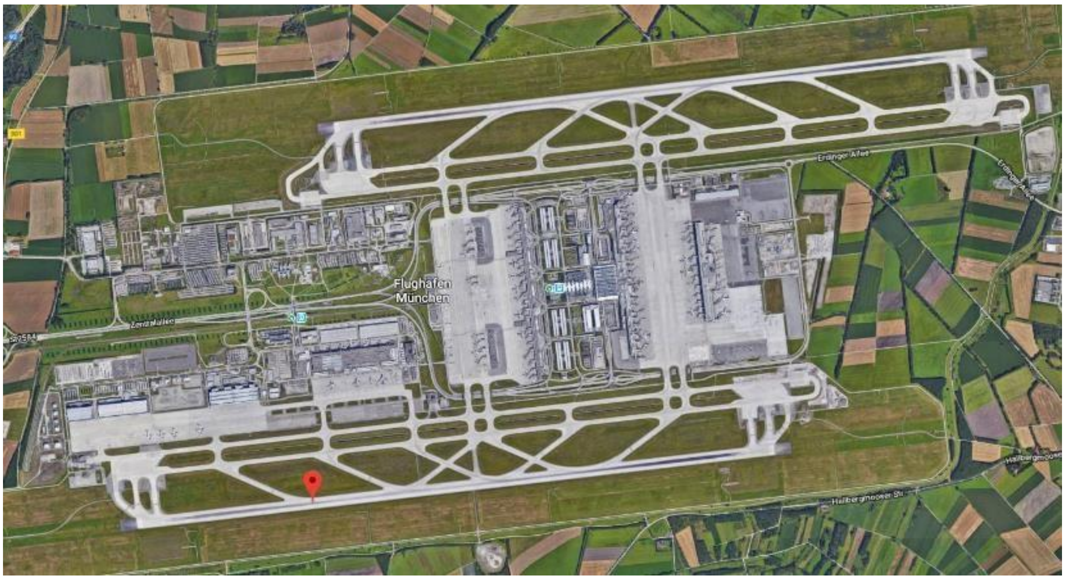

Figure 96: Position of the second threshold

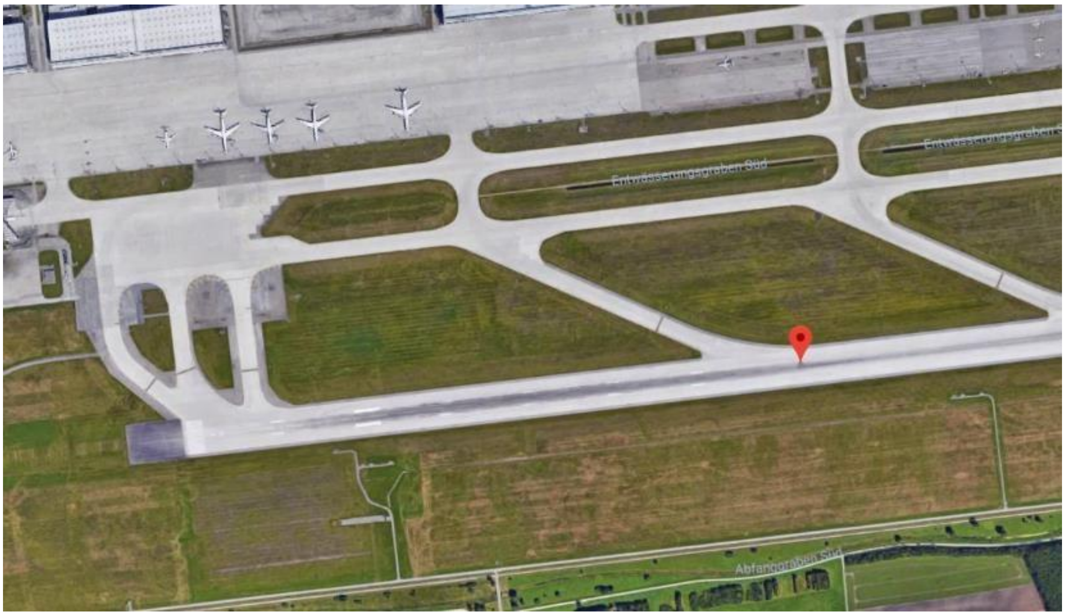

Figure 97: Position of the second threshold in detail

The environment used was Munich Airport with the added second threshold on runway 08R. The installed approach light system for this runway represented an ideal setup according to ICAO Annex 14 and EASA CS-ADR (certification specification for aerodrome design) requirements for a CAT II/III full approach light system. The runway has a length of 4000m and the steady solution for lighting was implemented - all approach lights, except the TDZ lights, were illuminated at the same time for both thresholds.

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Figure 98: Steady lighting configuration Rwy 08R/09R activated

10.1.1.1 Charts

Charts for SRAP and IGS-to-SRAP approach were developed based on existing EDDM ones (Jeppesen). They included in particular:

- the vertical profile to the second threshold with the remaining runway length
- a note explaining that the procedure is a SRAP one
- a note giving the location of the PAPI for the SRAP or IGS-to-SRAP approach.

A set of paper charts were given to pilots. The charts are attached in Appendix G.

10.1.1.2 Phraseology

In addition of the 2 pilots, the scientific test flight instructor from Lufthansa Aviation Training played the controllers' role, giving in particular the clearances for approach and landing. The phraseology used was the same as in R10 and R15.

Approach clearance was given before releasing the simulator in order to give time to pilots for briefing:

“ECTL021, Cleared ILS approach Runway 09R (or Cleared RNP approach Runway 09R), you are n°5 on final, preceding is B767 on lower glide”

The **landing clearance** is as follows:

“ECTL021, cleared to land RWY 09R, second threshold, wind xxx kts”

10.1.1.3 Scope of EXE-14.5-V3-VALP-R25

The aim of this exercise was:

- To further evaluate the static solution for runway lighting
- To confirm that the pilot tasks performance when flying an IGS-to-SRAP approach is not negatively impacted
- To confirm that IGS-to-SRAP does not negatively affect safety from the perspective of the crew
- To confirm that IGS-to-SRAP is operationally feasible from flight crew perspective.

The simulator had data recording capabilities allowing extraction of the flown 4D trajectory and conversion to Excel (or CSV) format for each flown scenario. Video recordings was made of the aircraft windscreen (external visual view) during each scenario.

The approach to the normal threshold was an ILS approach. The approach to the second threshold was an ILS or RNP APCH. This means that the simulator allowed programming an ILS with touchdown aiming point beyond the normal threshold and a second ILS to land on the second touchdown aiming point beyond the second threshold.

An aircraft database was provided and loaded in the simulator containing the ILS approach to the normal threshold, the ILS approach to the second threshold and the RNP APCH to the second threshold. Both ILS approaches had a 3 degree glide slope while the RNP APCH had a 3.5 degree final approach path.

Within the exercise several stakeholders have been involved. The stakeholder's expectations are given in the table below.

Stakeholder	Involvement	Why it matters to stakeholder
Airspace Users	Airspace Users (Airline Pilots) will be involved in the validation sessions	Airspace Users are interested in assessing the impact of SRAP and IGS-to-SRAP procedures on crew from safety and HP point of view.
ANSPs	No involvement in the validations.	ANSPs also need evidence to show that the SRAP and IGS-to-SRAP procedures are operationally feasible.
Airport Operators	No involvement in the validations.	Airport Operators are interested in the validation results of the exercise because SRAP concept could have a positive effect of noise reduction in the areas close to the airports. SRAP and IGS-to-SRAP may provide added value to alleviate any existing or future stringency on capacity due to noise and then improving quality of service to AUs.
Air Transport industry	Lufthansa Aviation Training is running the exercise.	Lufthansa need to assess the selected design solution to fly SRAP and IGS-to-SRAP approaches and in assessing the impact on the crew on safety and HP point of view. Expected positive effects of SRAP and IGS-to-SRAP concept on noise footprint, could give a competitive advantage to aircraft equipped with SRAP and IGS-to-SRAP capability.

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Stakeholder	Involvement	Why it matters to stakeholder
European Commission	Direct participation through SJU.	EC is interested into improving the main KPA related the ATM. Regarding PJ.02-W2-14.5 EC is interested in Capacity and Environment KPA possible benefits coming from SRAP and IGS-to-SRAP concept.
EUROCONTROL	EUROCONTROL is leading the solution PJ.02-W2-14.5.	EUROCONTROL is interested on the validation results of the exercise because they need evidence to show that safety will be maintained or improved. EUROCONTROL also needs evidence to show that the SRAP and IGS-to-SRAP procedures are operationally feasible from pilots' side.

Table 27: stakeholders' expectations of EXE-14.5-V3-VALP-R15

10.1.2Summary of Validation Exercise EXE-14.5-V3-VALP-R25 Validation Objectives and success criteria

Section 10.3.1 contains a summary of the validation objectives and success criteria, with the achieved results. To avoid duplication, the table is not repeated here.

10.1.3 Summary of Validation Exercise EXE-14.5-V3-VALP-R25 Validation scenarios

EXE-14.5-V3-VALP-R25 addressed SRAP and IGS-to-SRAP runway lighting steady solution from pilots' perspective. The exercise was performed using an Airbus A319-100 high level professional Level D/Type 7 flight crew training simulator without integration in a real ATM traffic environment.

In the reference scenario, the published standard ILS approach (conventional slope of 3 °) to the primary threshold Rwy 08R was flown (primary). In the solution runs, SRAP and IGS-to-SRAP approaches were flown. SRAP approaches were guided by an ILS to Rwy 09R, IGS-to-SRAP by RNAV procedures to Rwy 09R.

Twelve sessions involving two airline pilots have taken place. Each session encompassed:

- A briefing session where the concepts to be evaluated be explained to the pilots
- 16 runs described in the table below, each followed by a questionnaire
- 1 post session questionnaire followed by a post session debriefing

Run	ALS	Approach	THR	Wind	Visibility	weather
1	steady	ILS09R	09	calm	2500m	
2	steady	ILS09R	09	calm	1500m	
3	steady	ILS09R	09	calm	1500m	
4	steady	ILS08R	08	calm	2500m	
5	steady	ILS09R	09	calm	CAVOK	
6	steady	ILS09R	09	350/20/G28	3000m	Ceiling 400ft

7	steady	ILS09R	09	350/20/G28	3000m	Ceiling 400ft
8	steady	ILS09R	09	calm	2500m	
9	steady	ILS08R	08	calm	2500m	
10	steady	ILS09R	09	calm	CAVOK	
11	steady	RNP09R	09	calm	2500m	
12	steady	RNP09R	09	calm	2500m	
13	steady	RNP09R	09	350/20/G28	3000m	Ceiling 400ft
14	steady	ILS08R	08	350/20/G28	3000m	Ceiling 400ft
15	steady	ILS08R	08	calm	1500m	
16	steady	RNP09R	09	calm	1500m	

Table 28: Scenario List of R25 (in blue, IGS-to-SRAP runs)

10.1.4Summary of Validation Exercise EXE-14.5-V3-VALP-R25 Validation Assumptions

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
R25-ASS1	IGS-to-SRAP landing minima	Procedure in place	Pilots are expected to use the landing minima from the charts (no increase to be applied by pilots).	As per IGS-to-SRAP concept definition, if there is an impact on landing minima for IGS-to-SRAP, it should be transparent for the pilots.	Approach	Interoperability	OSED	n/a	PJ02-W2-14.5	MEDIUM

Table 29: R25 Validation Assumptions overview

10.2Deviation from the planned activities

R25 was not described in the Validation Plan. Most of what was written in EXE-14.5-V3-VALP-R15 Plan is valid for R25. What is not included in R25 is all that concerns the switching lighting which is not assessed in R25.

10.3Validation Exercise EXE-14.5-V3-VALP-R25 Results

10.3.1Summary of Validation Exercise EXE-14.5-V3-VALP-R25 Results

The table below provides an overview of the Validation Objectives and the Success Criteria as mentioned in the EXE-14.5-V3-VALP-R15 Plan. For each objective, the table provides the paragraph numbers in which the results for each objective are discussed. Finally, the table indicates for each objective whether the validation objective analysis status is OK, partially OK or NOK.

Validation Exercise R25 Validation Objective ID	Validation Exercise R25 Validation Objective Title	Validation Exercise R25 Success Criterion ID	Validation Exercise R25 Success Criterion	Sub-operating environment	Exercise R25 Validation Results	Validation Exercise R25 Validation Objective Status
OBJ-14.5-V3-VALP-0203	To confirm that IGS-to-SRAP does not negatively affect safety from the perspective of the crew	CRT-14.5-V3-VALP-0203	There is evidence that the level of operational safety is maintained and not negatively impacted under IGS-to-SRAP procedures compared to the reference scenario, from the perspective of the crew	Aircraft, Crew	See 10.3.2.1	OK
OBJ-14.5-V3-VALP-0204	To confirm that the Second Runway Aiming Point (SRAP) is operationally feasible from crew perspective	CRT-14.5-V3-VALP-0204-001	Pilot succeeds to manage IGS-to-SRAP operation by applying existing SOPs.	Aircraft, Crew	See 10.3.2.2	Ok
		CRT-14.5-V3-VALP-0204-002	Pilots are confident when flying IGS-to-SRAP operation	Aircraft, Crew	See 10.3.2.2	Ok
OBJ-14.5-V3-VALP-0301	To confirm that the phraseology used by ATCO and Flight Crew for IGS-to-SRAP is clearly understandable	CRT-14.5-V3-VALP-0301-002	Proposed phraseology does not lead to errors related to perception & interpretation of	Aircraft, Crew	See 10.3.2.3	OK

Validation Exercise R25 Validation Objective ID	Validation Exercise R25 Validation Objective Title	Validation Exercise R25 Success Criterion ID	Validation Exercise R25 Success Criterion	Sub-operating environment	Exercise R25 Validation Results	Validation Exercise R25 Validation Objective Status
			auditory information.			
		CRT-14.5-V3-VALP-0301-003	Pilots accept and judge the proposed phraseology as being appropriate for all encountered operating		See 10.3.2.3	Ok

Table 30: Validation Objectives for Exercise R25 (IGS-to-SRAP)

10.3.2 Analysis of Exercise EXE-14.5-V3-VALP-R25 Results per Validation objective

The sections below provide the results per validation objective.

10.3.2.1 OBJ-14.5-V3-VALP-0203 Results

This chapter presents the results on the subjective feeling of safety recorded after each flight. The pilots were asked to rate if they think that their perceived level of safety decreased, stayed the same or increased compared to today's operation.

The following graphs indicate the perception of safety after all runs for the pilot flying and the pilot non-flying respectively.

Overall, it can be summarized that from pilot perspective the level of safety is not influenced using the steady approach light configuration under various circumstances (reduced visibility, crosswind). Only a few runs without any tendency regarding visibility or wind have been rated with a decrease of safety.

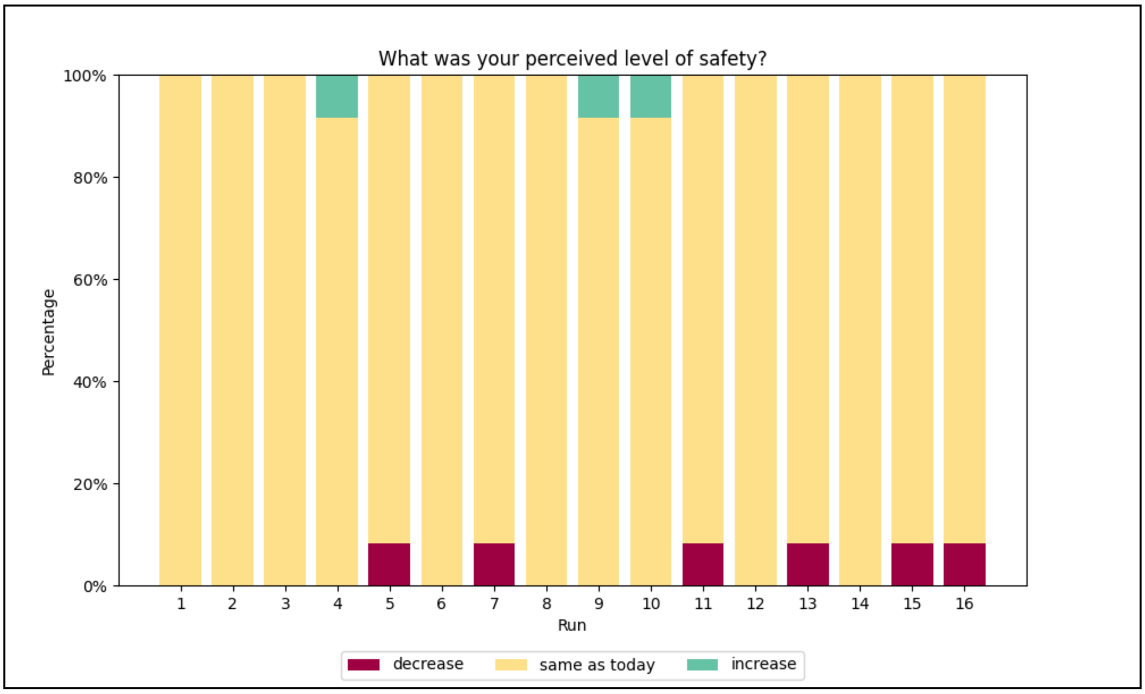

Figure 99: Perceived level of safety after all runs Pilot flying

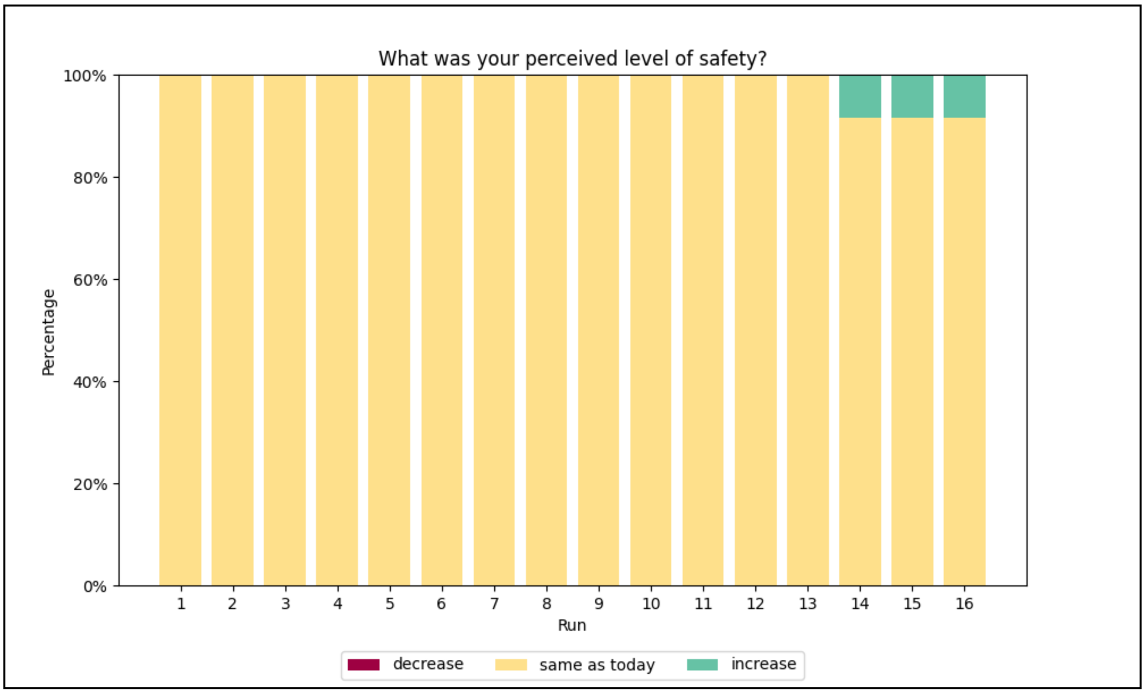

Figure 100: Perceived level of safety after all runs Pilot non-flying

10.3.2.2 OBJ-14.5-V3-VALP-0204 Results

To be in line with the objective the chapter outlines the results on the question of operational feasibility.

The pilots filled a questionnaire after the simulation where they were asked questions regarding the standard operating procedures (SOPs), and the acceptability of the different concepts.

More than 95% of the pilots indicated that they executed all tasks in line with the SOPs and that they can imagine using the concept of Secondary Runway Aiming Point in an every-day operation. Some pilots stated that there already some airports using displaced threshold which is causing no operational problems. Consequently, it can be preliminary concluded that the concept is operational feasible.

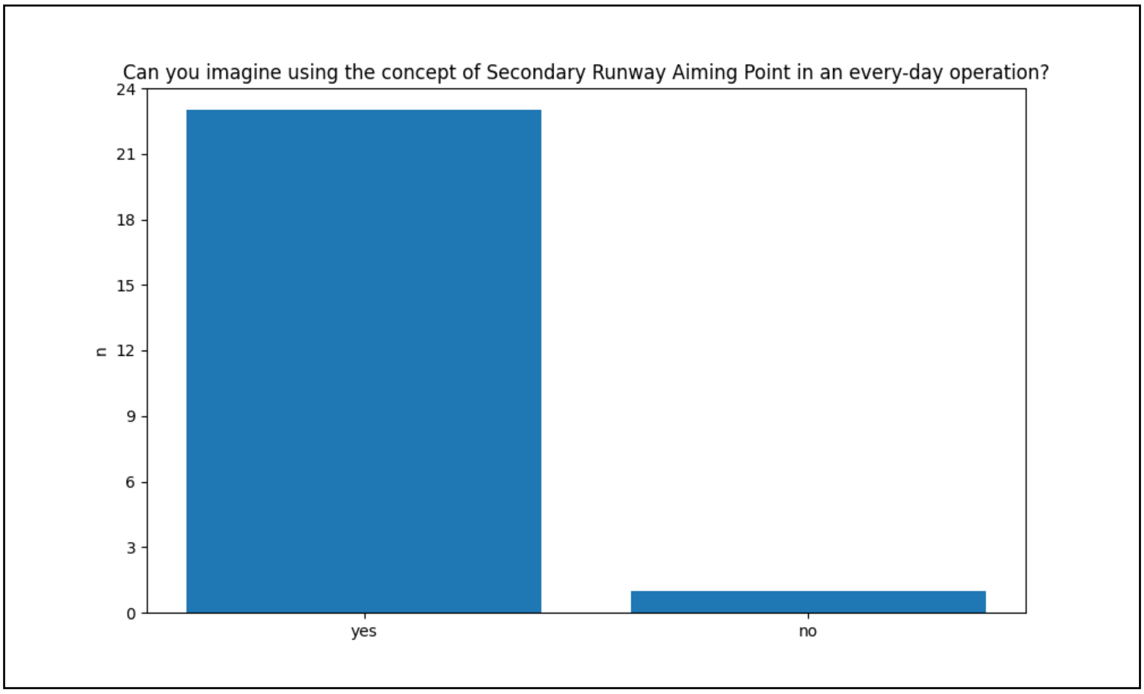

Figure 101: Pilot`s acceptance using SRAP/IGS-SRAP in daily operations

During one session several go-arounds have been initiated due to unstable approaches during the final segment. The go-around could be performed without any problems. The pilots stated thereafter the causing factors were:

- Sitting on the left seat as a first officer without experience flying from the left side
- Airbus rating but flying currently a Boeing B777F

Both pilots stated that neither the new approach light configuration nor the second threshold caused the unstable approach.

The visual indications are one of the factors contributing to operational feasibility and are therefore reported hereafter.

10.3.2.2.1 PAPI

The pilots were asked several questions about the visual indications like PAPI, runway marking and the approach light configuration.

The graph below indicates the answer to the question whether the PAPI is acceptable to the pilots. Pilots were asked to answer to the question “The PAPI indications were acceptable to me” with a rating from 1 “strongly disagree” to 5 “strongly agree”.

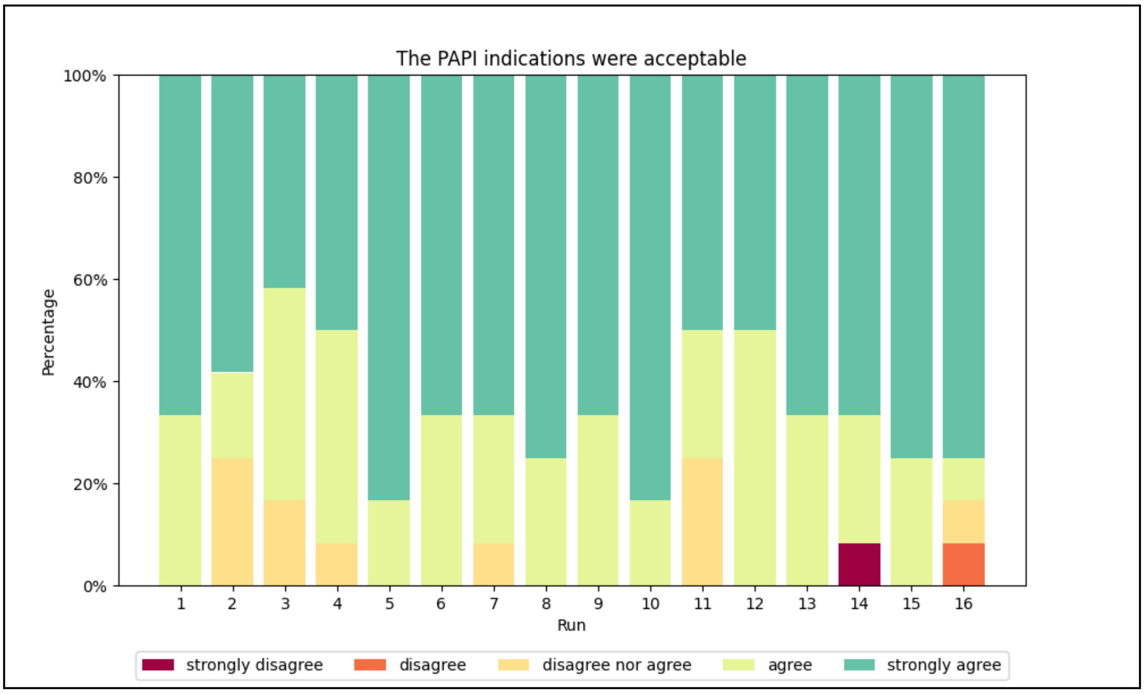

Figure 102: Acceptability of different PAPI settings for the pilot flying

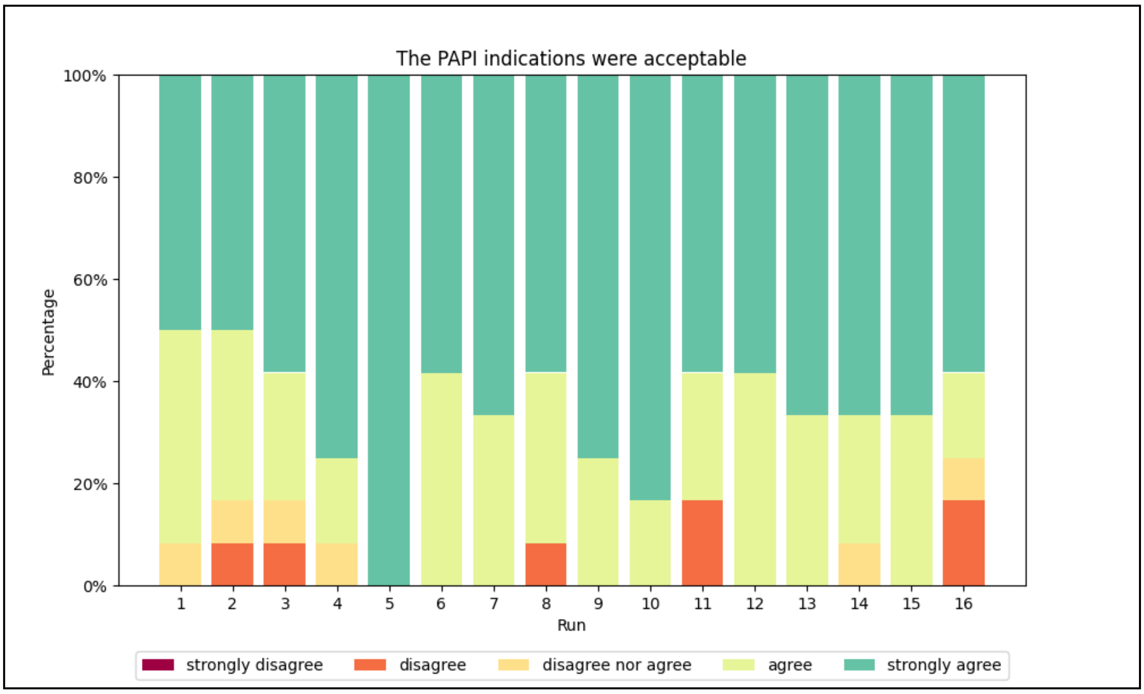

Figure 103: Acceptability of different PAPI settings for the pilot-non-flying

Based on the overall result the PAPI was acceptable – at least 80% of the pilots stated for all scenarios 80% “strongly agree” and “agree”. Only a few pilots stated the PAPI indications were not acceptable.

However, no clear tendency was to be identified regarding any wind/visibility scenario or using the first or second threshold. The pilots who rated a “disagree” or “strongly disagree” noted, that the PAPI was very late visibly. However, based on the chosen visibility and position of the aircraft on the approach slope, it was at that point not possible to see the second PAPI. Due to the circumstance that the first PAPI for the first threshold was already visible, the pilots had the tendency to expect to have the second PAPI visible at the same time – what was not possible due to the fact of the displacement of 1100m.

10.3.2.2.2 Threshold identification

The graph below indicates the answer to the question if the threshold identification were acceptable to the pilots. They were asked to answer to the question "The threshold identification was acceptable to me" with a rating from 1 "strongly disagree" to 5 "strongly agree".

Overall, at least 90% of the pilots during all scenarios stated that the threshold identification was acceptable using "agree" or "strongly agree". The both "strongly disagree" and ""disagree" have been identified within post-analysis as wrong statements and can be ignored.

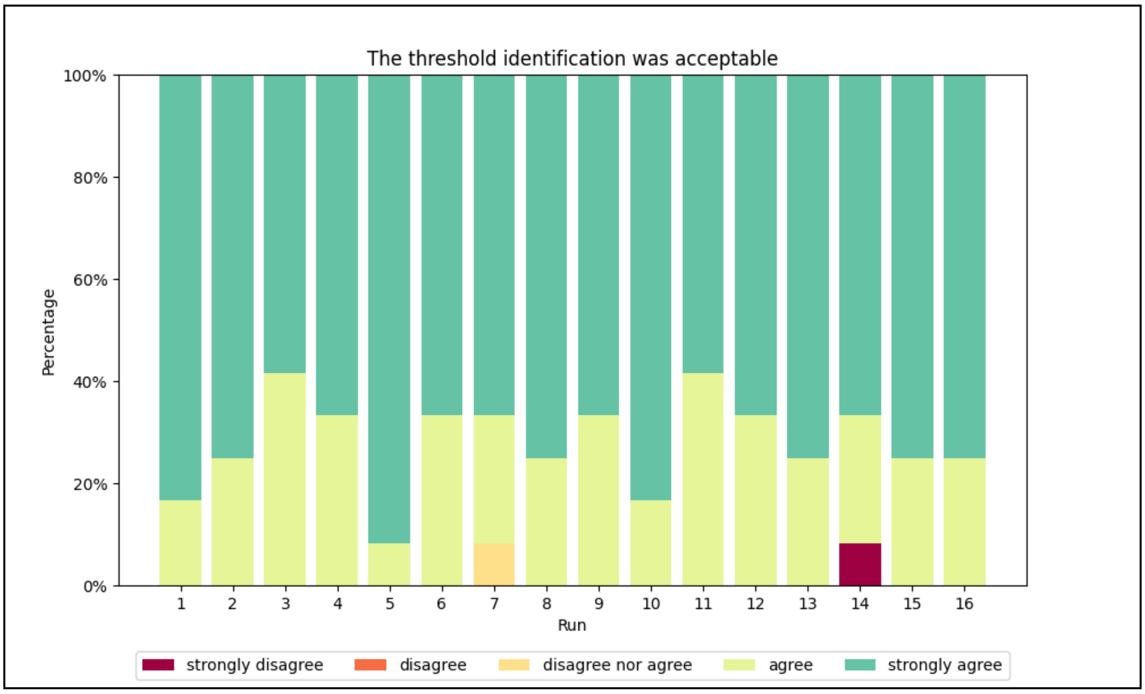

Figure 104: Acceptability of the threshold identification for the pilot flying

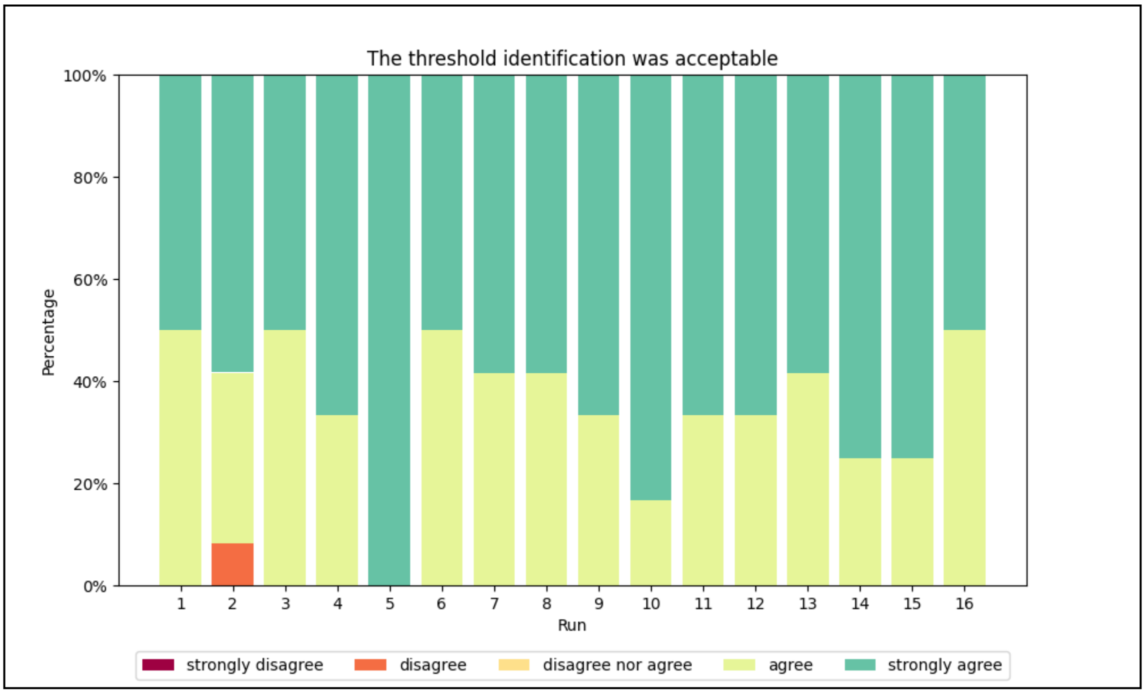

Figure 105: Acceptability of the threshold identification for the pilot-non-flying

10.3.2.2.3 Approach Light Configuration

The graphs below indicate the answer to the question if the approach light configuration was acceptable to the pilots. They were asked to answer to the question "The approach light configuration was acceptable to me" with a rating from 1 "strongly disagree" to 5 "strongly agree". The two figures show all scenarios according to the scenario list in Table 17 for pilot flying and pilot-non-flying.

The results show at least 90% of the pilots could accept the threshold identification during all scenarios flown, only a few stated "disagree nor agree". The only statement "strongly disagree" can be disregarded. During post-analysis it has been identified that the pilot forgot to answer these questions. Consequently, all answers have been "strongly disregard" by default setting. Overall, it can be noted that the approach lighting configuration "steady" has been fully accepted.

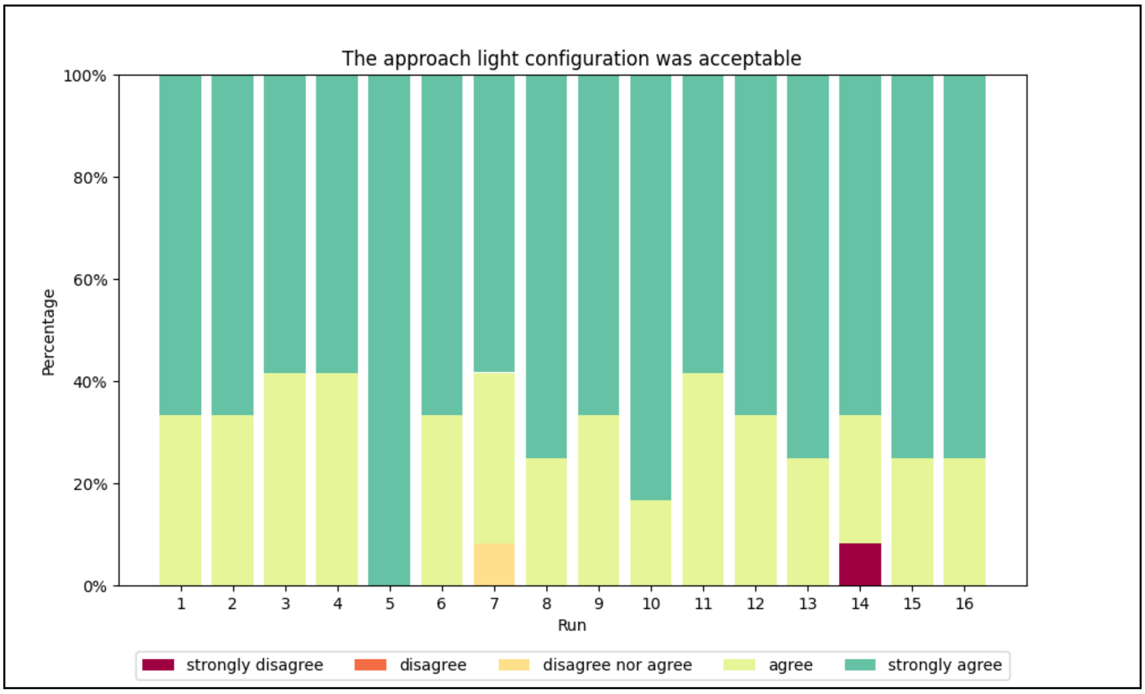

Figure 106: Acceptability of the approach light configuration for the pilot flying

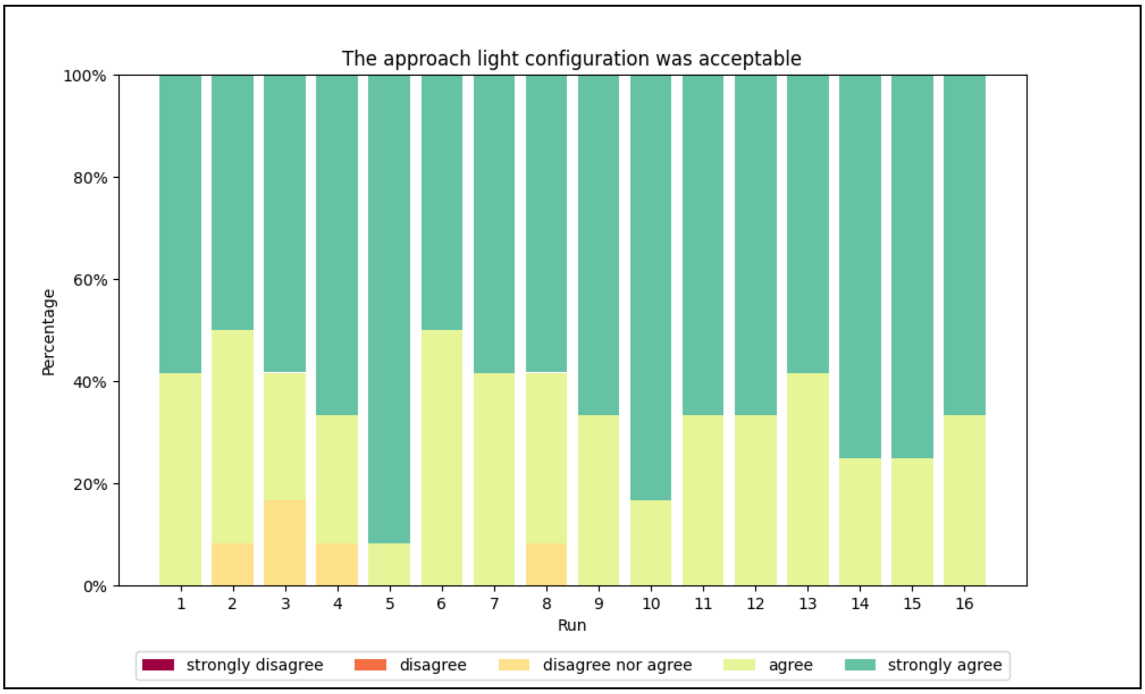

Figure 107: Acceptability of the approach light configuration for the pilot non-flying

After the simulation, the pilots were asked their general feeling on the used steady approach lighting configuration during the SRAP and IGS-to-SRAP scenarios. Figure 108 provides the results from the debriefing questionnaire. All pilots could accept the steady concept, no pilots felt uncomfortable or very uncomfortable.

Furthermore, after the simulations the pilots have been asked about possibility to be put consistently on the second threshold. Figure 109 provides the results from the debriefing questionnaires – the results show a clear acceptance, only one pilot stated "no".

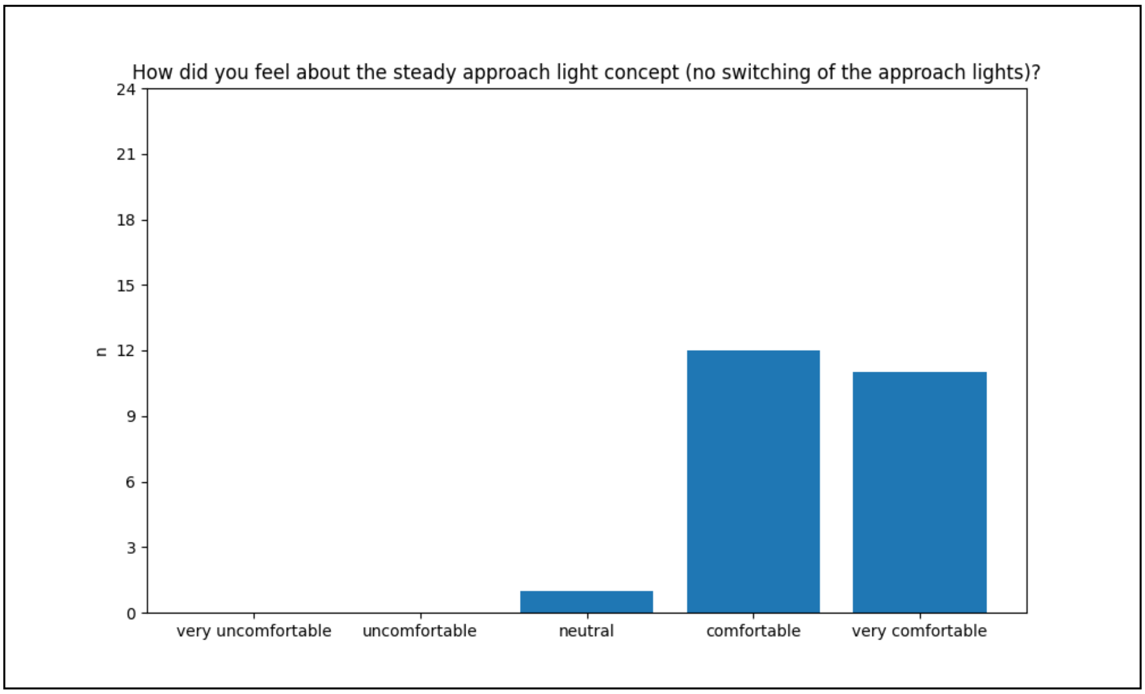

Figure 108: Overall acceptability of Lighting Concept

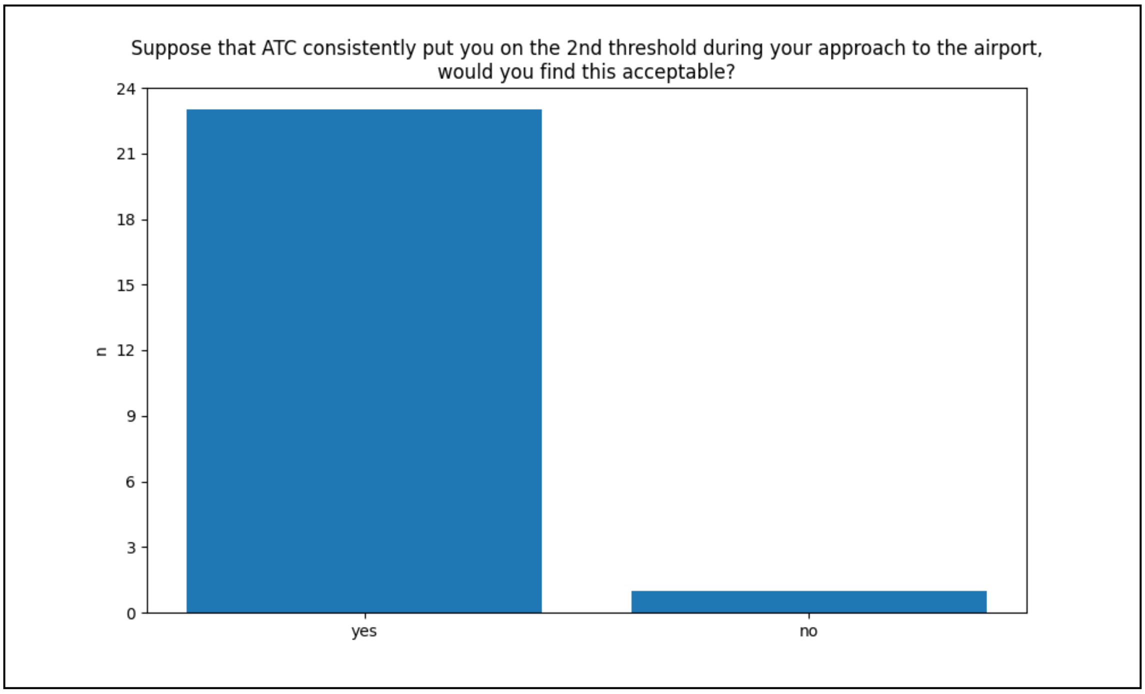

Figure 109 Acceptability of the consistent use of the second threshold

The last question has been asked in the debriefing questionnaire was regarding the concept for the numbering/naming of the second threshold/approach. Four options have been proposed:

a. Different RWY numbers for the 2 thresholds, like in the simulation (xLS 08R & xLS 09R)

b. Same RWY number for the 2 thresholds and approach charts with a suffix (xLS Z 08R & xLS Y 08R)

c. Same RWY number for the 2 thresholds and approach charts with a non-standard suffix, indicating that this an operation to a secondary threshold (xLS Z 08R & xLS S 08R)

d. Different RWY numbers with secondary runway identified with a suffix (xLS 08R & xLS 08RS). Note that this would require changes to ICAO and database coding standards

Figure 110 shows the result of the question "which option you prefer" – a clear tendency to option "a" could be identified. Option "a" was used during the simulations and was fully accepted by the pilots.

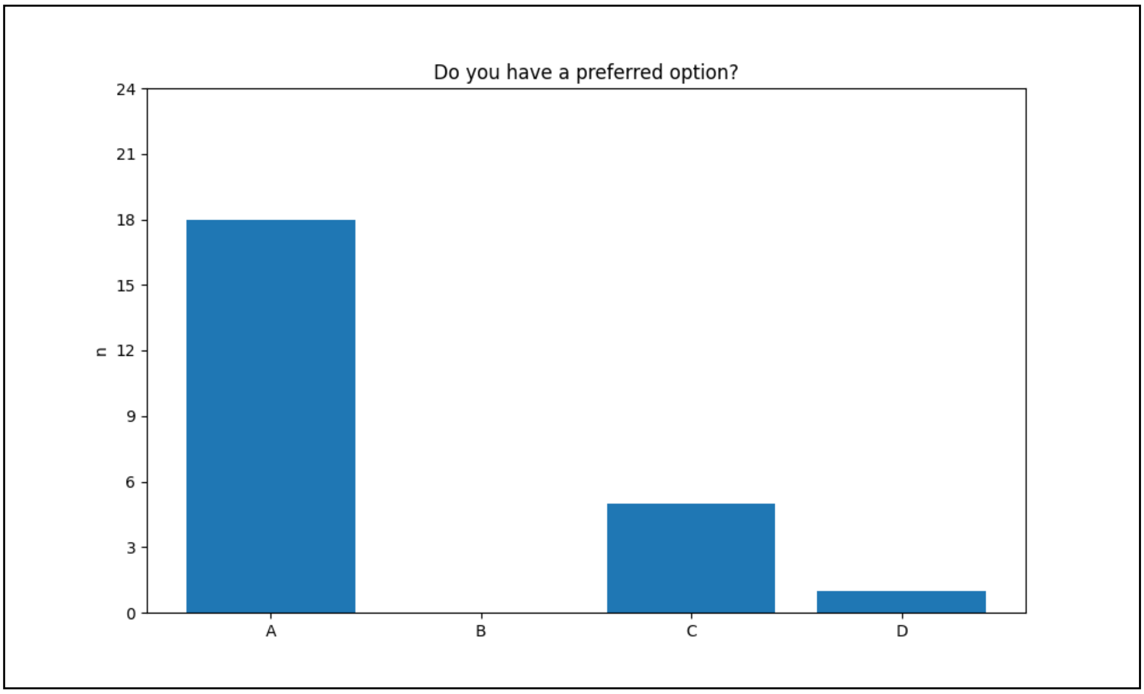

Figure 110: Preferred Options for IGS-to-SRAP Runway Designator

10.3.2.3 OBJ-14.5-V3-VALP-0301 Results

The phraseology used is described in section 10.1.1.2.

The pilots found the phraseology well adapted and giving them useful and necessary information. In particular, all pilots stated that the information from ATC about the preceding aircraft and the flown glide raised their situational awareness regarding the intended approach and related threshold.

No changes were suggested by the pilots.

10.3.3 Unexpected Behaviours/Results

There are no unexpected behaviours to be reported.

10.3.4 Confidence in Results of Validation Exercise EXE-14.5-V3-VALP-R25

10.3.4.1 Level of significance/limitations of Validation Exercise Results

There are no limitations identified, the standard SOP have been applied including ATC, communication, adapted charts and a Level D simulator.

10.3.4.2 Quality of Validation Exercises Results

The simulations were run in a professional Level D certified flight simulator of type Airbus A319. The approaches were flown by certified type rated airline pilots.

10.3.4.3 Significance of Validation Exercises Results

The results of the simulations are operationally significant as they were run using the highest level of realism concerning the cockpit environment and visual system and operated by certified airline pilots.

10.3.5 Conclusions

The aim of this simulation campaign to assess the influence of adverse weather situation with reduced visibility and challenging crosswind conditions. The additional scenarios have been reduced to the steady approach lighting solution for the SRAP and IGS-to-SRAP approaches to provide confidence in that option.

Overall, the conclusion can be drawn that the pilots found the approaches fully acceptable and feasible to fly. The general concept for the usage of a second runway aiming point was accepted and the benefits with respect of capacity and improved separation clearly understood. The influence of adverse weather could not be clearly identified. Moreover, most of the pilots stated that they can imagine having the IGS-to-SRAP solution in daily operation available.

The steady approach light configuration provided a fully accepted and robust option to provide IGS-to-SRAP operations.

Furthermore, the provided option for the runway designator for the second threshold seems to be the best compromise for raising situational awareness during short final and limitations regarding FMS coding possibilities.

10.3.6 Recommendations

The tests were overall positively acknowledged by most pilots. The tests allowed to make a few recommendations:

- (recurrent) Training on different approach types to IGS-to-SRAP has to be ensured
- In the cockpit, special focus has to be put on the briefing:
    - Briefing has to include the expected lighting configuration
    - Special briefing is needed in case of 3.5°approach
- ATC should communicate the approach type of the previous aircraft

The approach naming shall be indicated by a different runway number (e.g. xLS 08R & xLS 09R)

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Appendix A Analysis for EXE-14.5-V3-VALP-R01: ISA vs Event Per Run

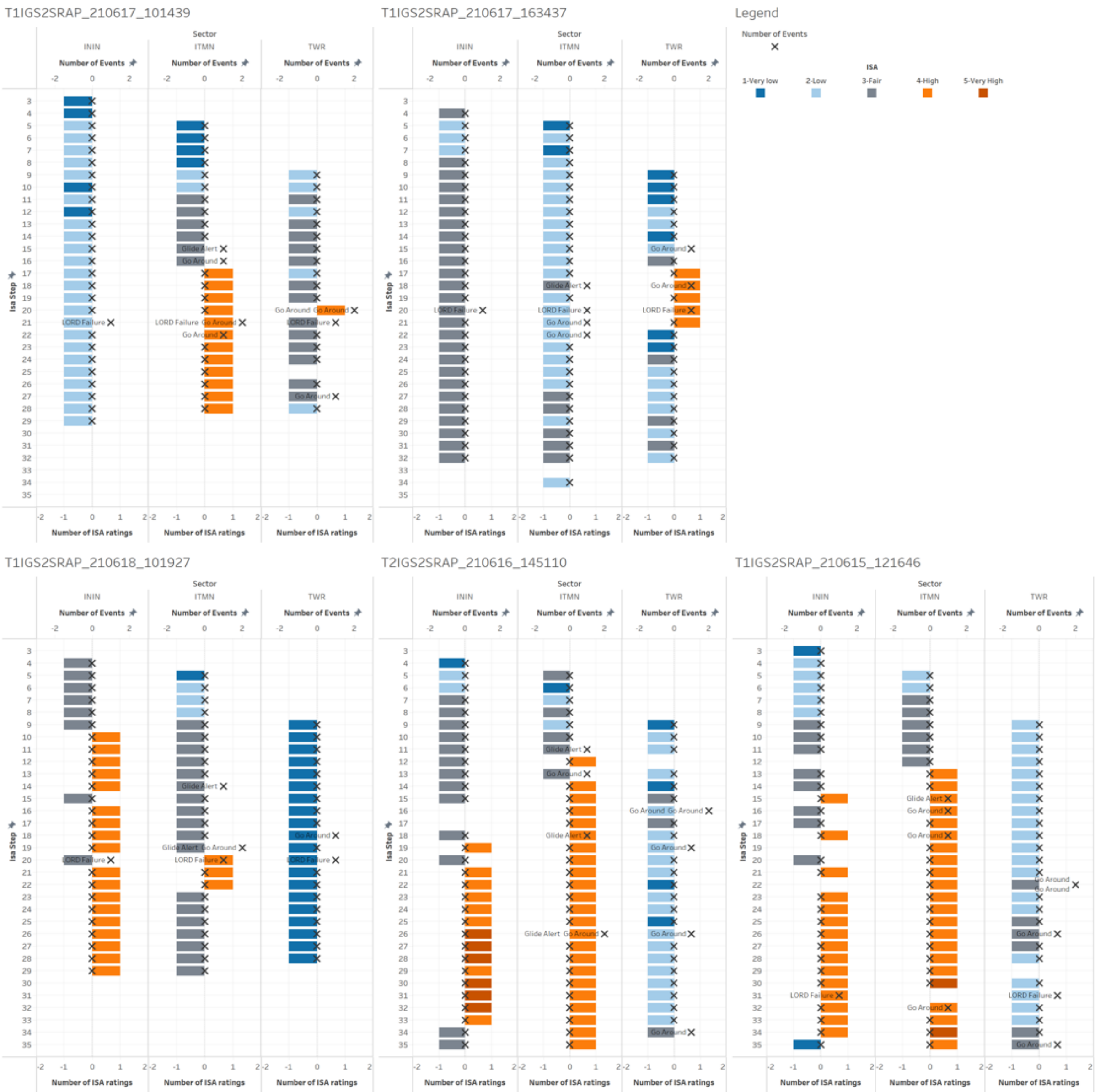


Figure 111: ISA rating scores per two minutes for each IGS-to-SRAP exercises with the number of events that occurred within those two minutes

Appendix B Analysis for EXE-14.5-V3-VALP-R01: Teamwork

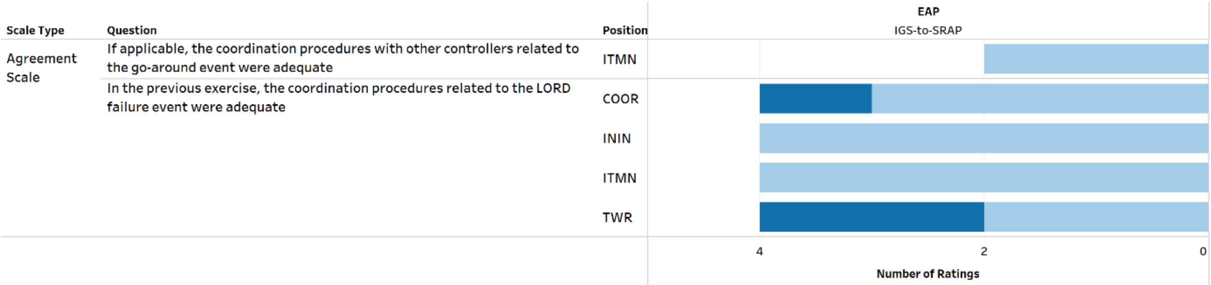


Figure 112: Subjective feedback from the PEQ about coordination and teamwork

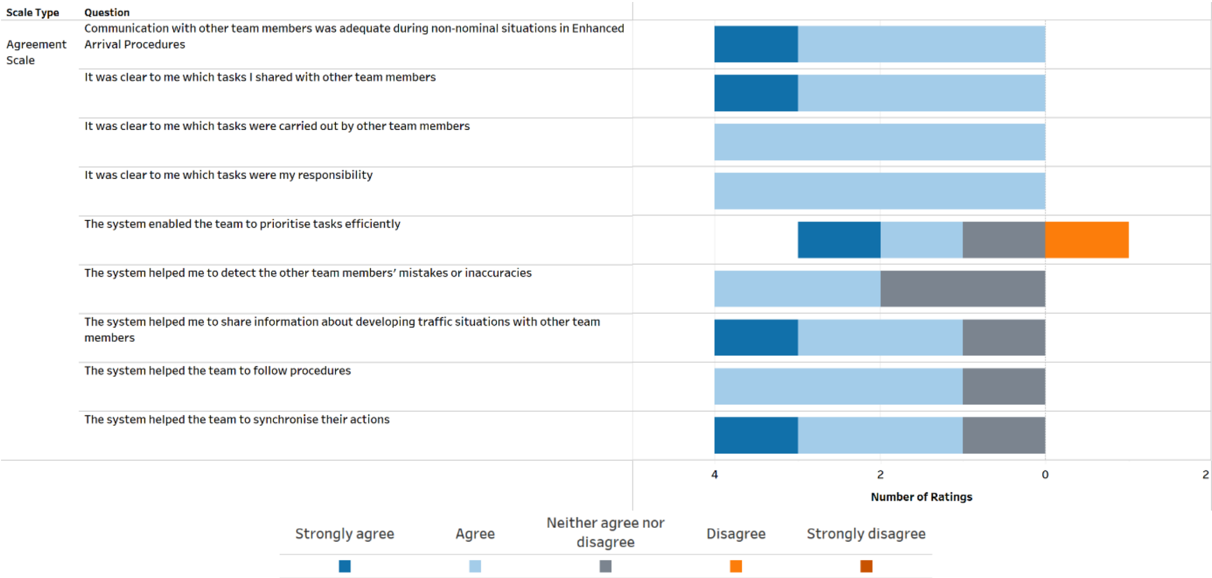


Figure 113: Subjective feedback from the PSQ about coordination and teamwork

Appendix C EXE-14.5-V3-VALP-R10 - Recorded data for each scenario (vertical path)

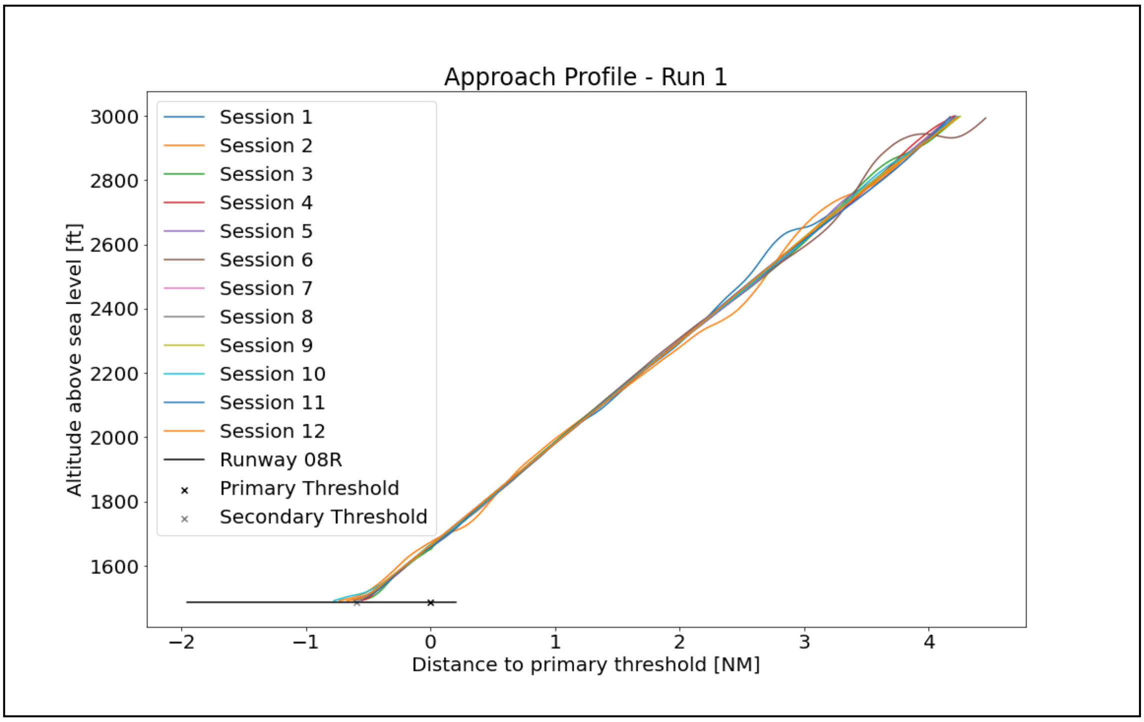


Figure 114: Vertical Path Run 1

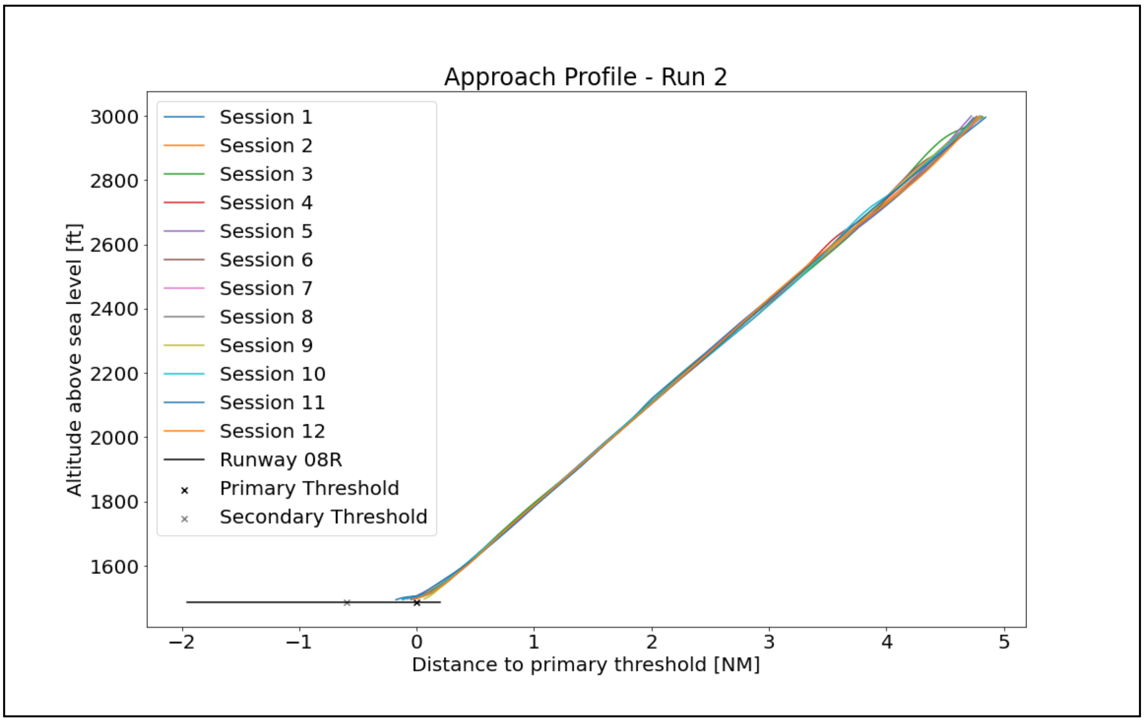


Figure 115: Vertical Path Run 2

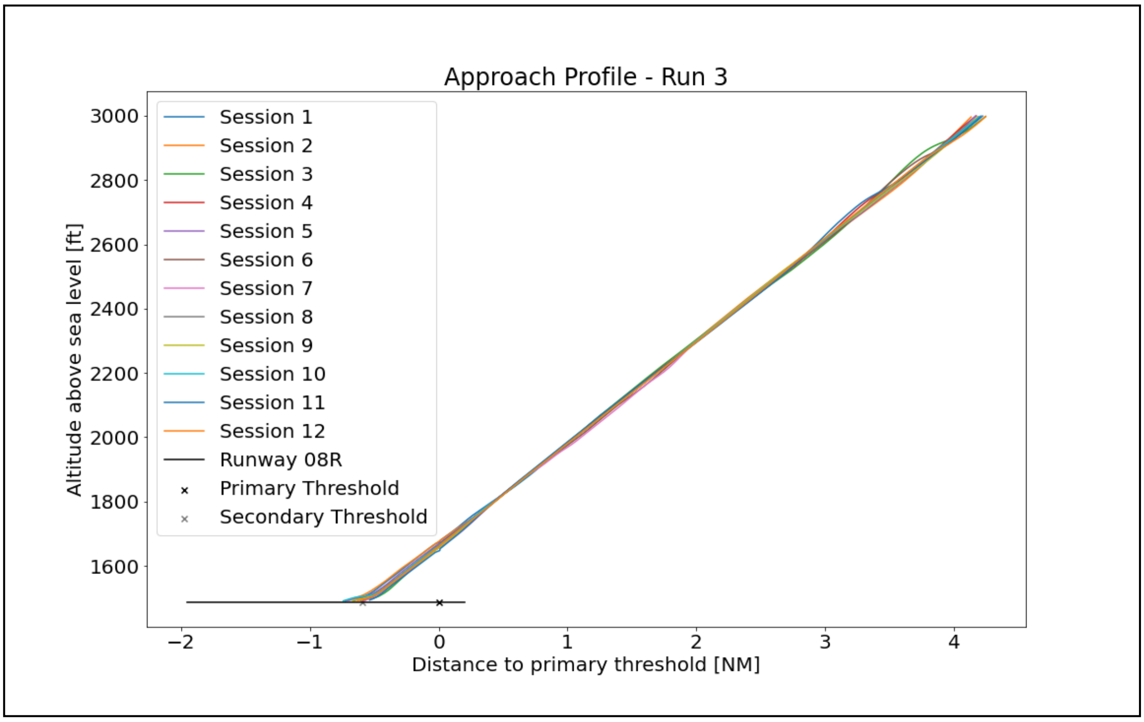


Figure 116: Vertical Path Run 3

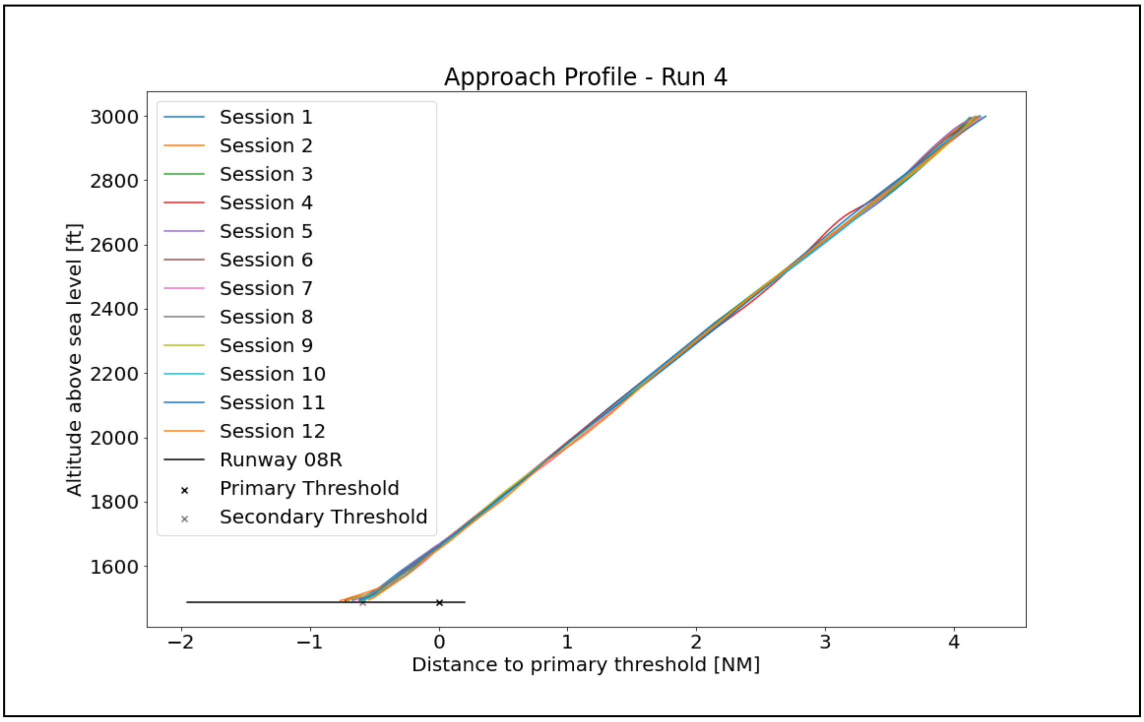


Figure 117: Vertical Path Run 4

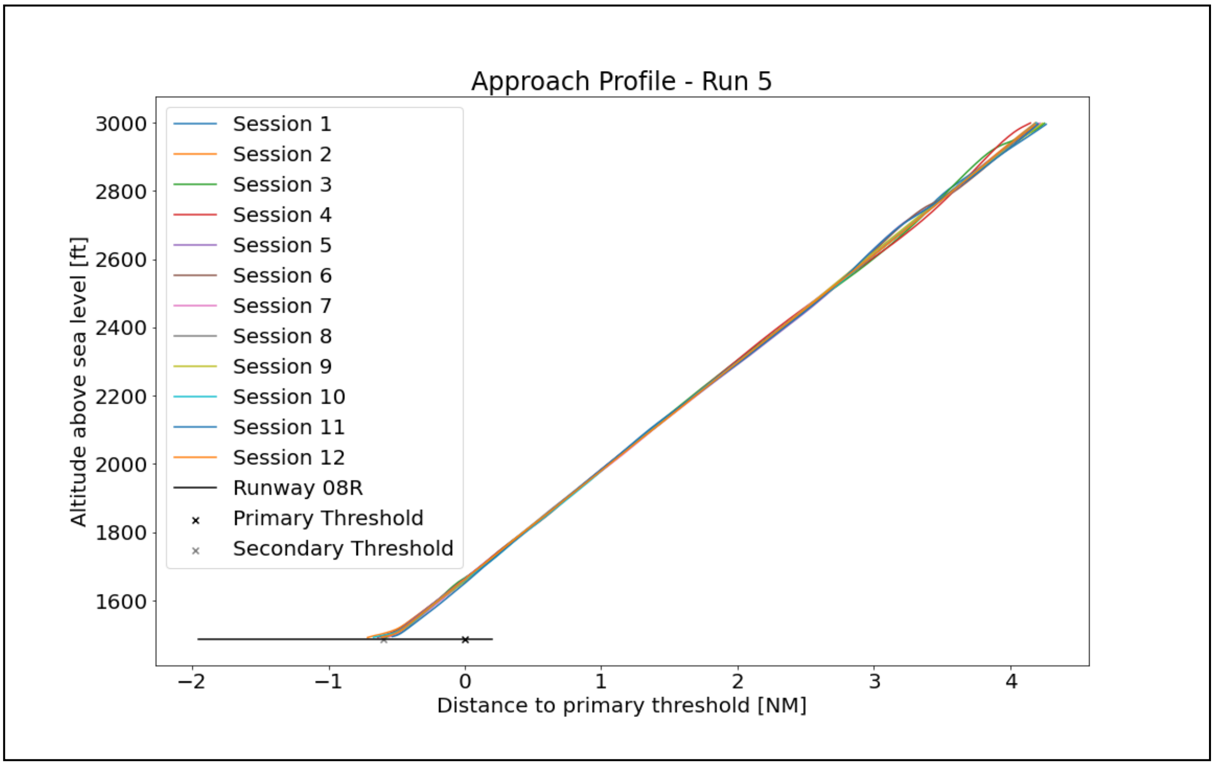


Figure 118: Vertical Path Run 5

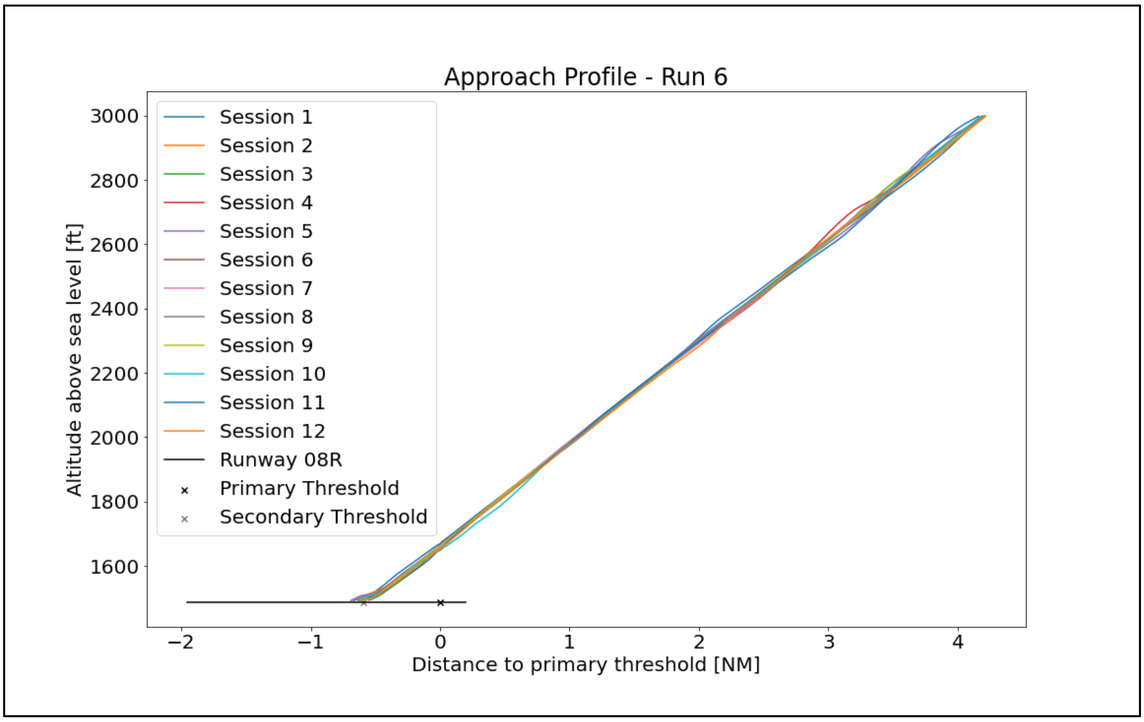


Figure 119: Vertical Path Run 6

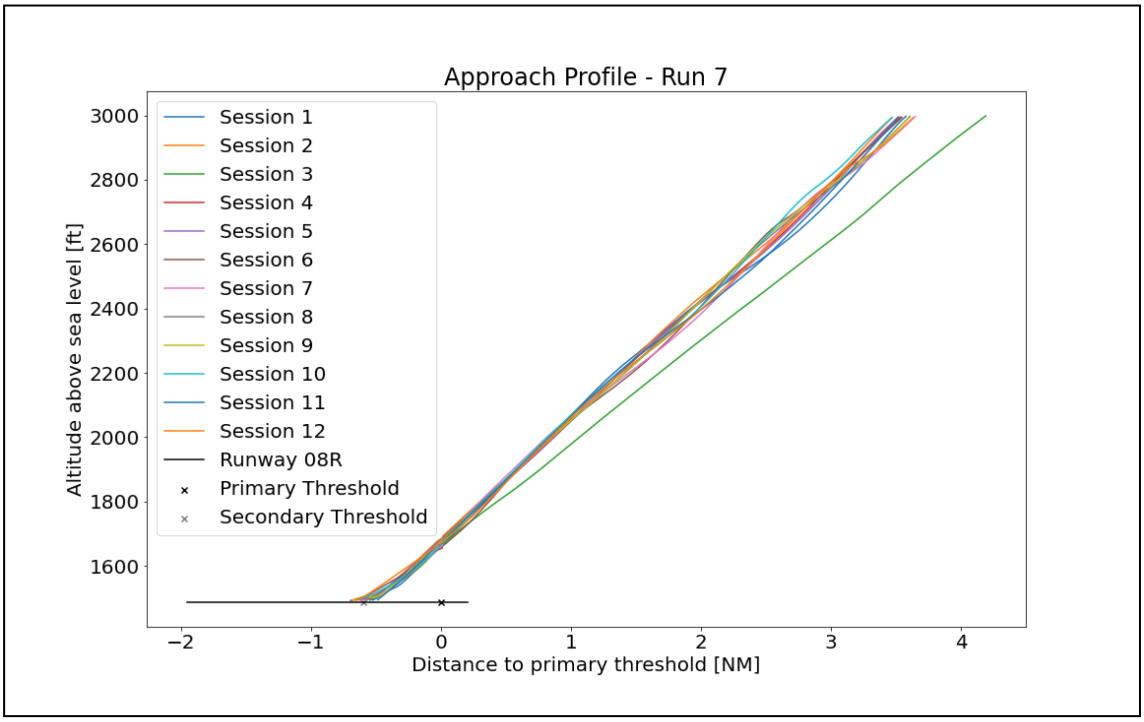


Figure 120: Vertical Path Run 7

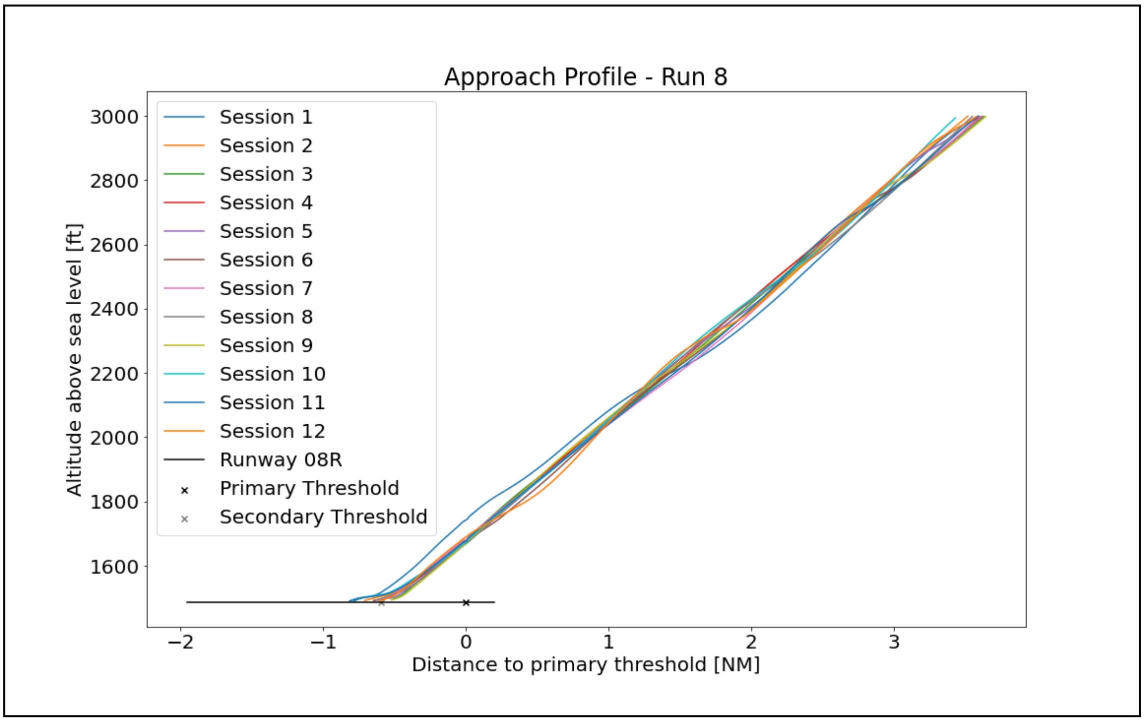


Figure 121: Vertical Path Run 8

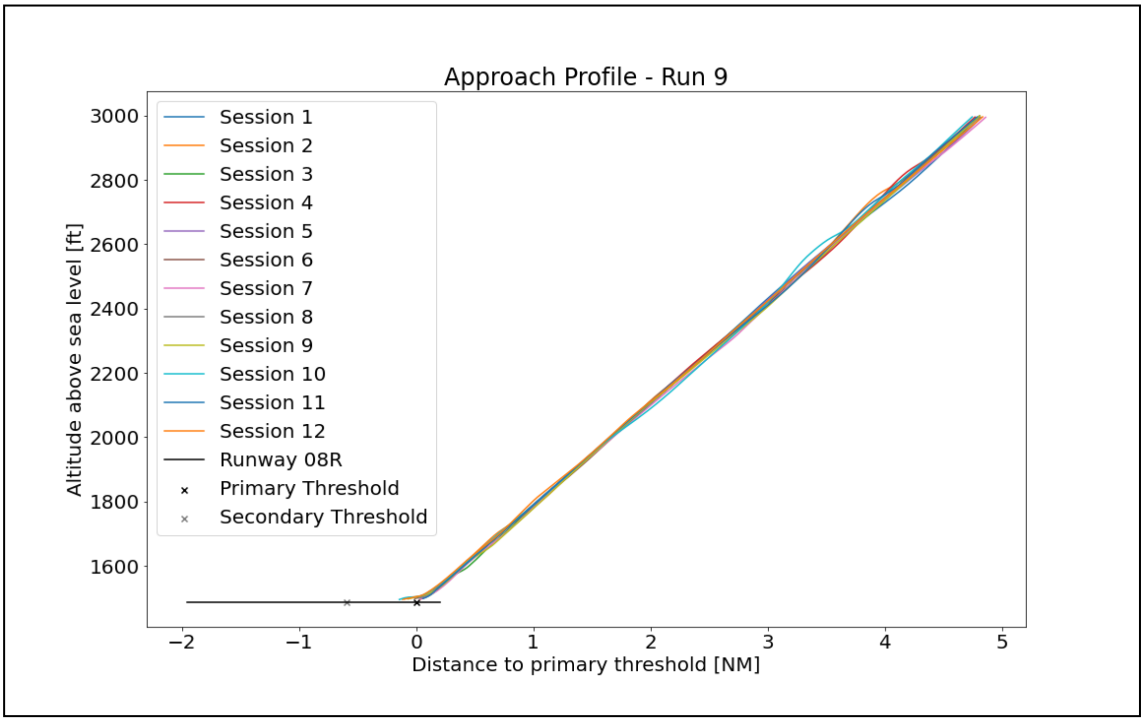


Figure 122: Vertical Path Run 9

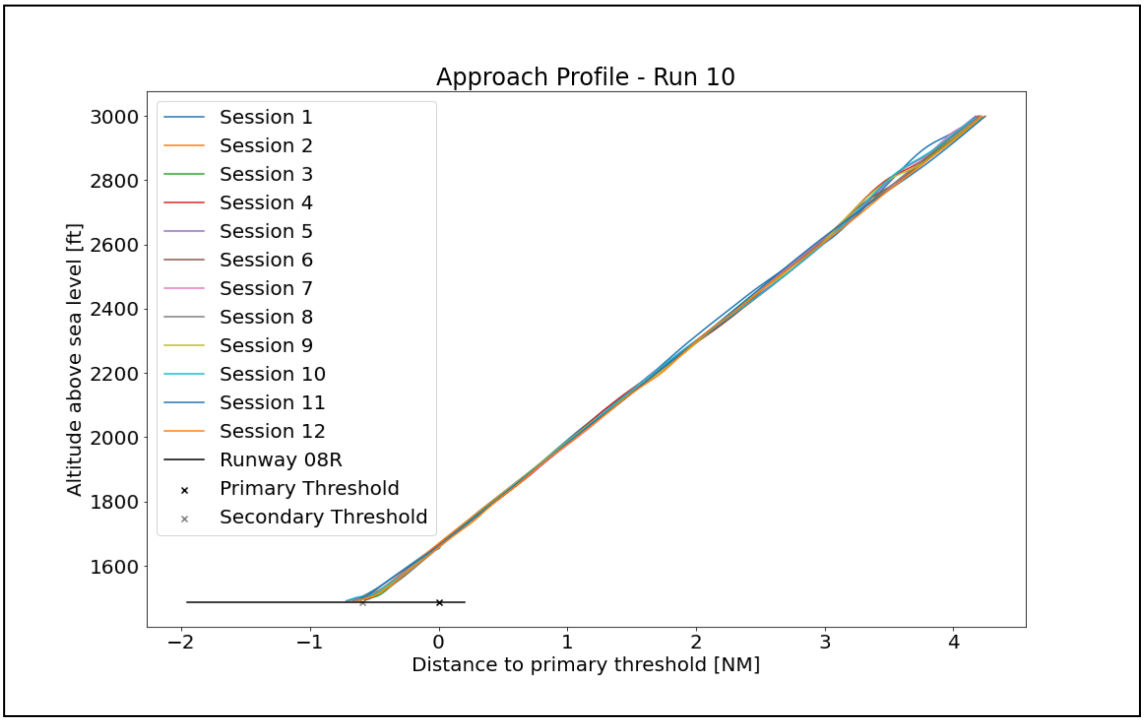


Figure 123: Vertical Path Run 10

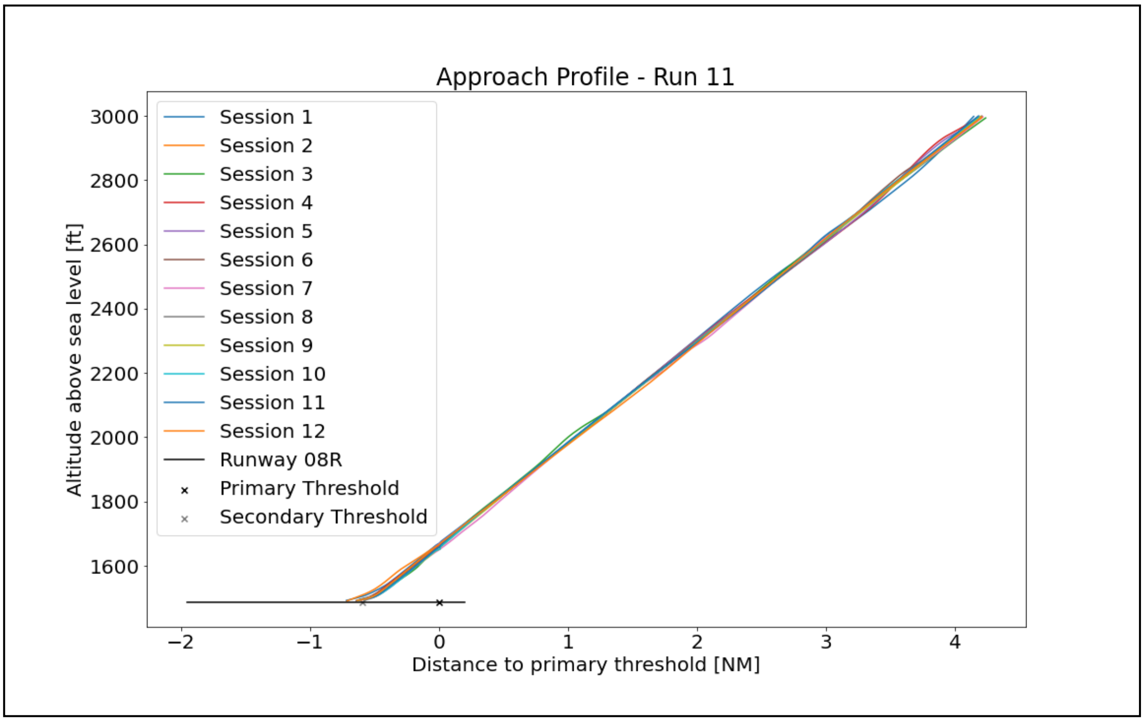


Figure 124: Vertical Path Run 11

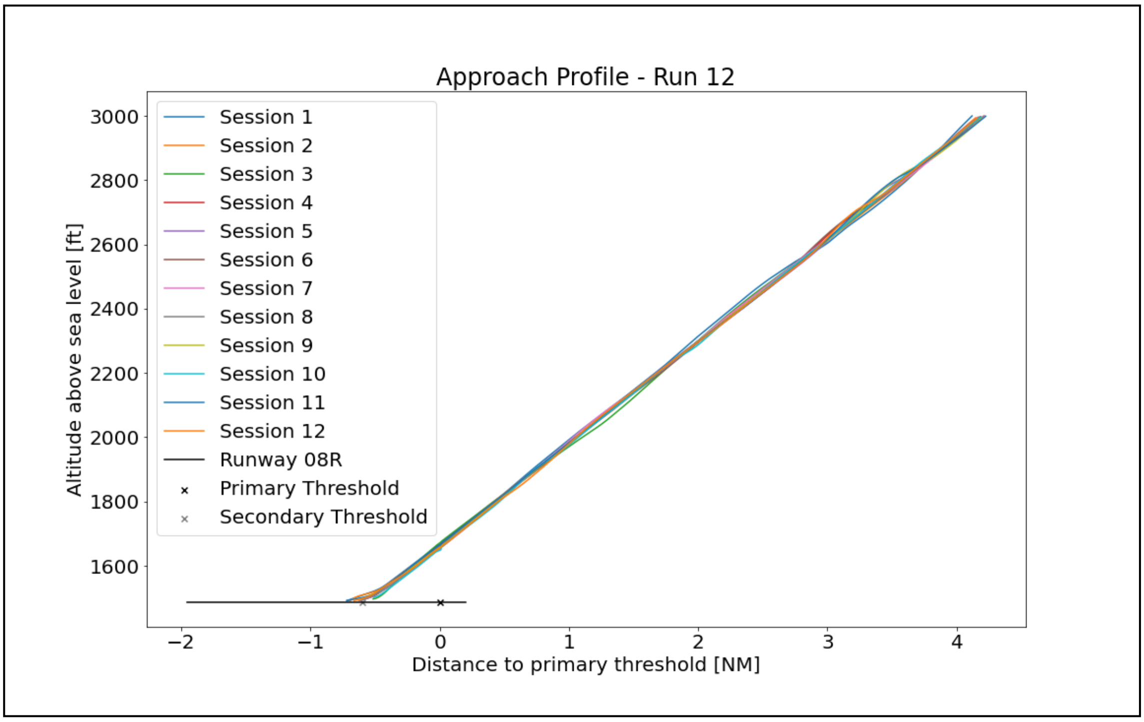


Figure 125: Vertical Path Run 12

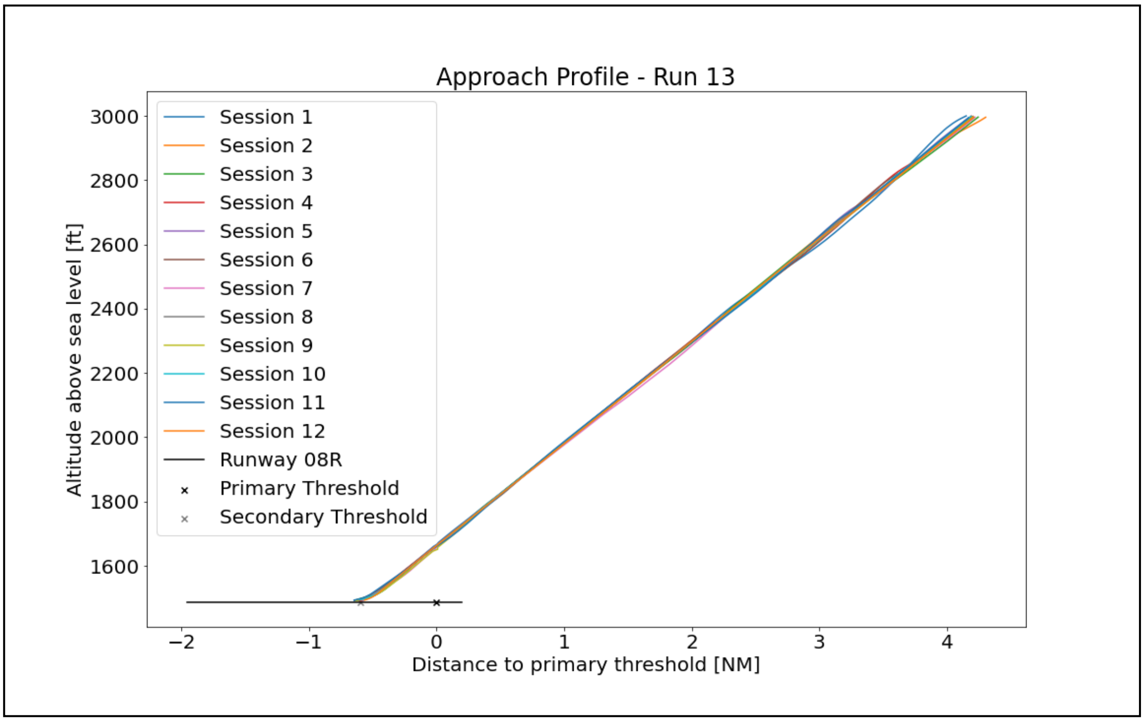


Figure 126: Vertical Path Run 13

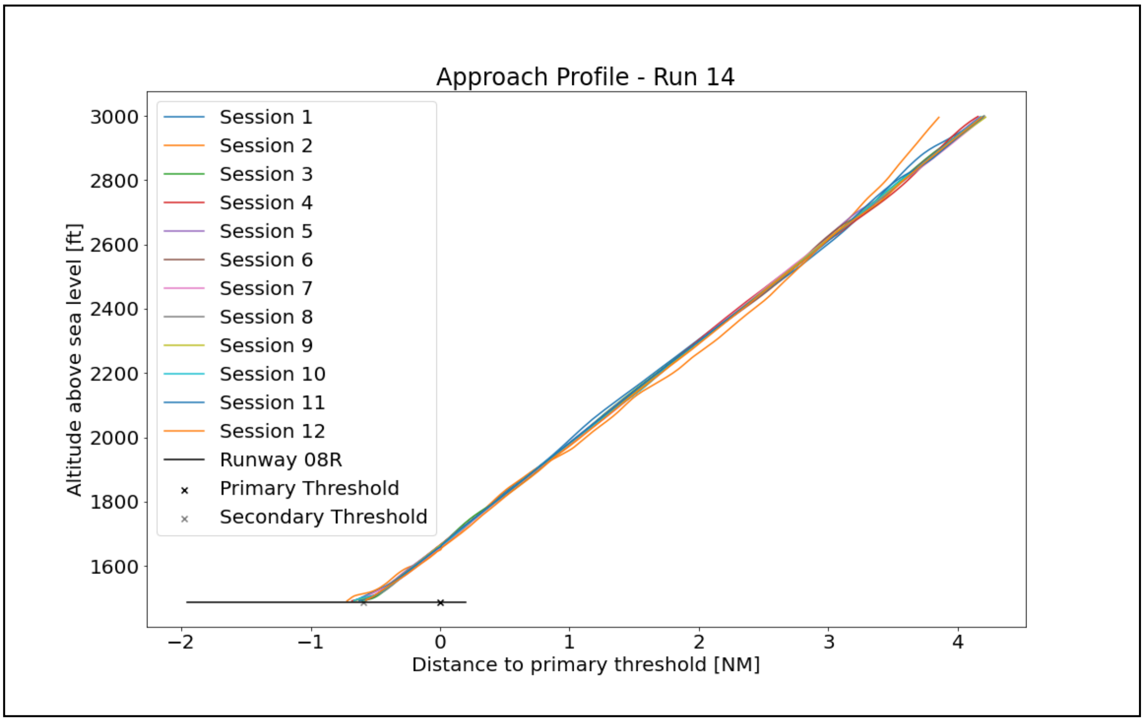


Figure 127: Vertical Path Run 14

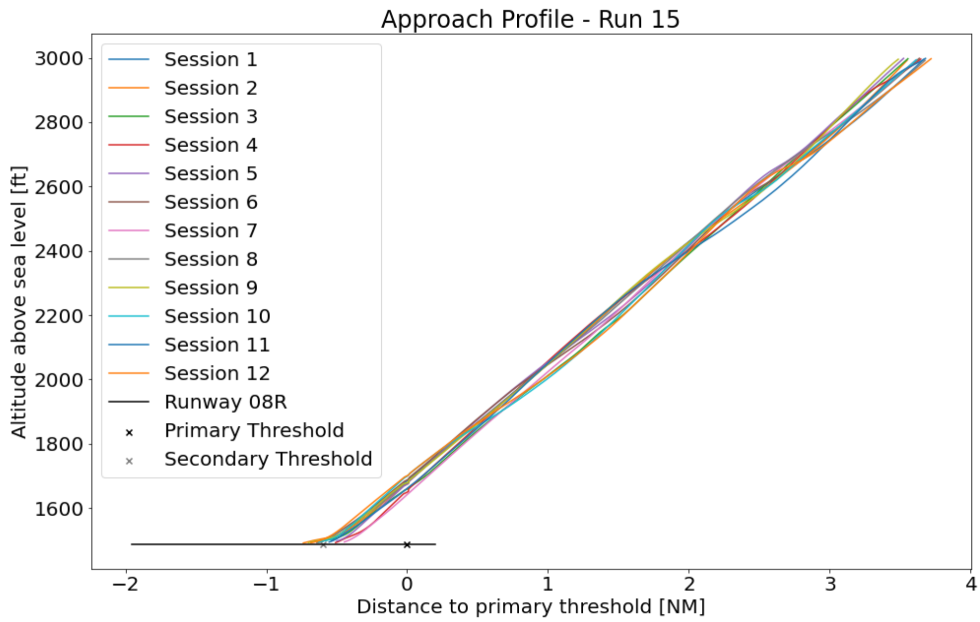


Figure 128: Vertical Path Run 15

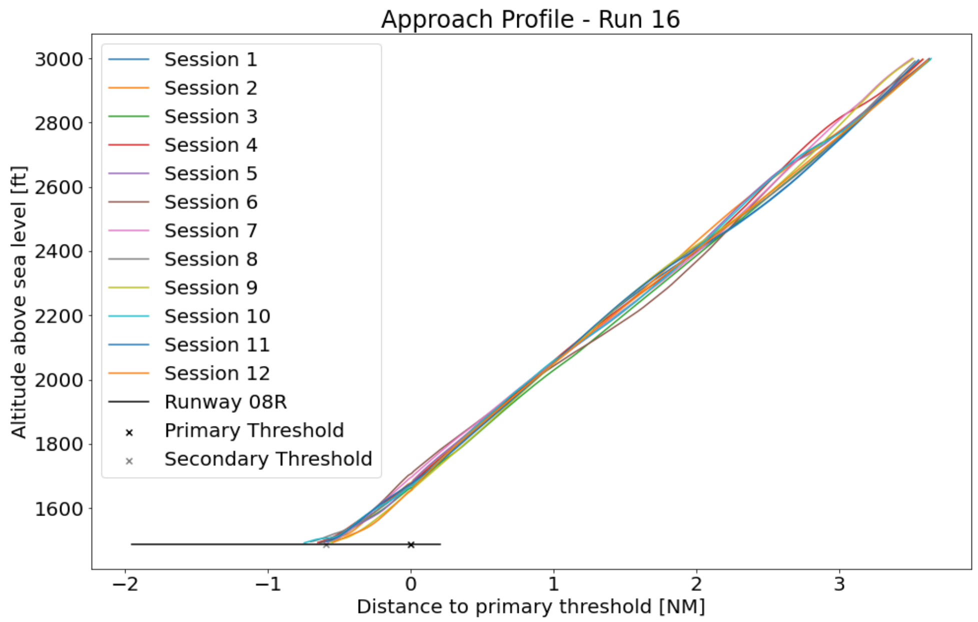


Figure 129: Vertical Path Run 16

Appendix D EXE-14.5-V3-VALP-R15- Recorded data for each scenario (vertical path)

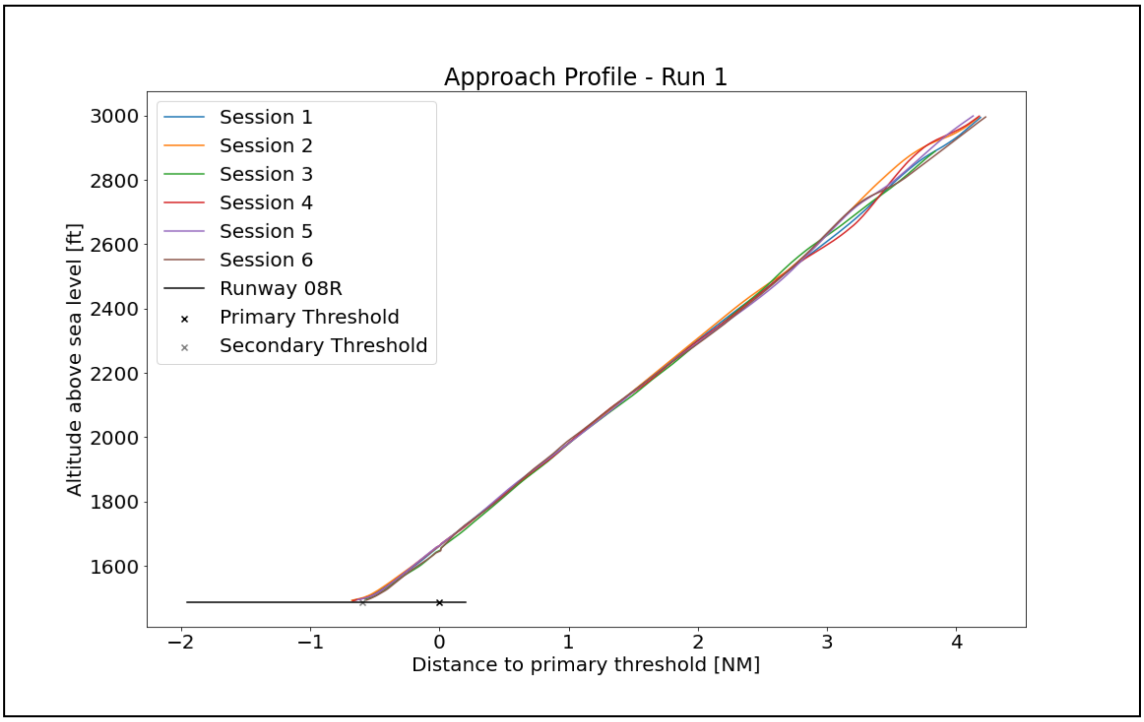


Figure 130: Vertical Path Run 1 (Session 1-6)

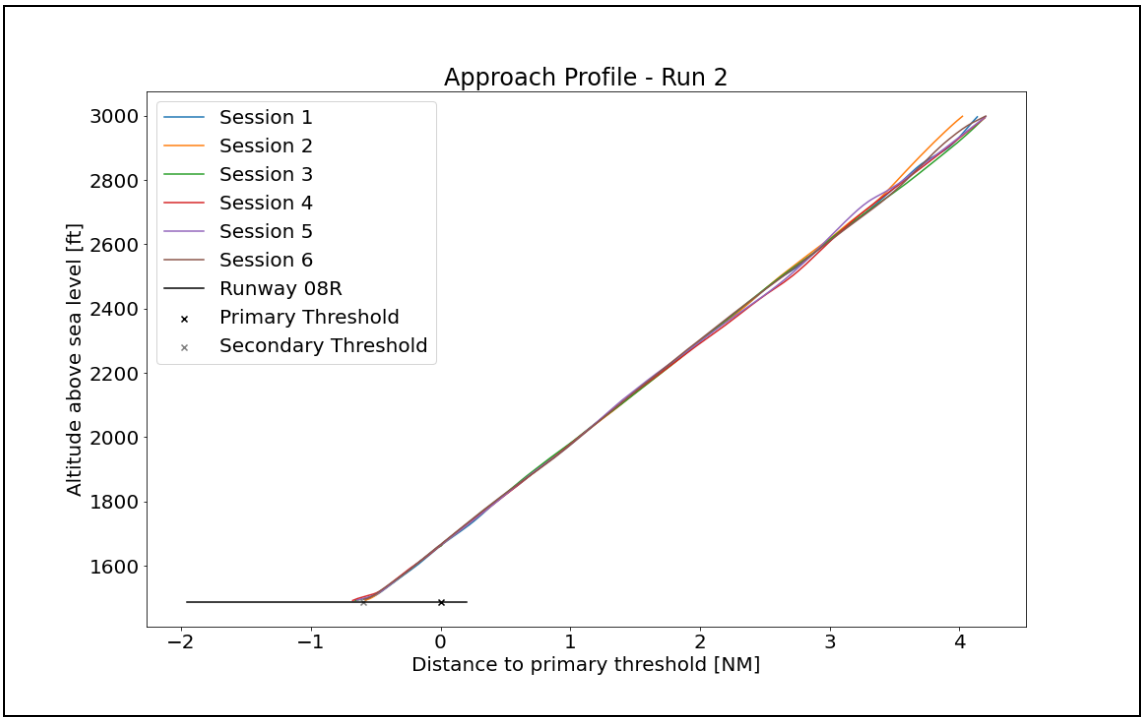


Figure 131: Vertical Path Run 2 (Session 1-6)

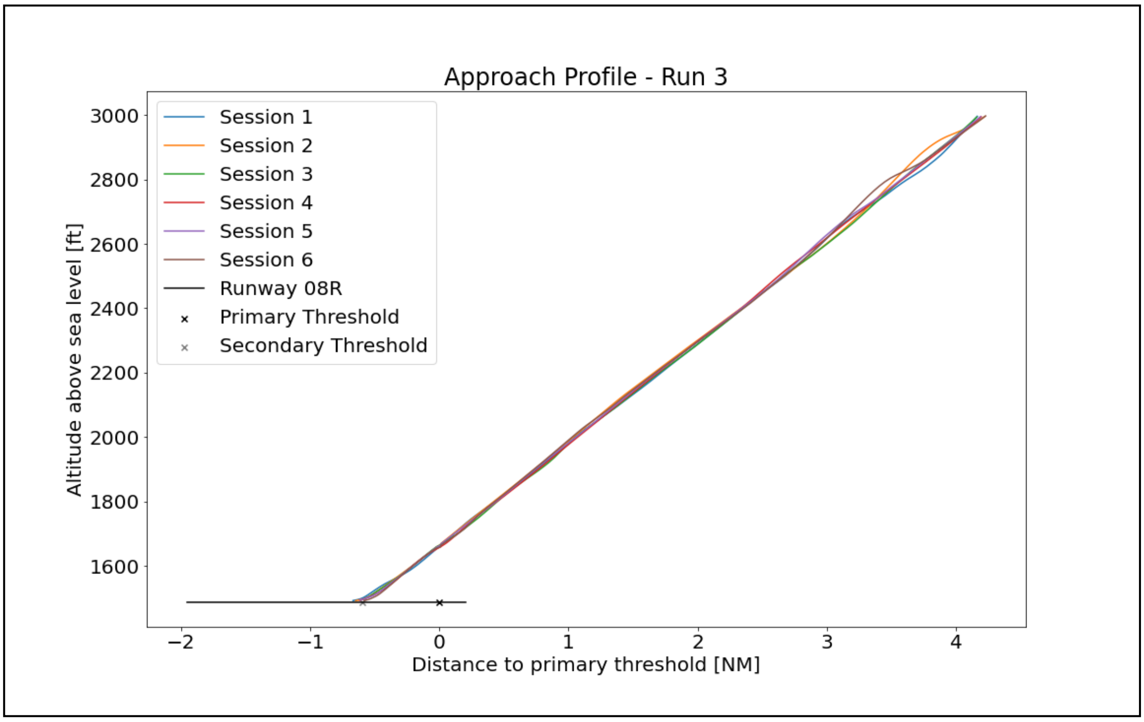


Figure 132: Vertical Path Run 3 (Session 1-6)

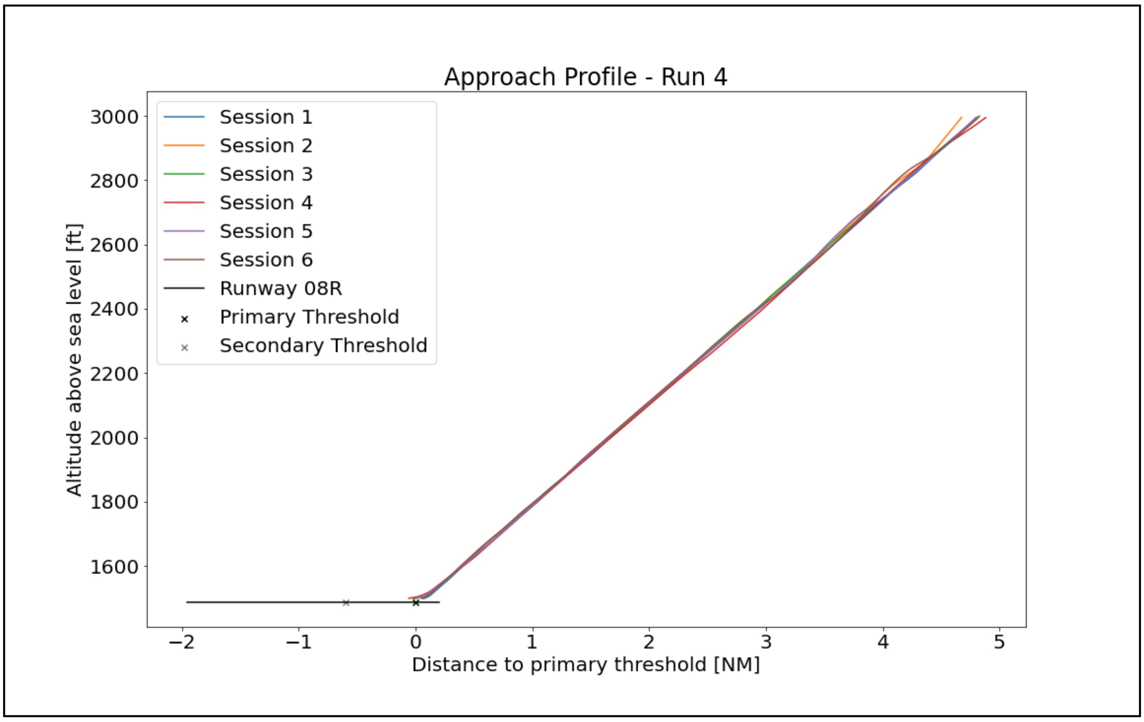


Figure 133: Vertical Path Run 4 (Session 1-6)

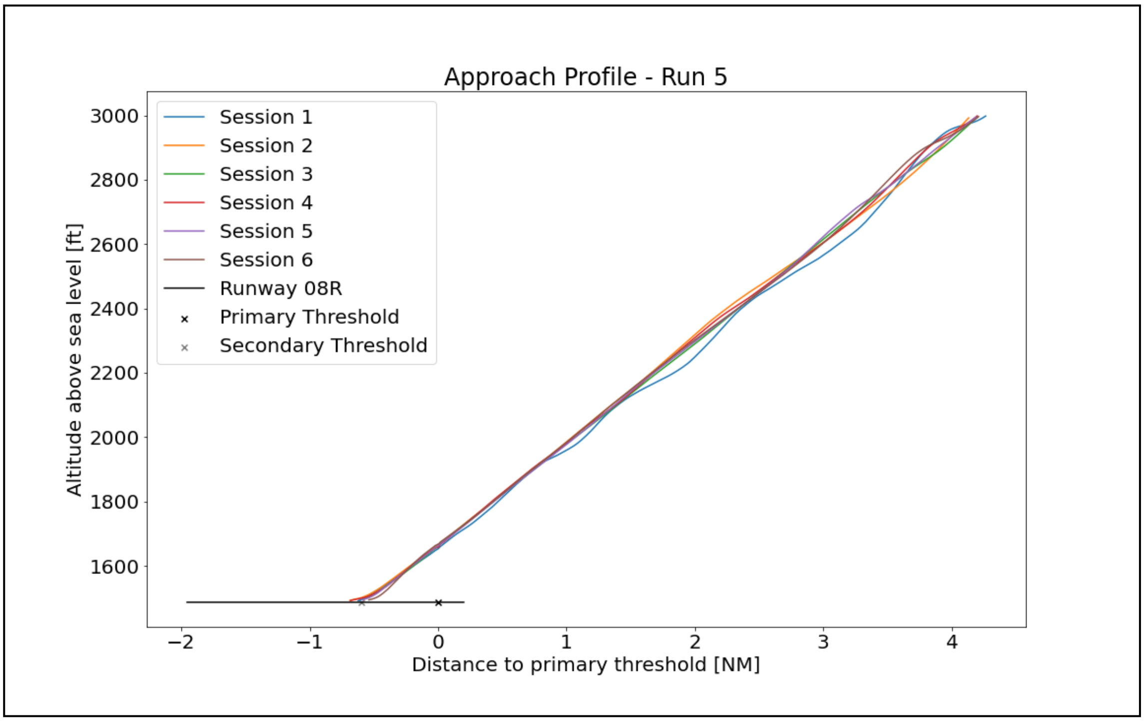


Figure 134: Vertical Path Run 5 (Session 1-6)

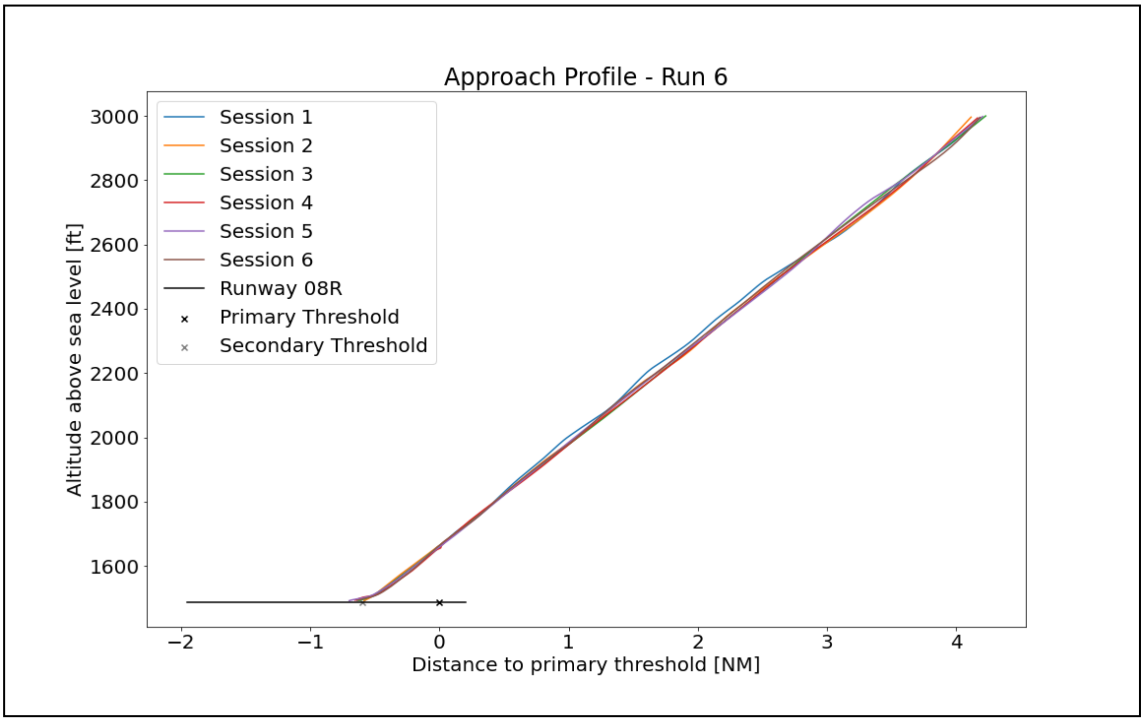


Figure 135: Vertical Path Run 6 (Session 1-6)

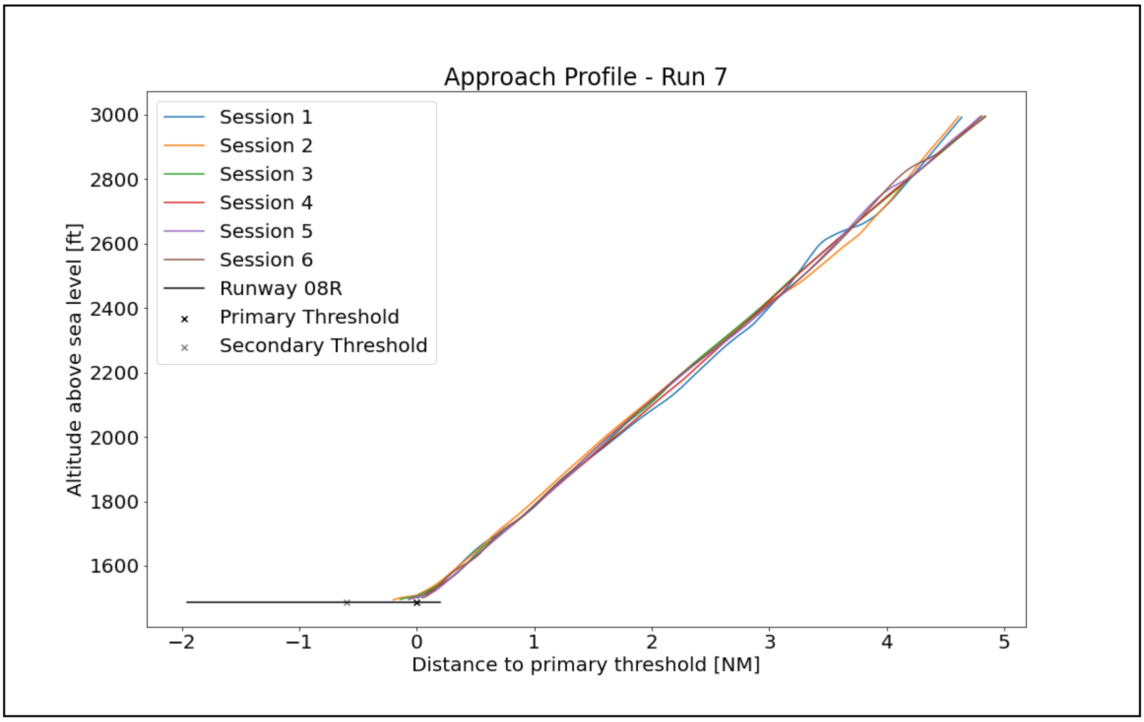


Figure 136: Vertical Path Run 7 (Session 1-6)

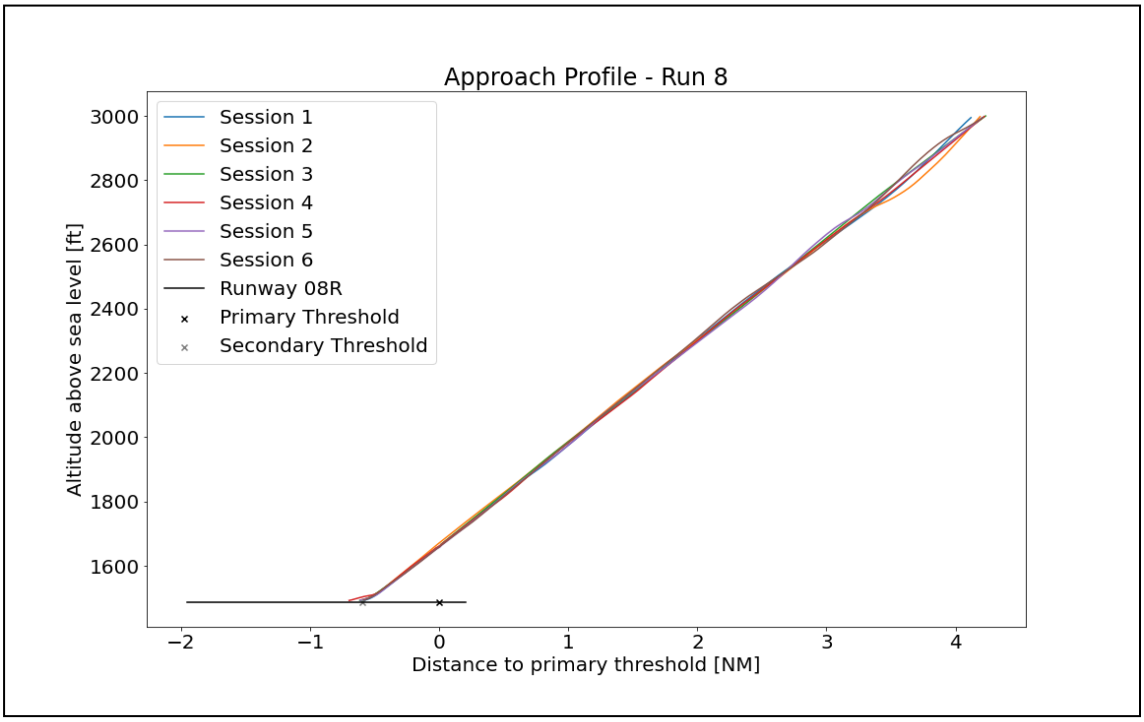


Figure 137: Vertical Path Run 8 (Session 1-6)

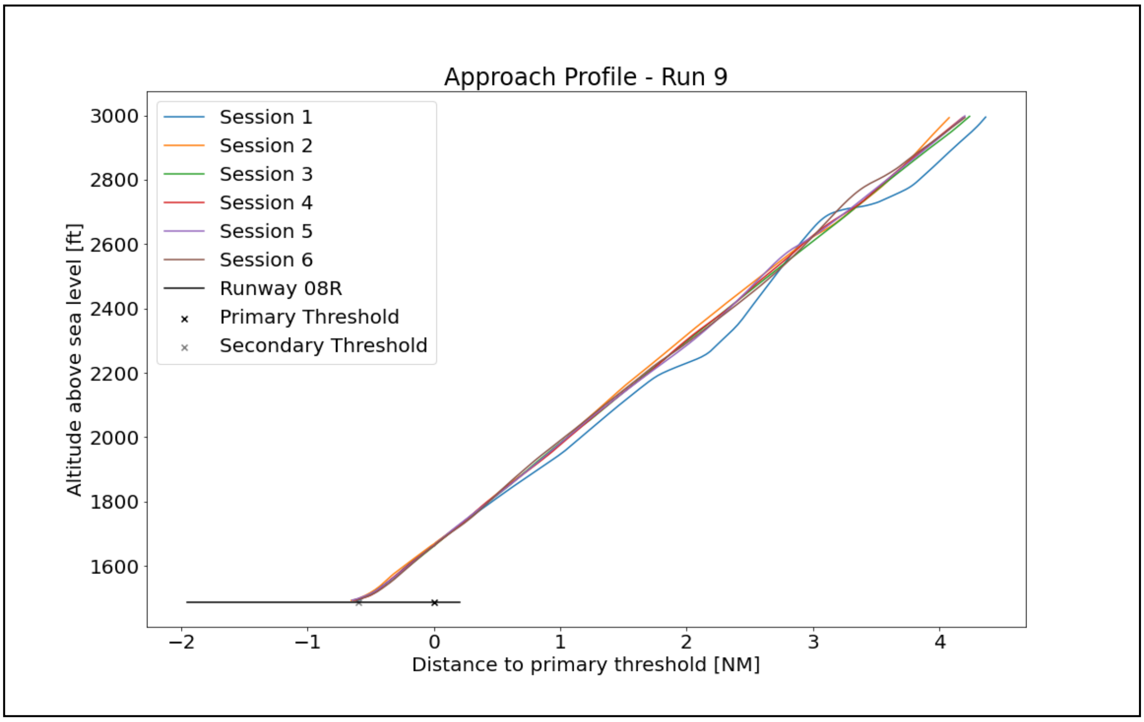


Figure 138: Vertical Path Run 9 (Session 1-6)

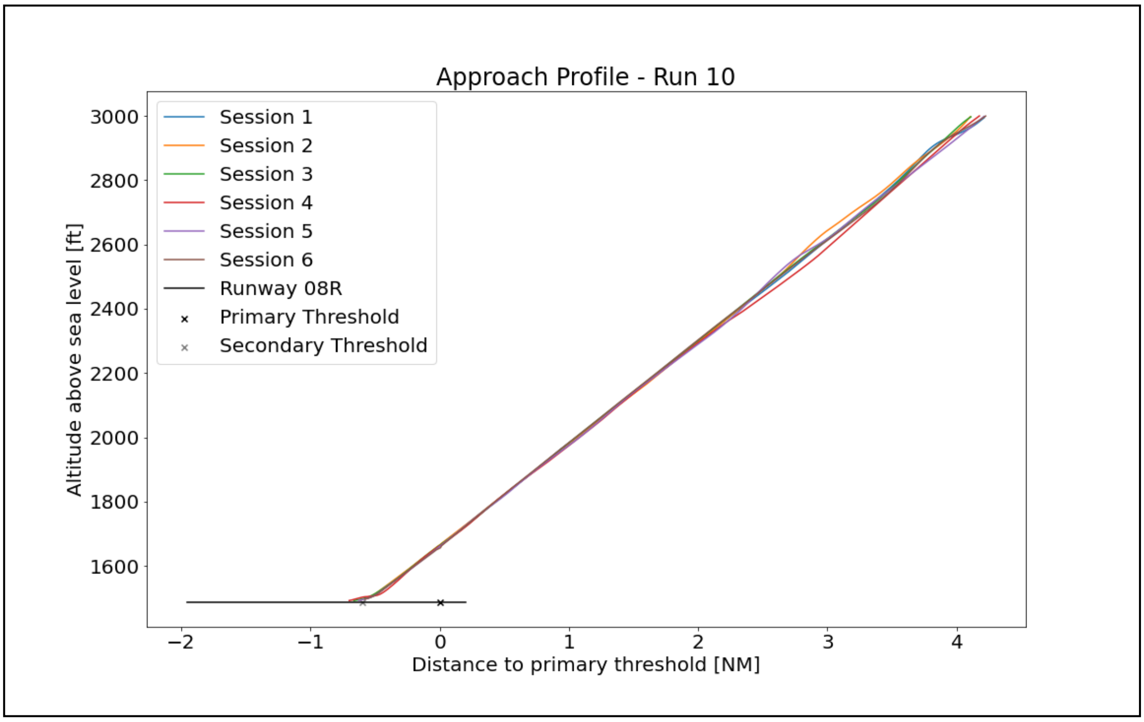


Figure 139: Vertical Path Run 10 (Session 1-6)

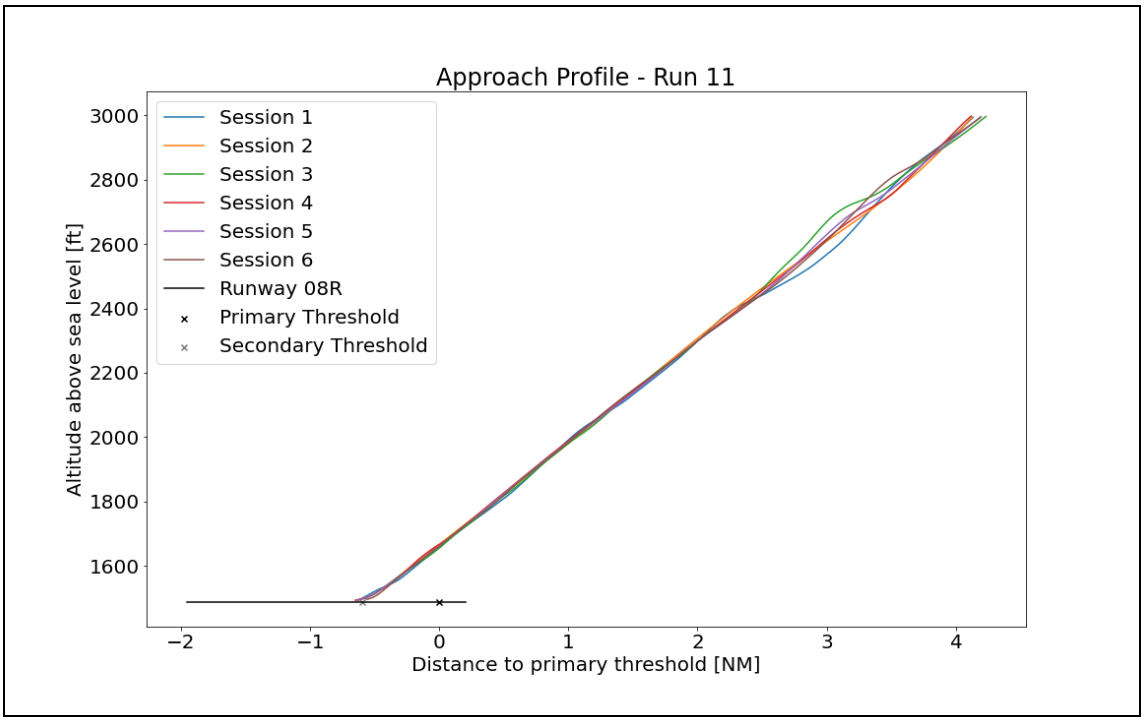


Figure 140: Vertical Path Run 11 (Session 1-6)

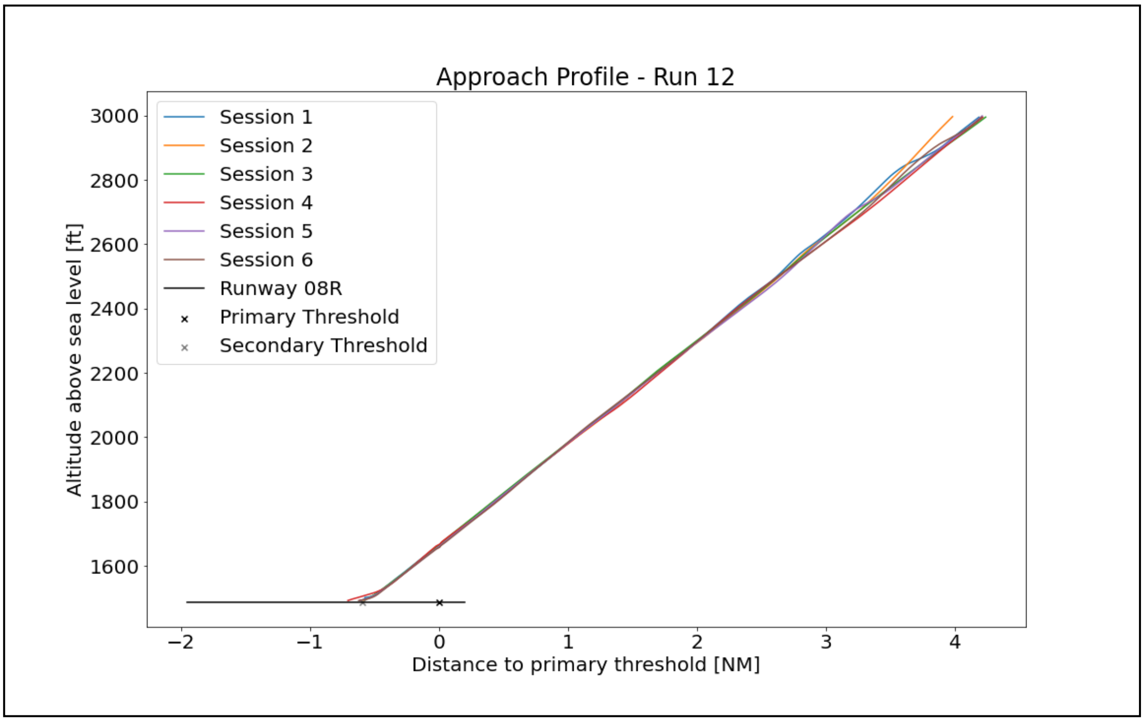


Figure 141: Vertical Path Run 12 (Session 1-6)

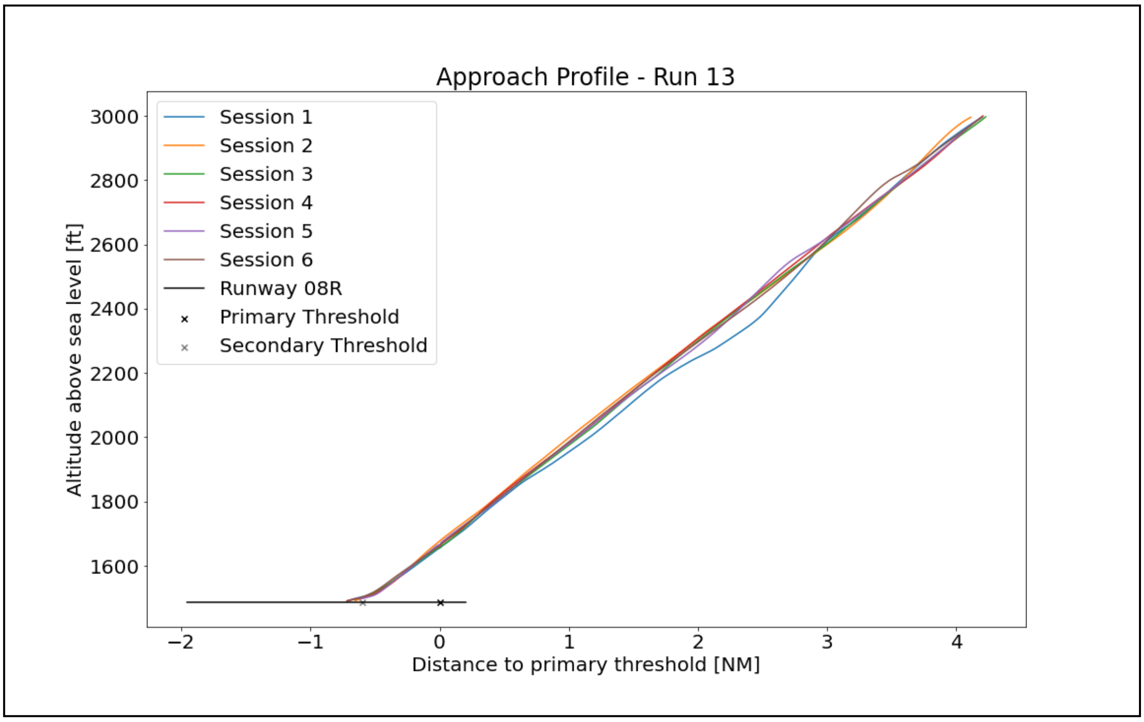


Figure 142: Vertical Path Run 13 (Session 1-6)

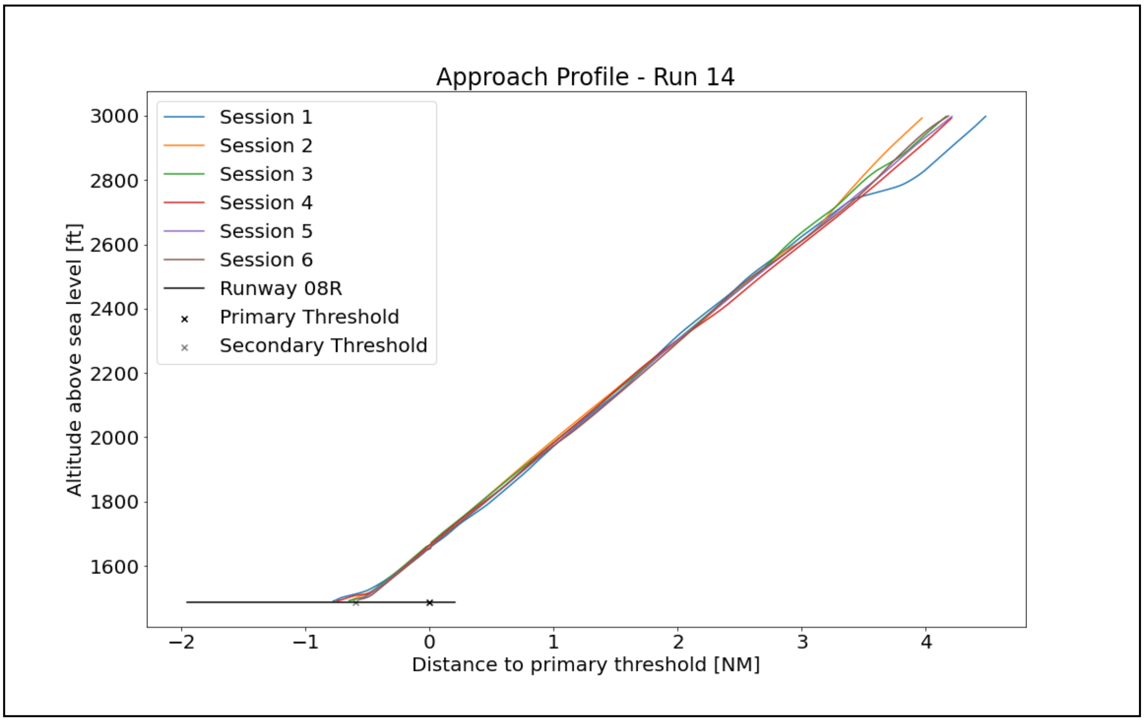


Figure 143: Vertical Path Run 14 (Session 1-6)

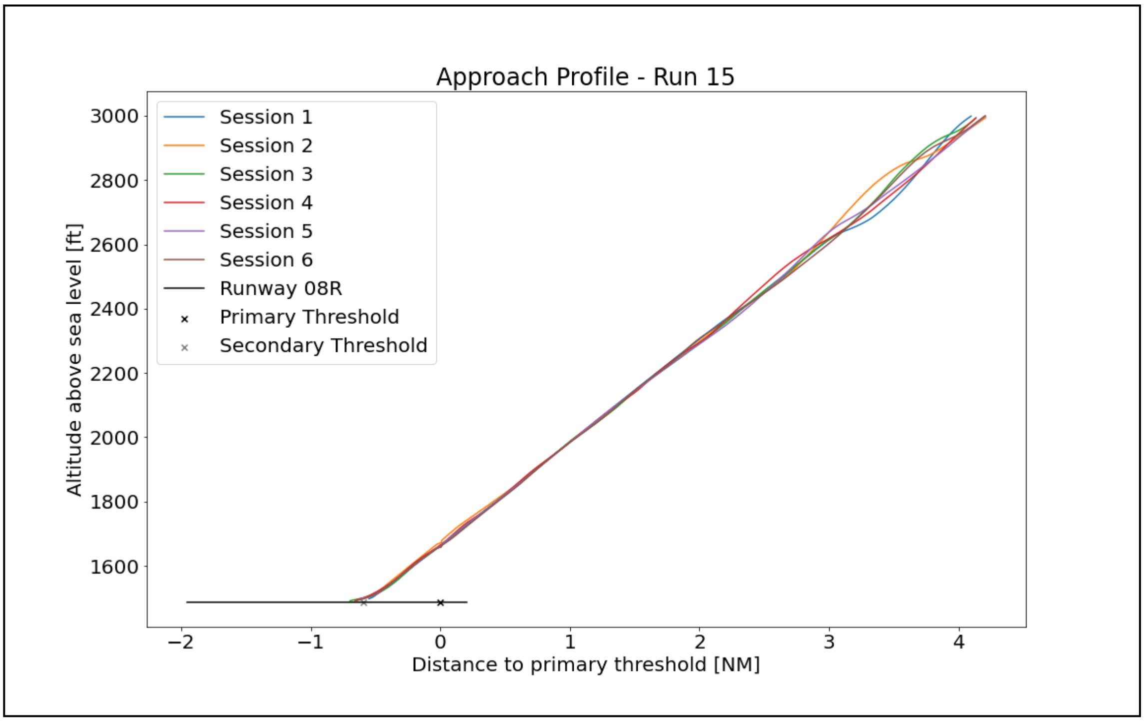


Figure 144: Vertical Path Run 15 (Session 1-6)

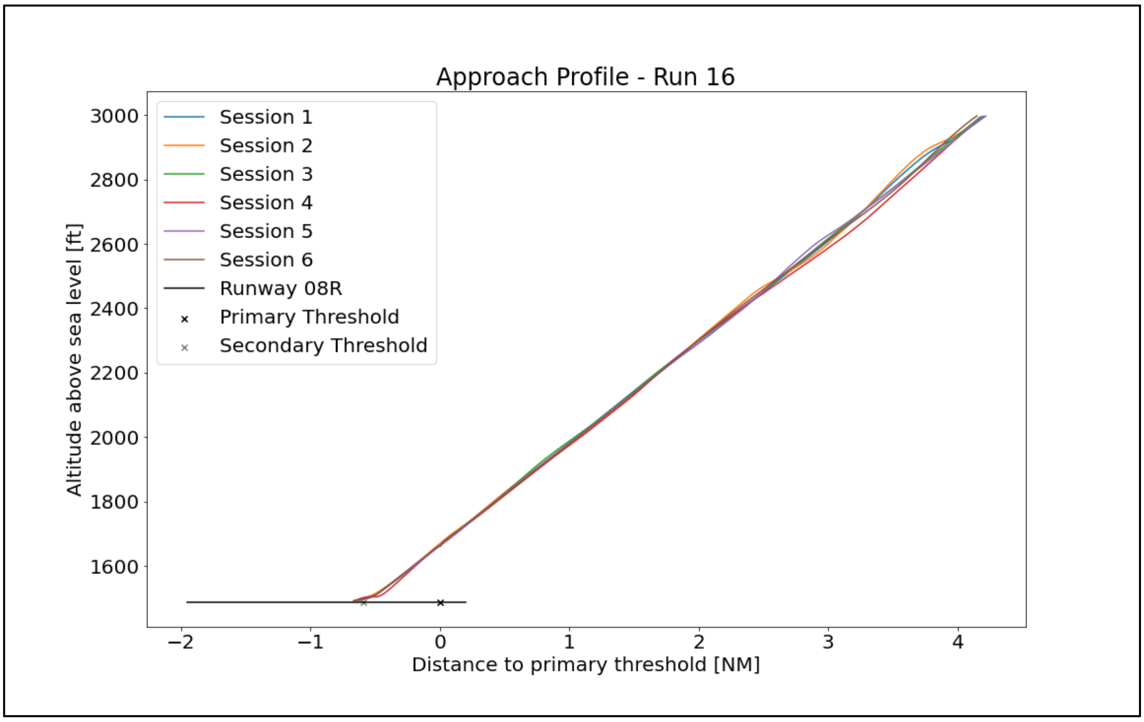


Figure 145: Vertical Path Run 16 (Session 1-6)

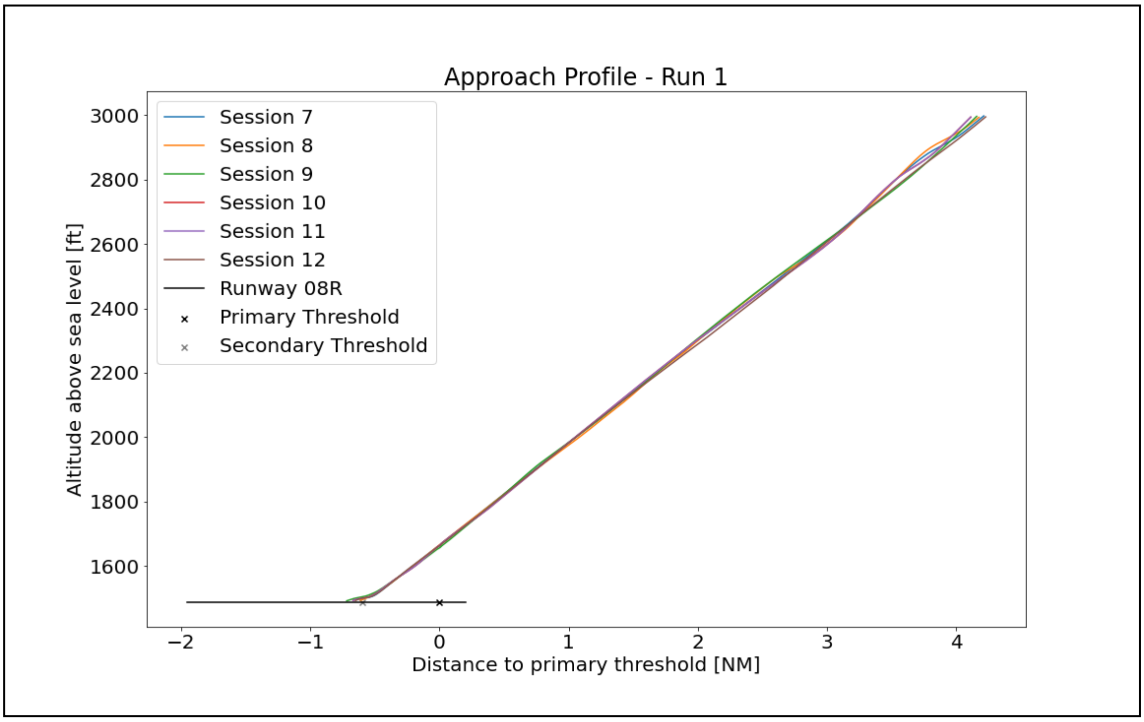


Figure 146: Vertical Path Run 1 (Session 7-12)

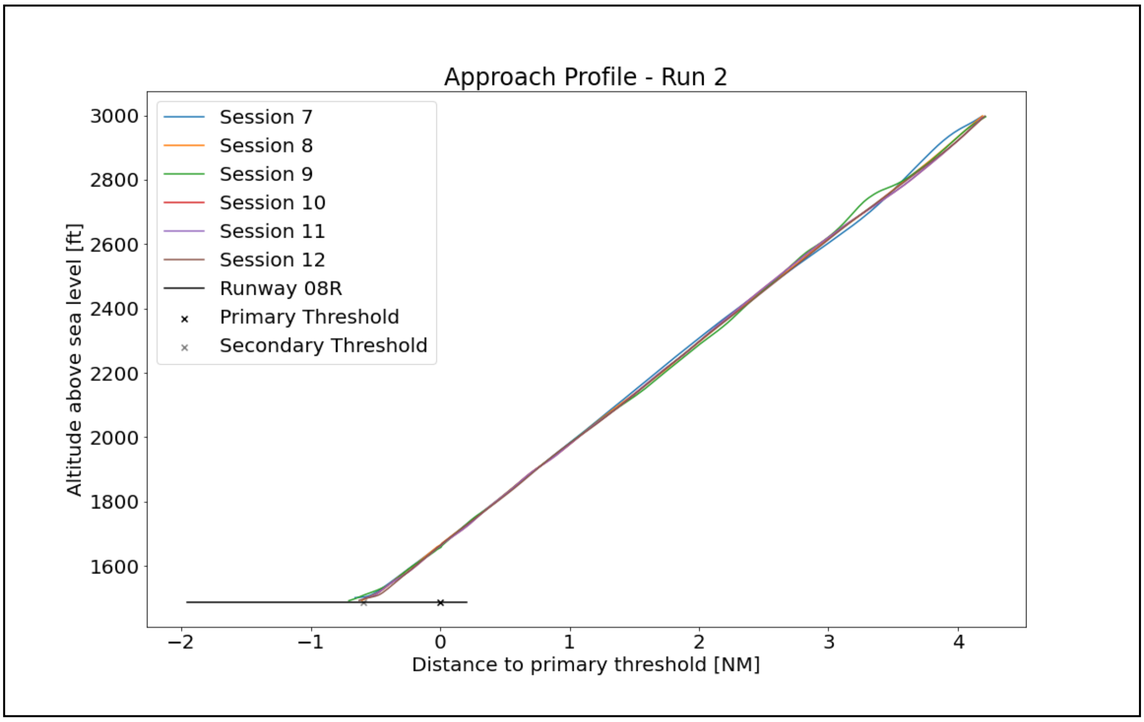


Figure 147: Vertical Path Run 2 (Session 7-12)

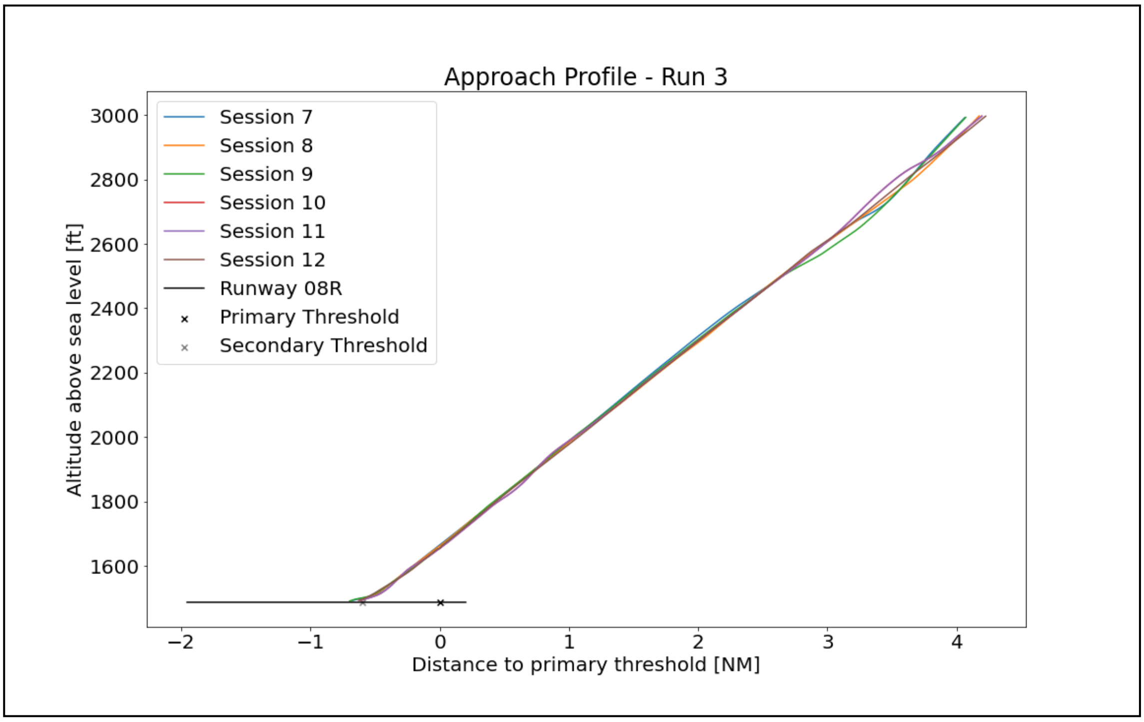


Figure 148: Vertical Path Run 3 (Session 7-12)

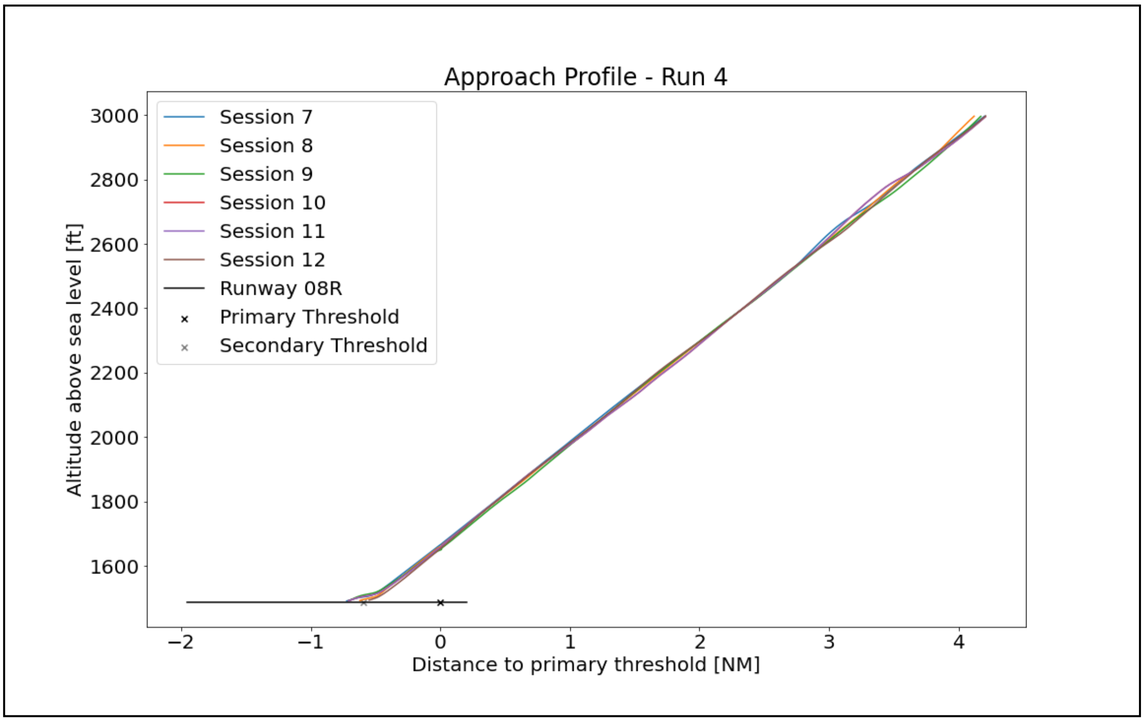


Figure 149: Vertical Path Run 4 (Session 7-12)

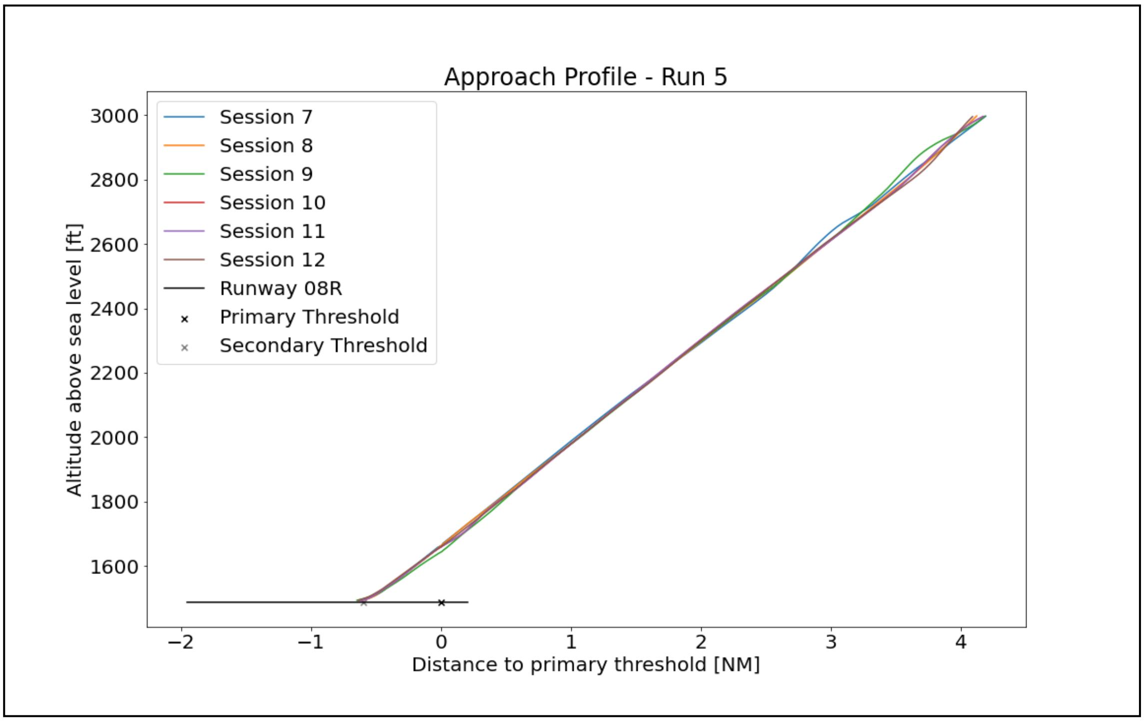


Figure 150: Vertical Path Run 5 (Session 7-12)

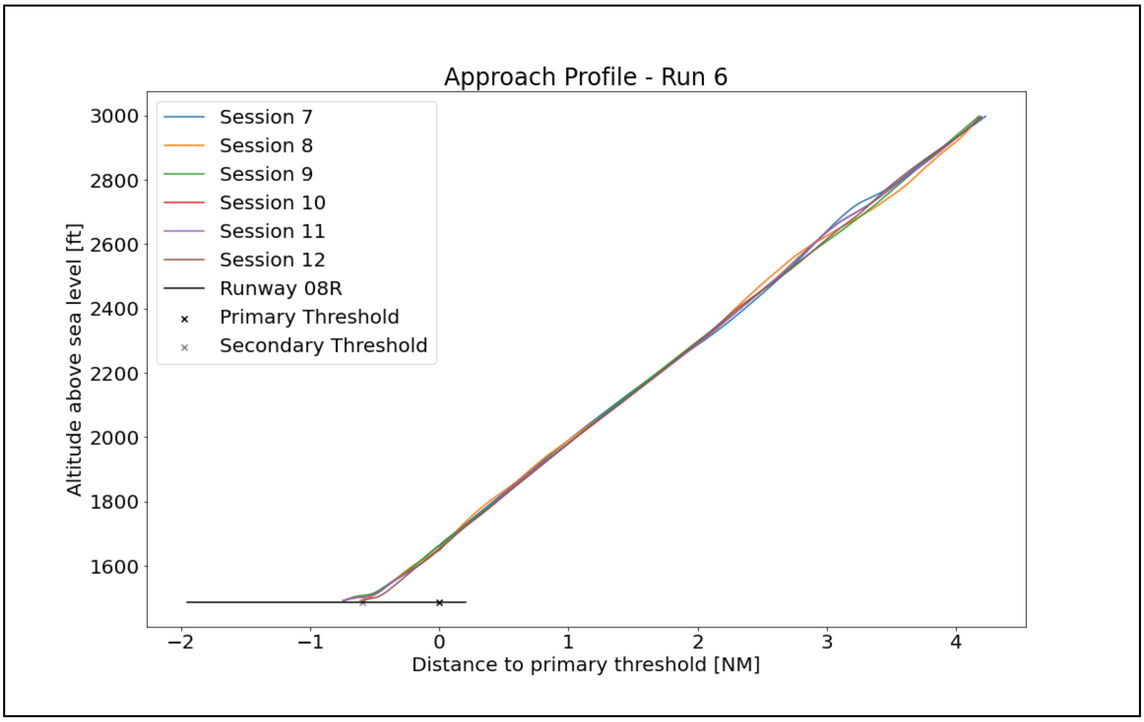


Figure 151: Vertical Path Run 6 (Session 7-12)

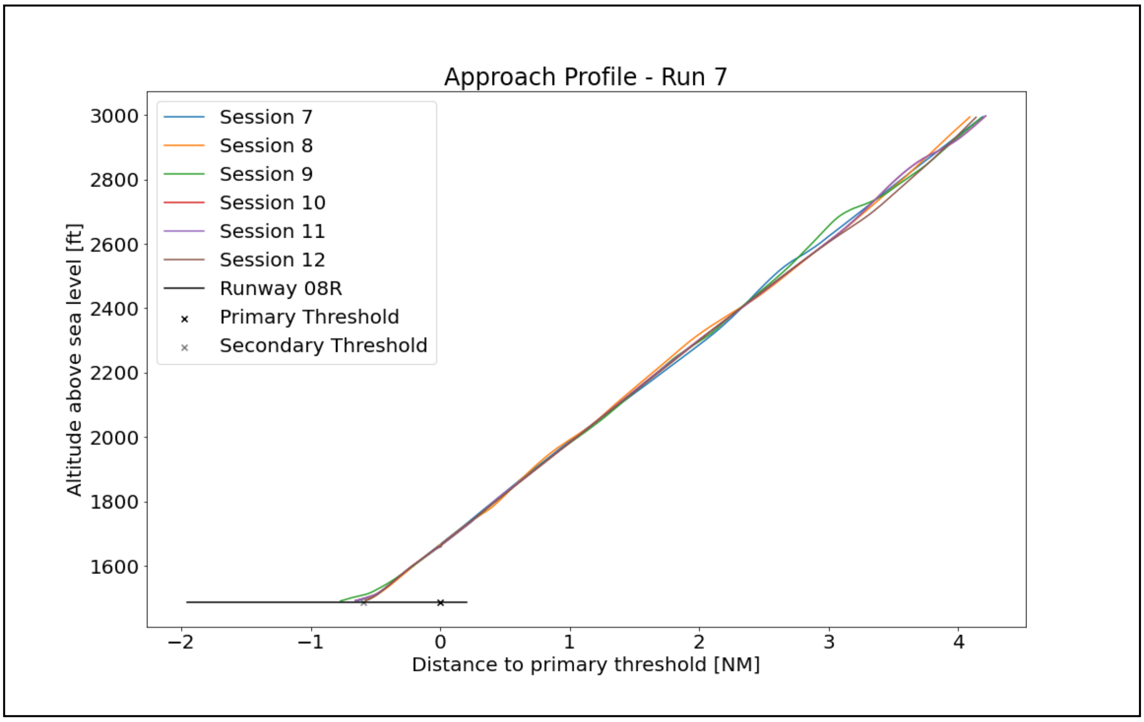


Figure 152: Vertical Path Run 7 (Session 7-12)

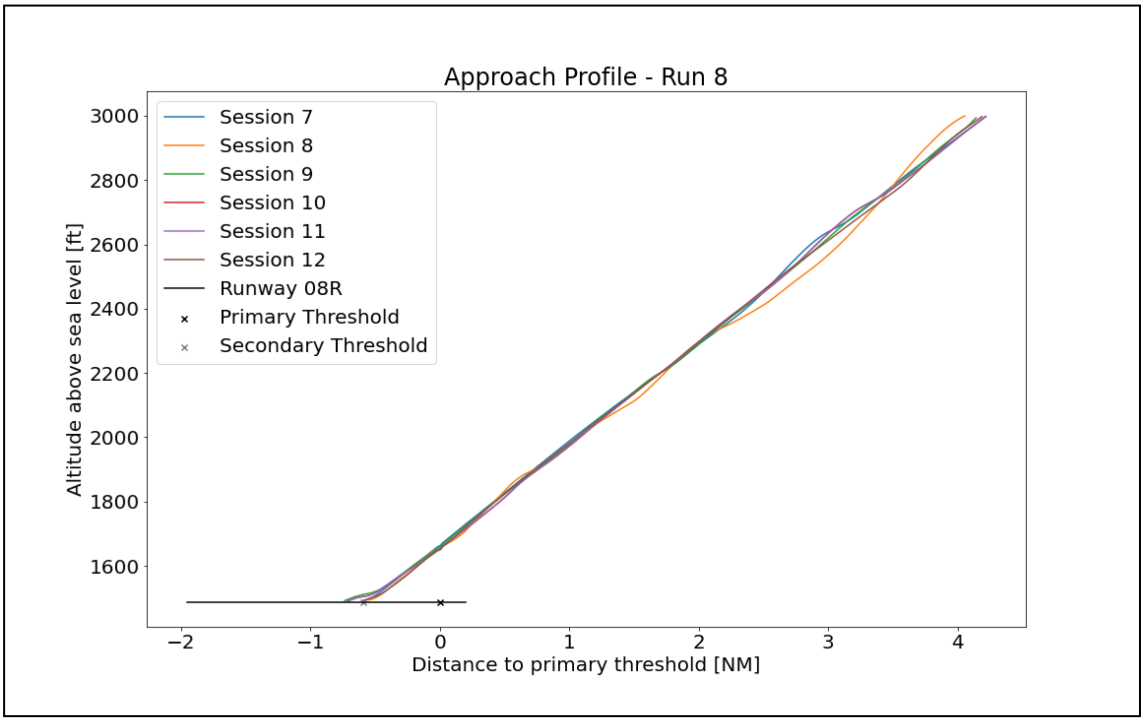


Figure 153: Vertical Path Run 8 (Session 7-12)

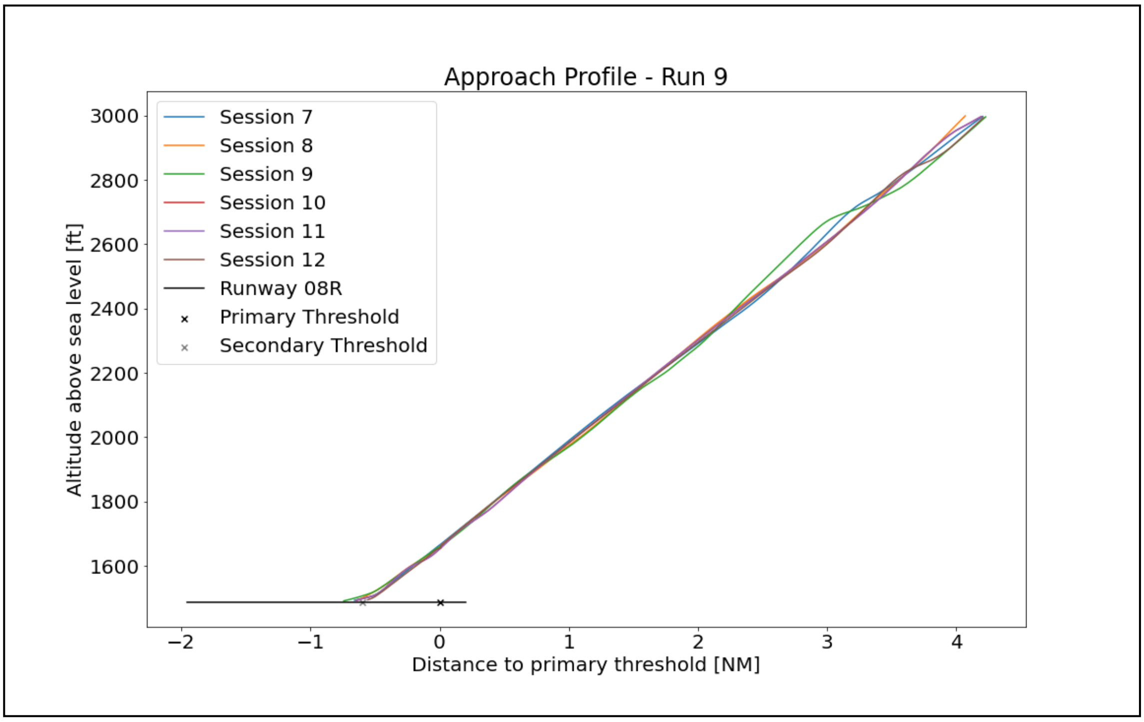


Figure 154: Vertical Path Run 9 (Session 7-12)

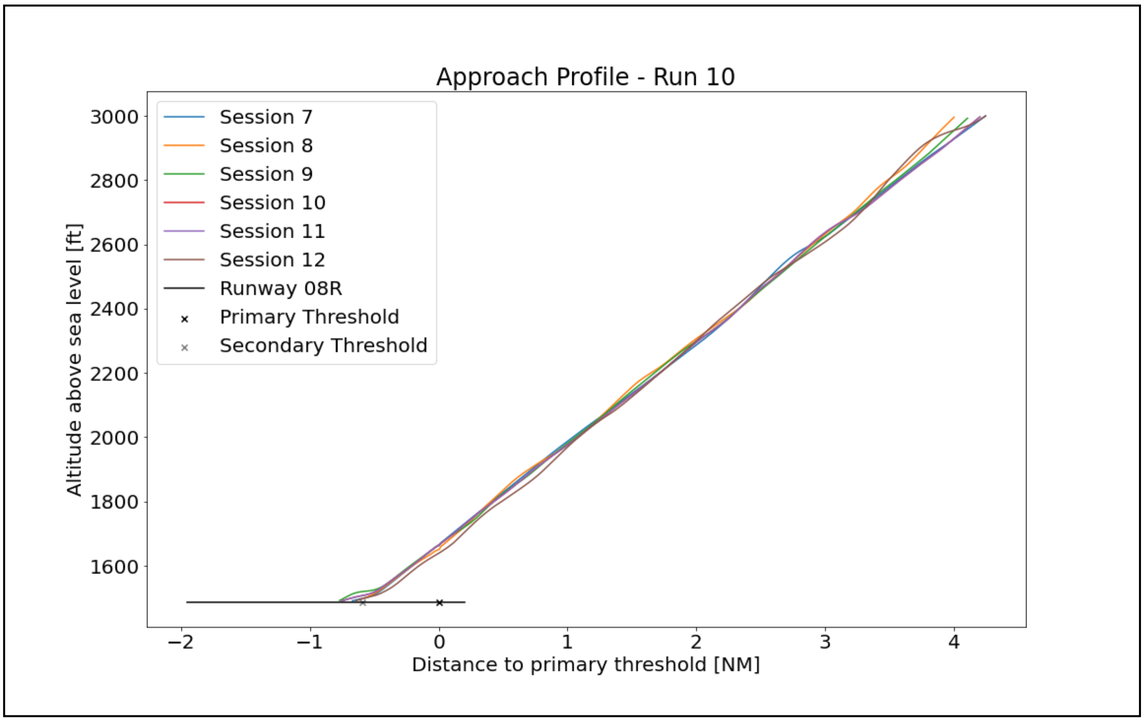


Figure 155: Vertical Path Run 10 (Session 7-12)

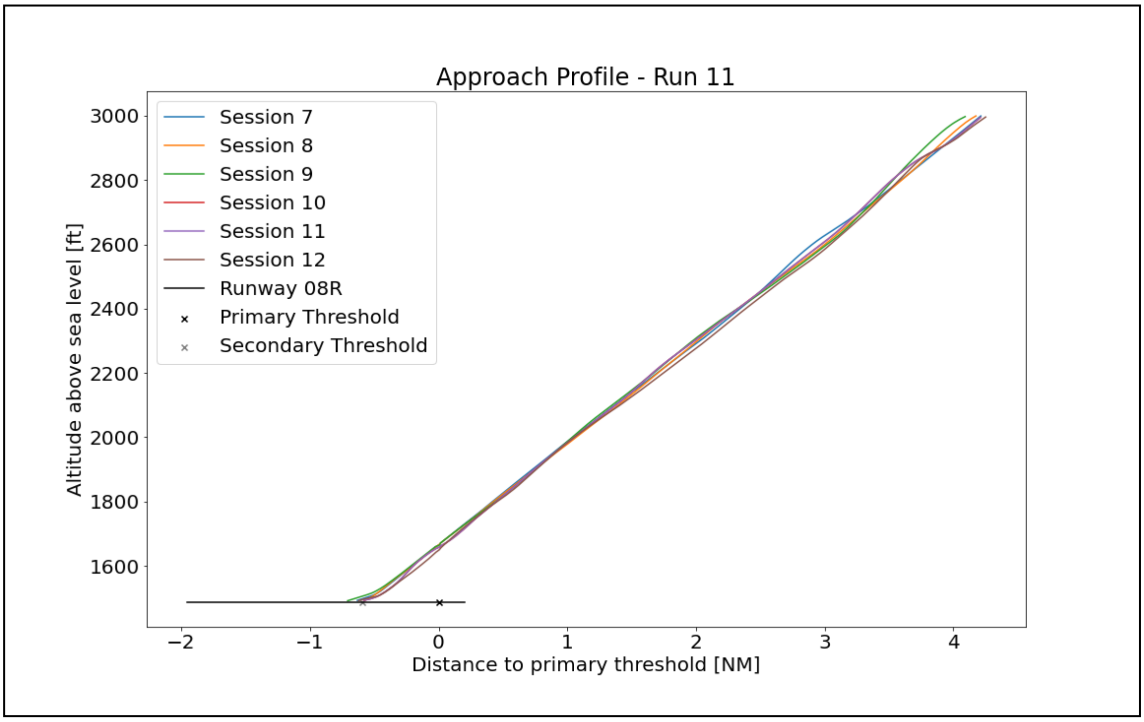


Figure 156: Vertical Path Run 11 (Session 7-12)

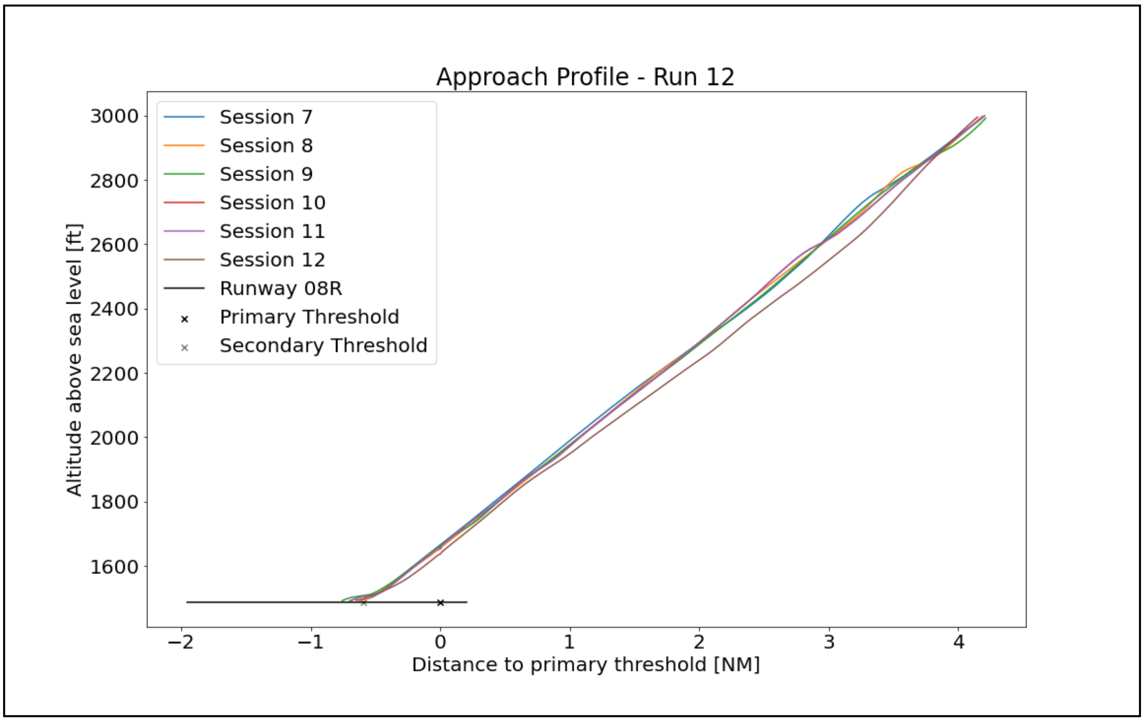


Figure 157: Vertical Path Run 12 (Session 7-12)

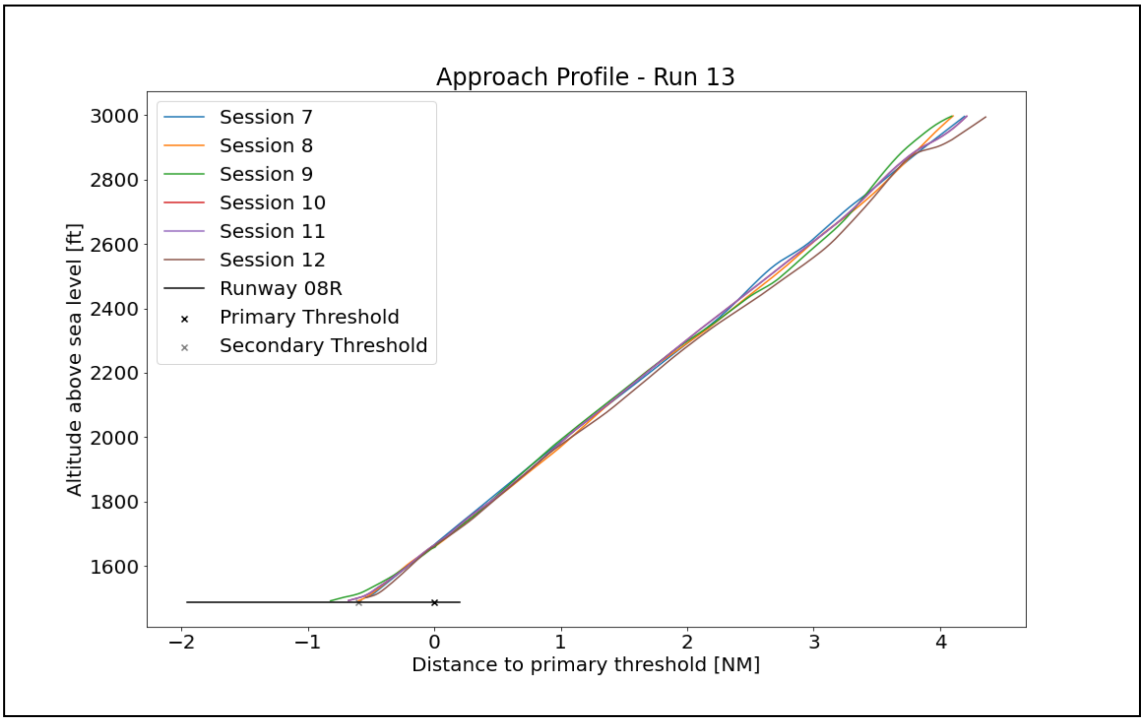


Figure 158: Vertical Path Run 13 (Session 7-12)

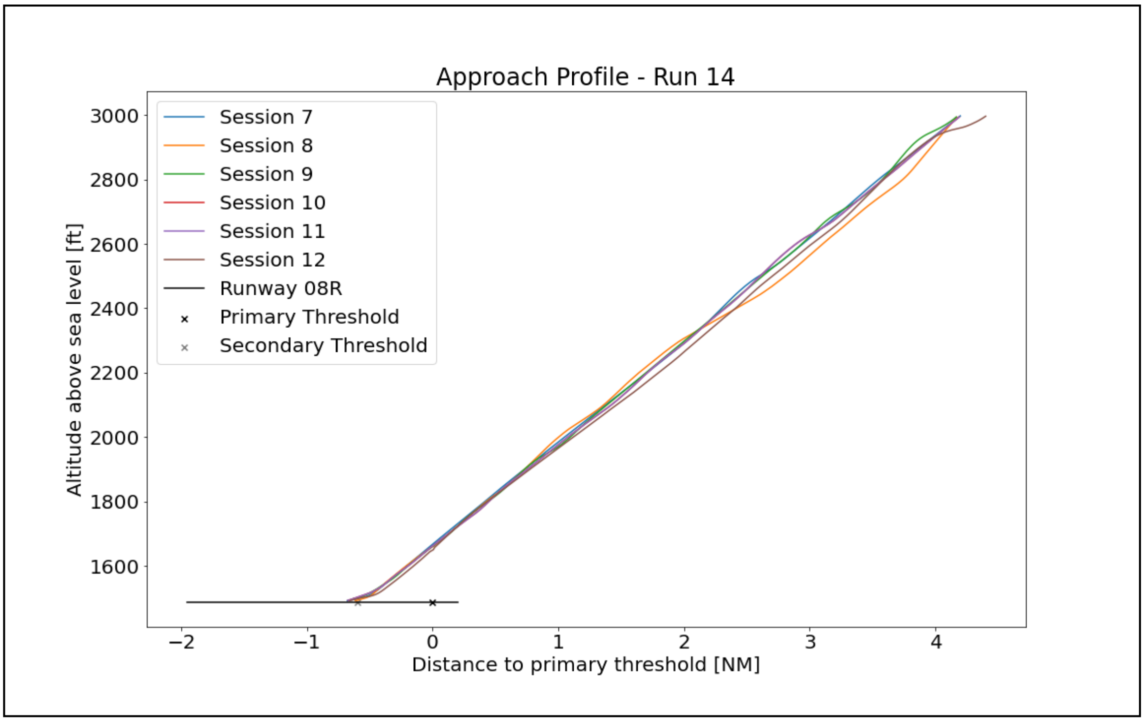


Figure 159: Vertical Path Run 14 (Session 7-12)

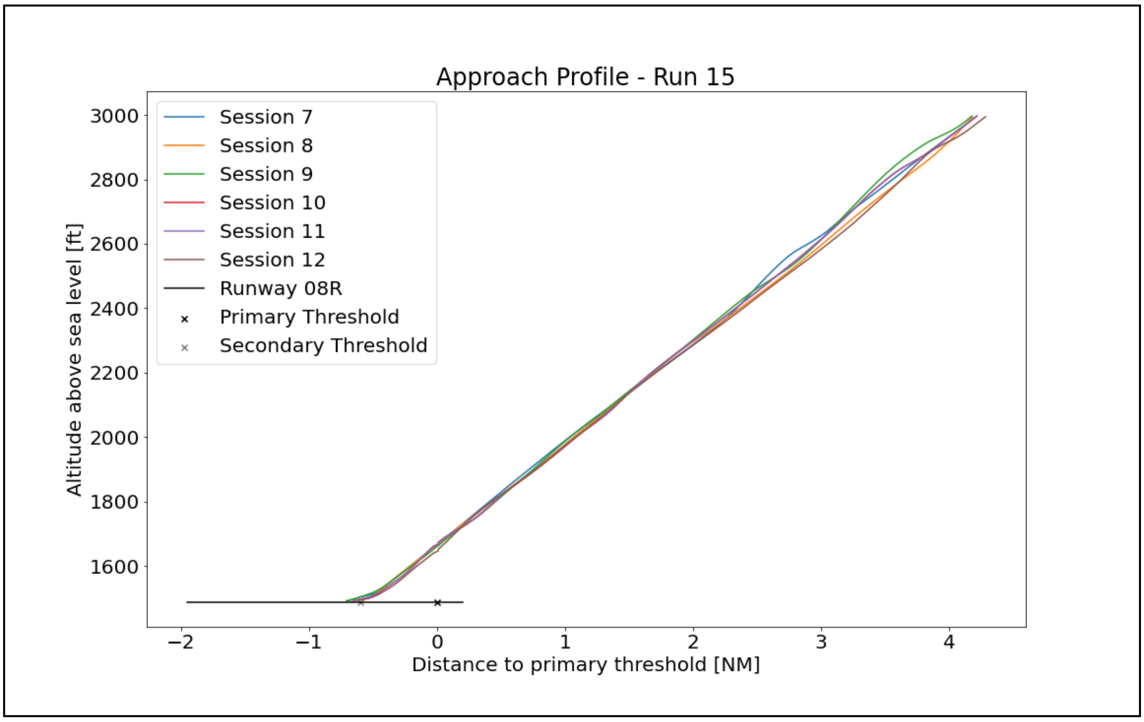


Figure 160: Vertical Path Run 15 (Session 7-12)

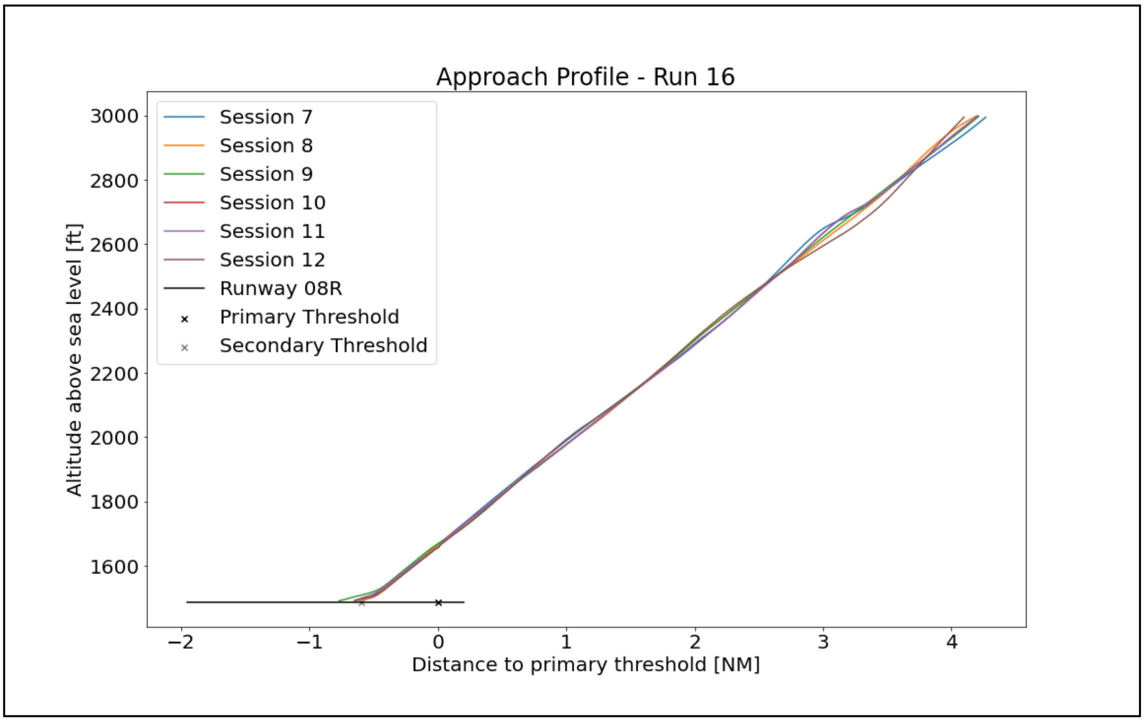
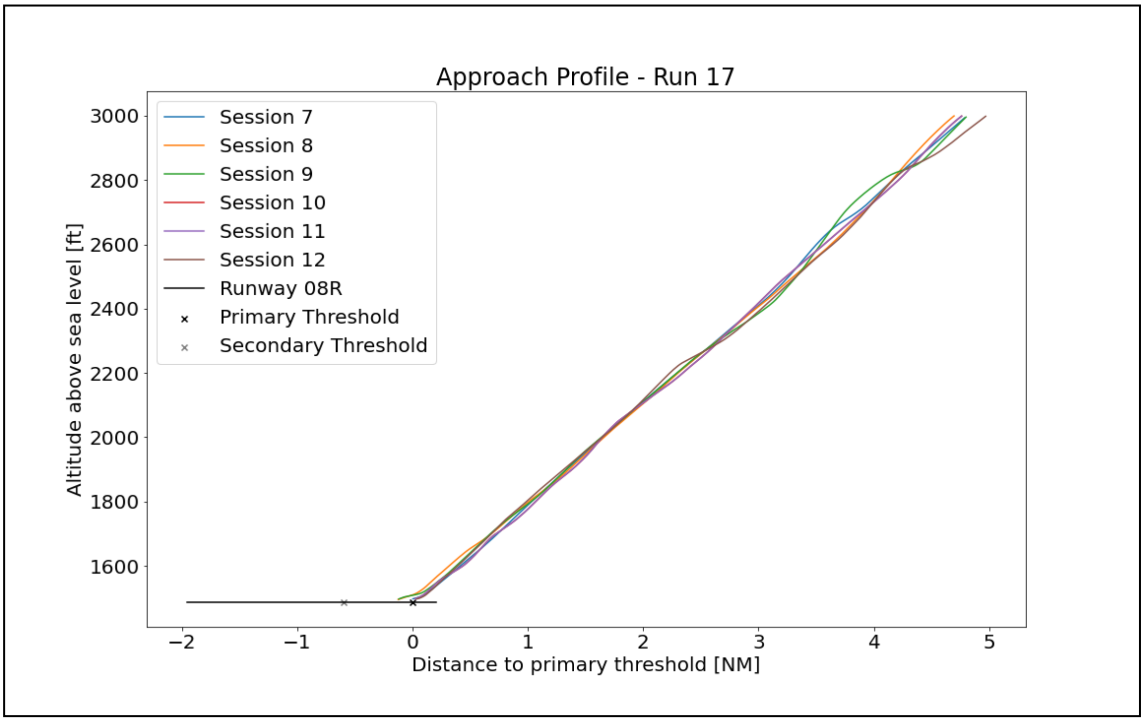


Figure 161: Vertical Path Run 16 (Session 7-12)



3478

3479 **Figure 162: Vertical Path Run 17 (Session 7-12)**

Appendix E Charts used in EXE-14.5-V3-VALP-R10

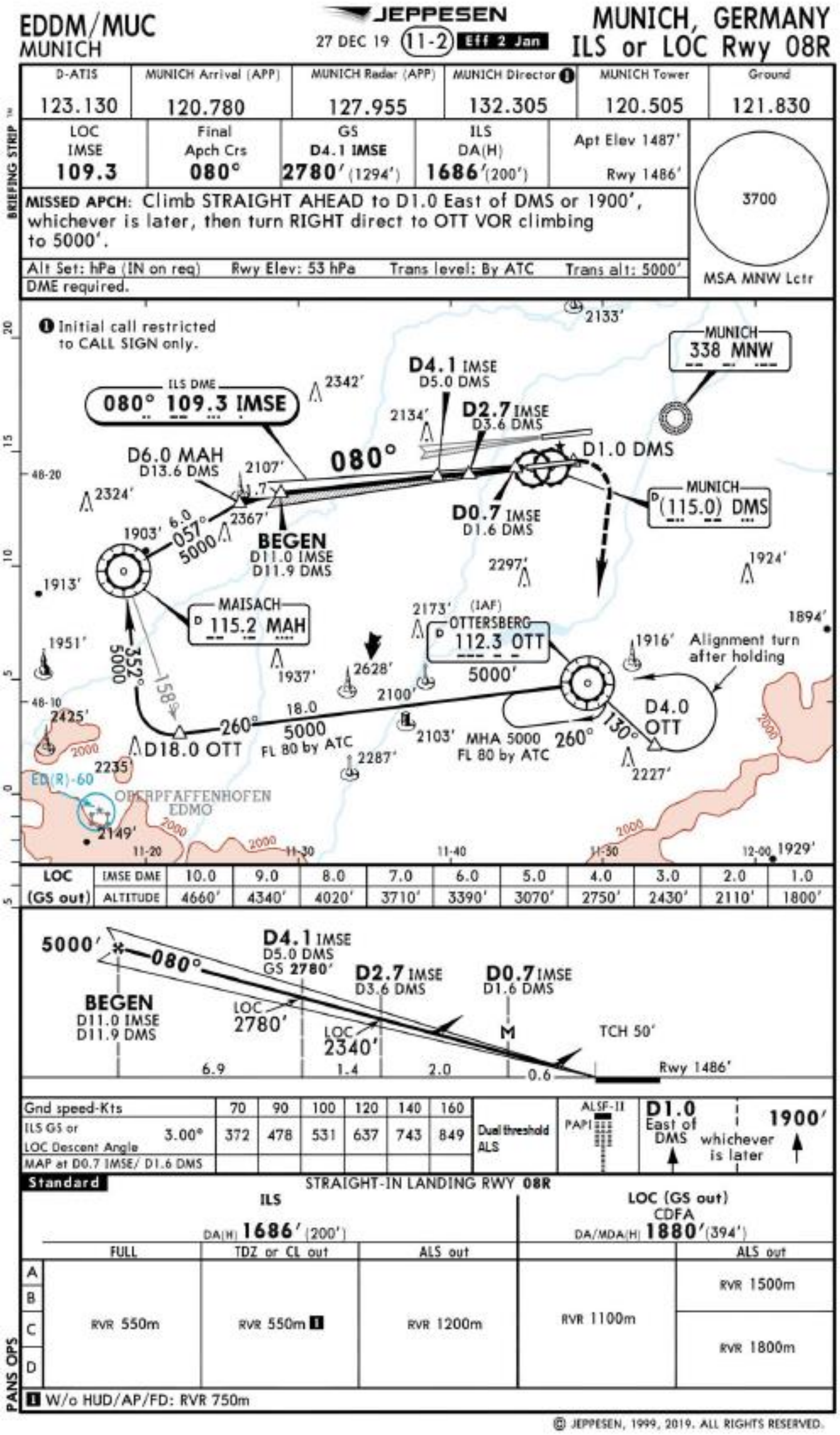


Figure 163: R10 chart for threshold ILS 08R – steady mode (first threshold)

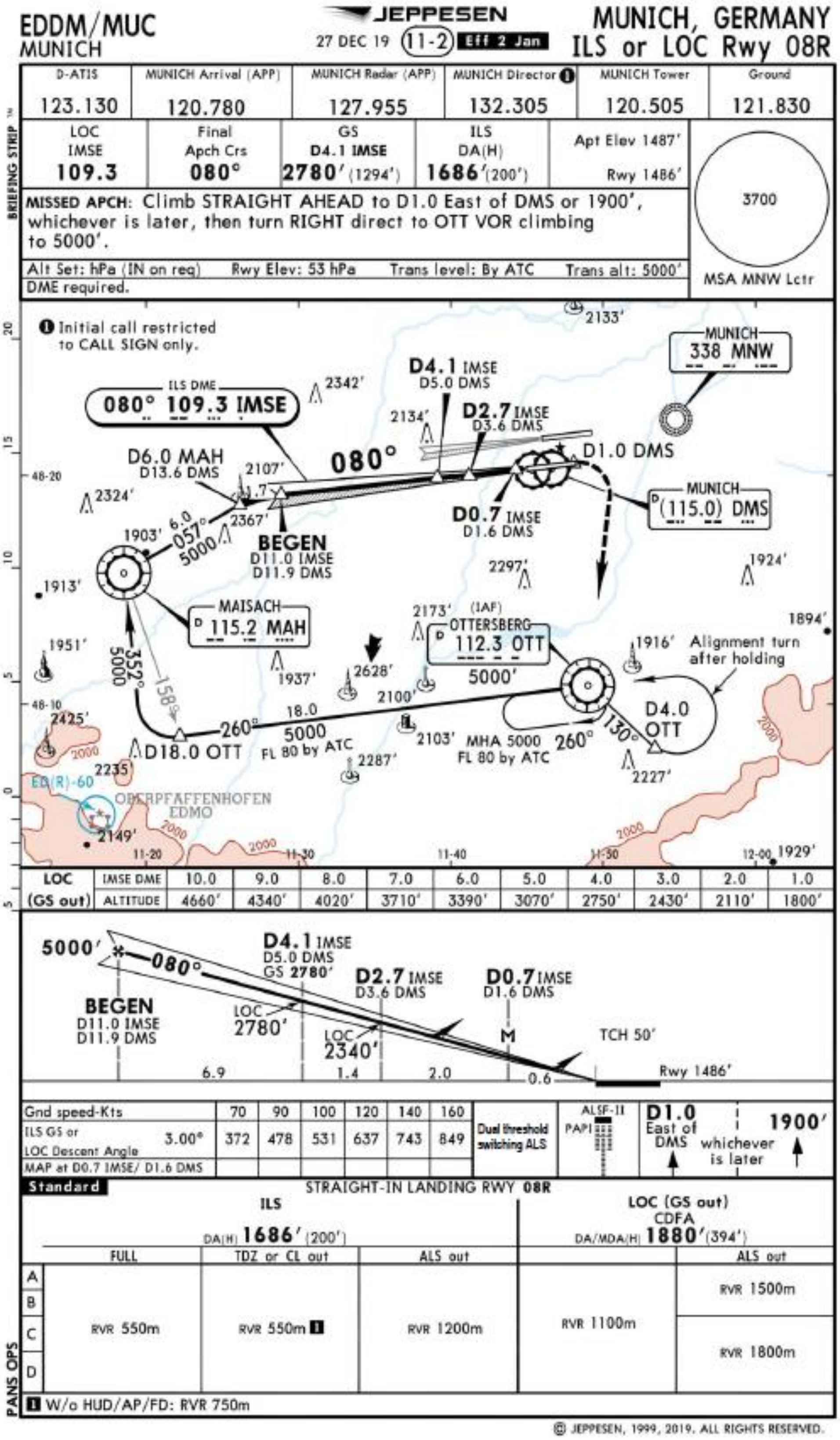


Figure 164: R10 chart for threshold ILS 08R – switching mode (first threshold)

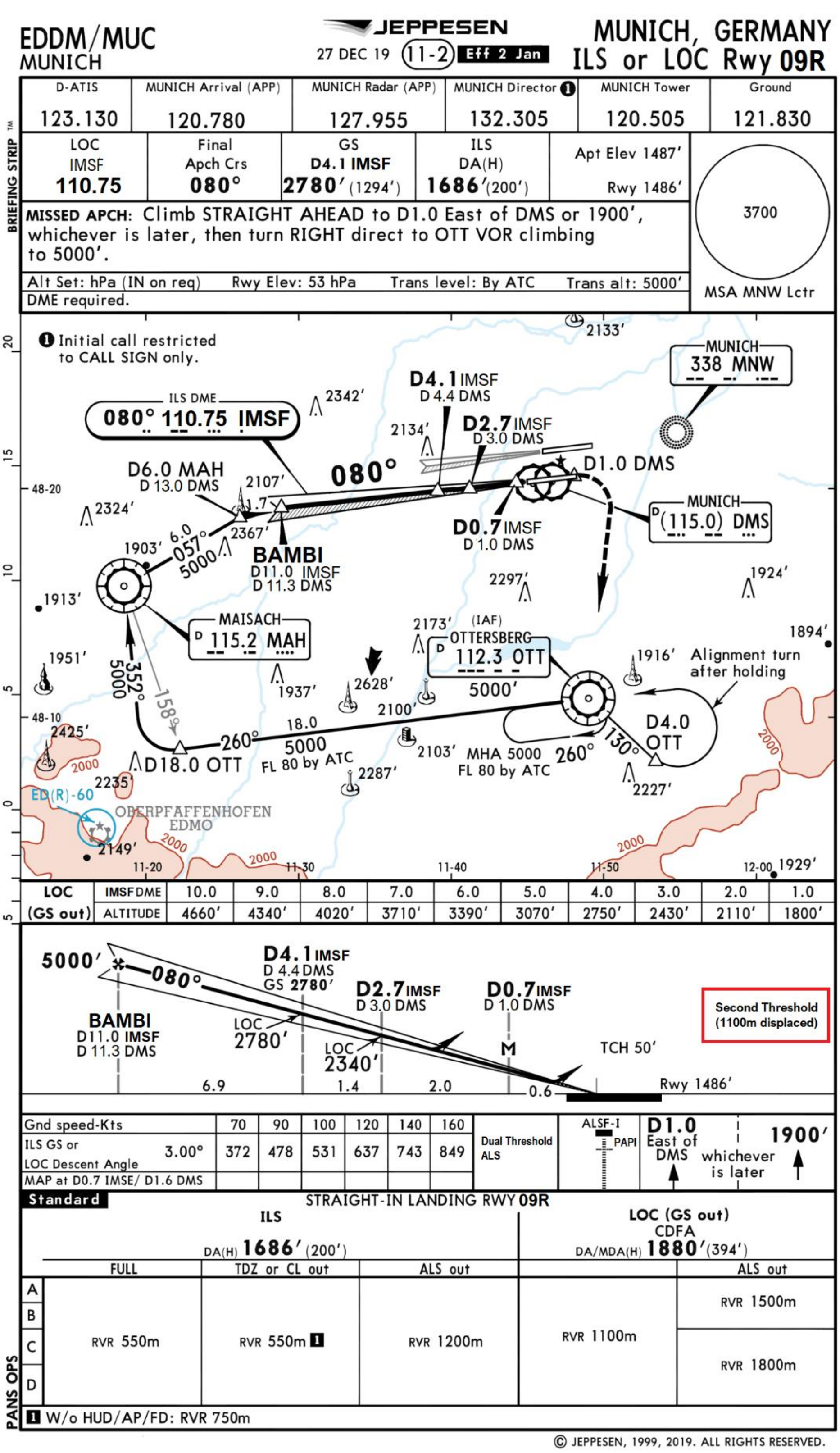


Figure 165: R10 chart for threshold ILS 09R – steady mode (second threshold)

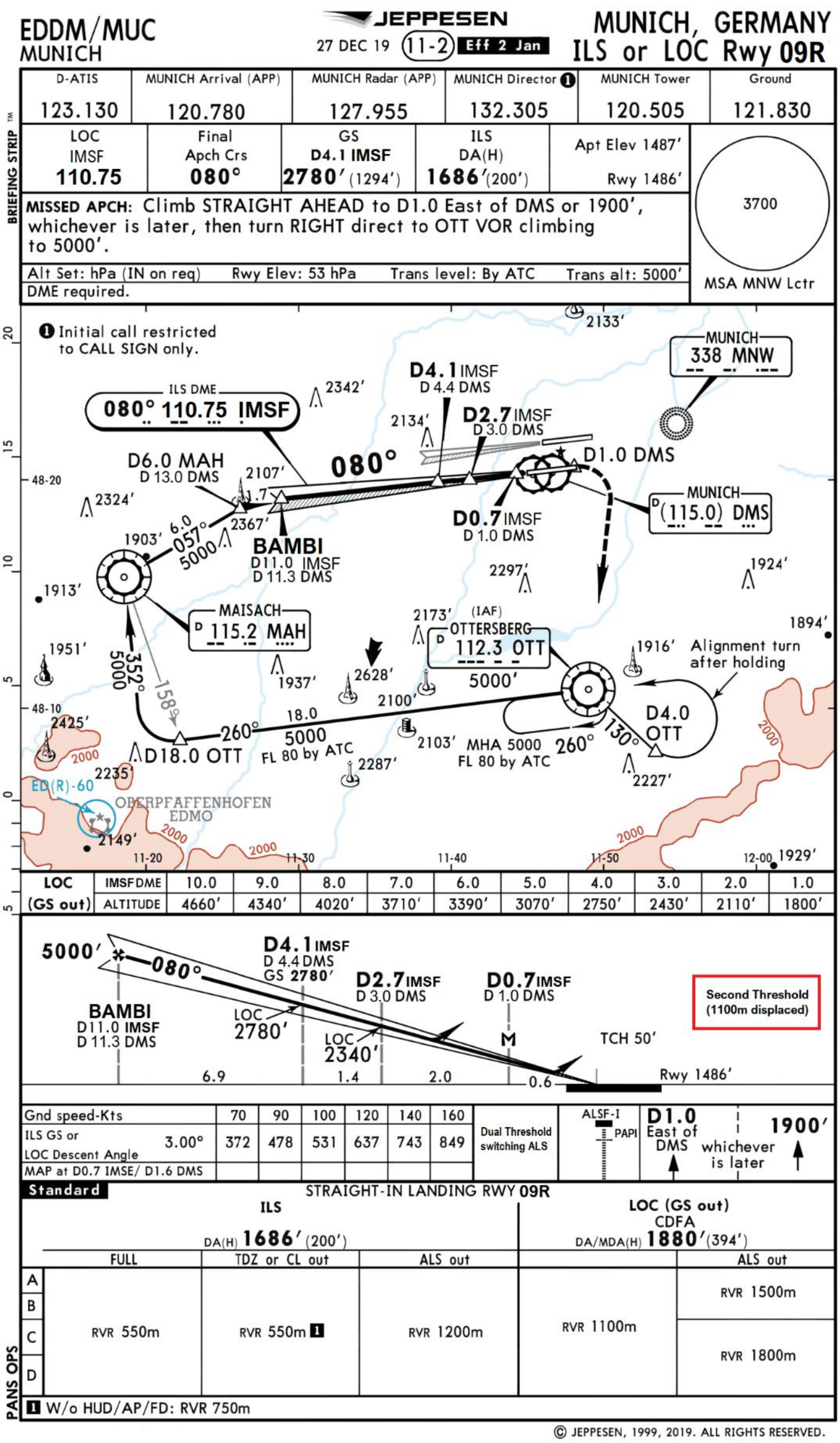


Figure 166: R10 chart for threshold ILS 09R – switching mode (second threshold)

Appendix F Charts used in EXE-14.5-V3-VALP-R15

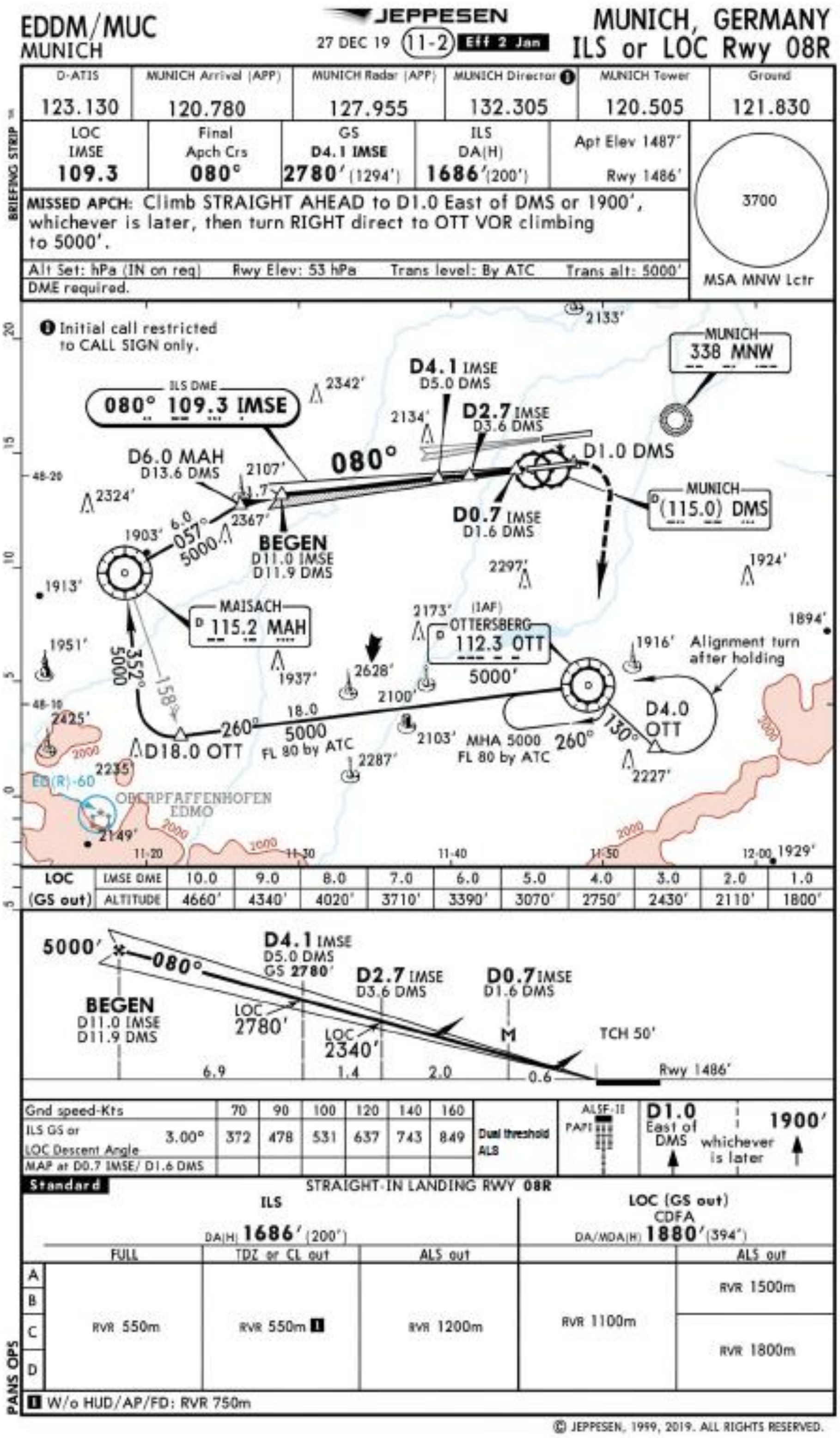


Figure 167: R15 chart for threshold 08R

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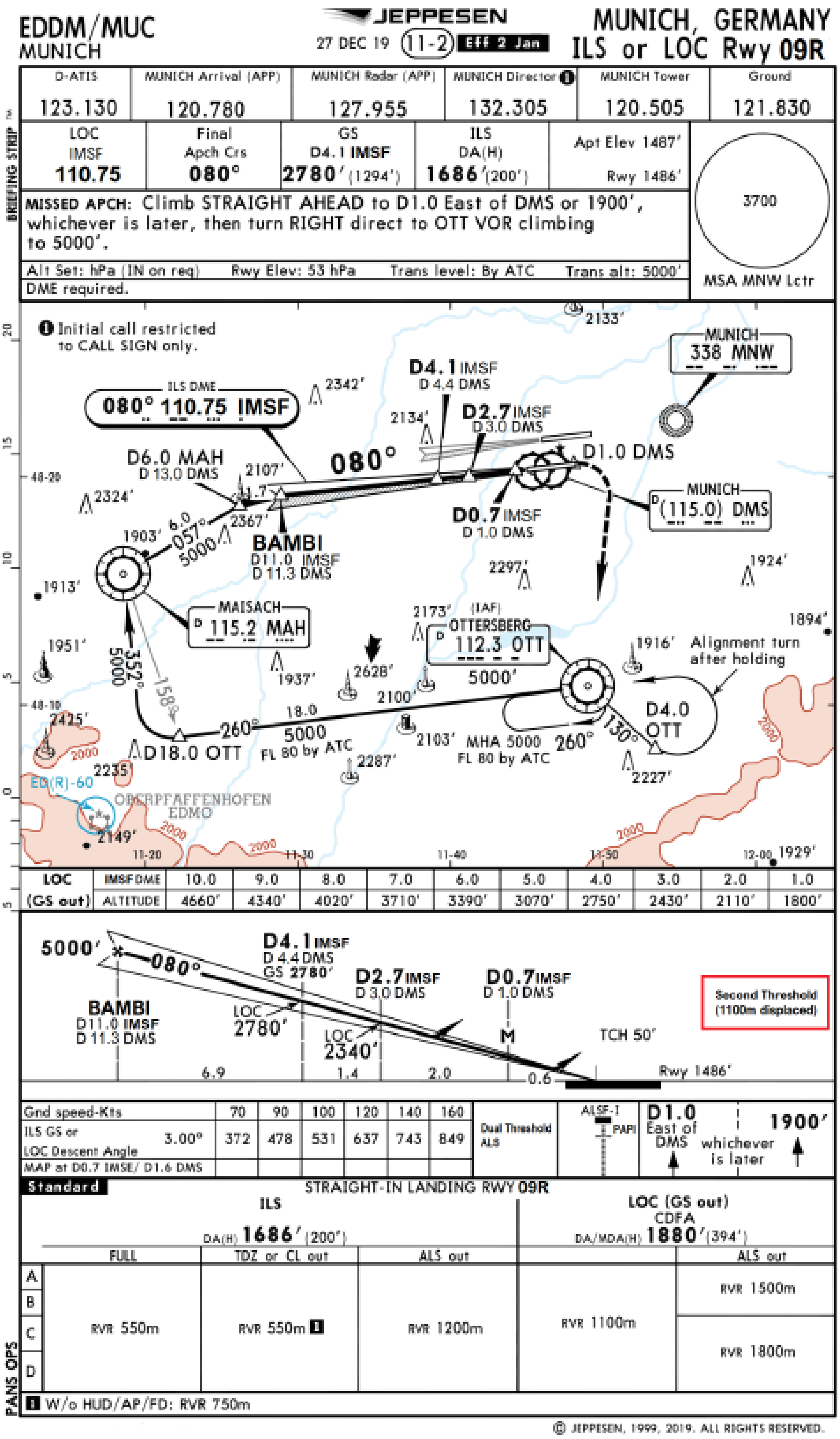

Figure 168: R15 chart for threshold 09R

Appendix G Charts used in EXE-14.5-V3-VALP-R25

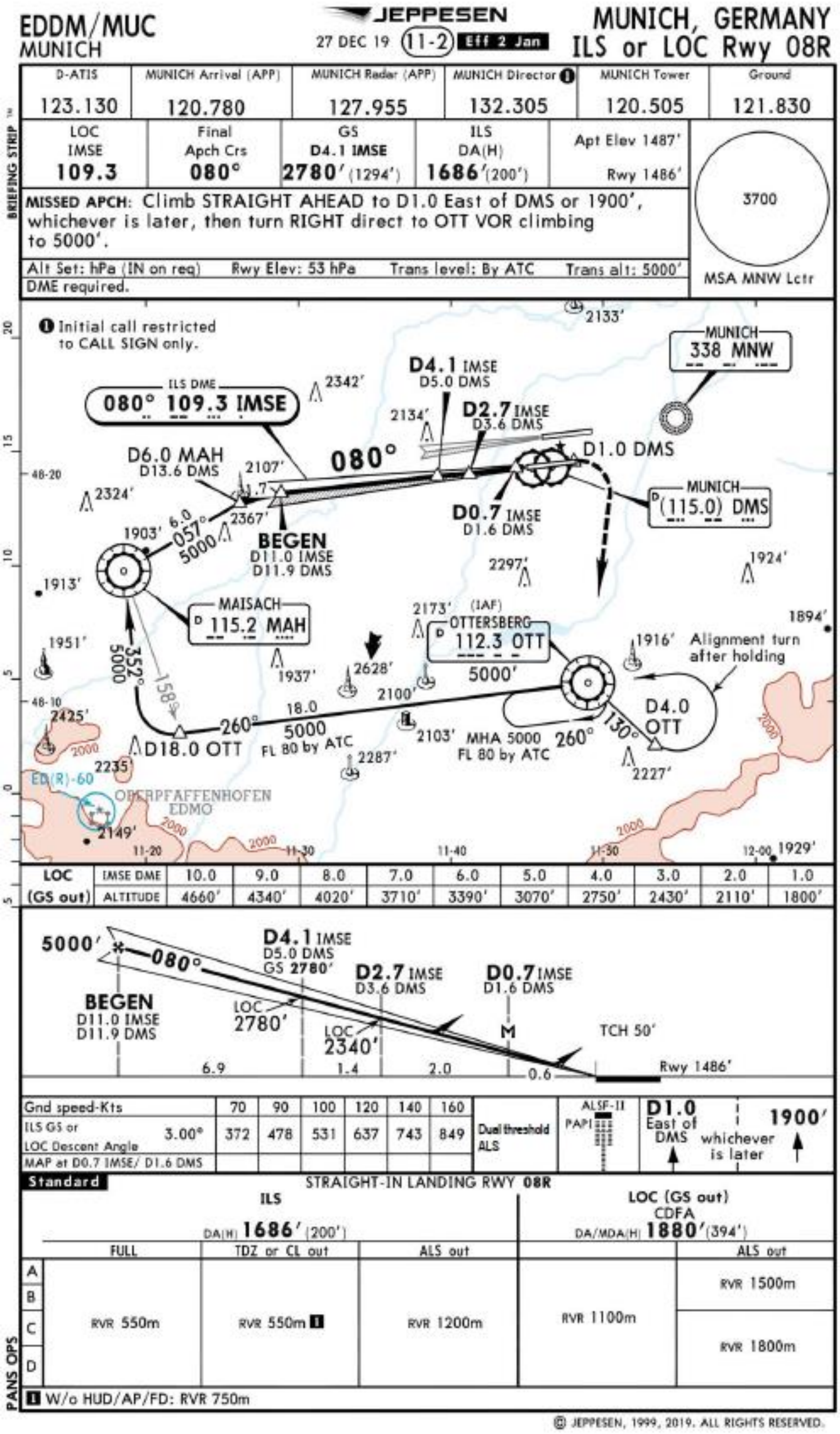

Figure 169: R25 chart for threshold 08R

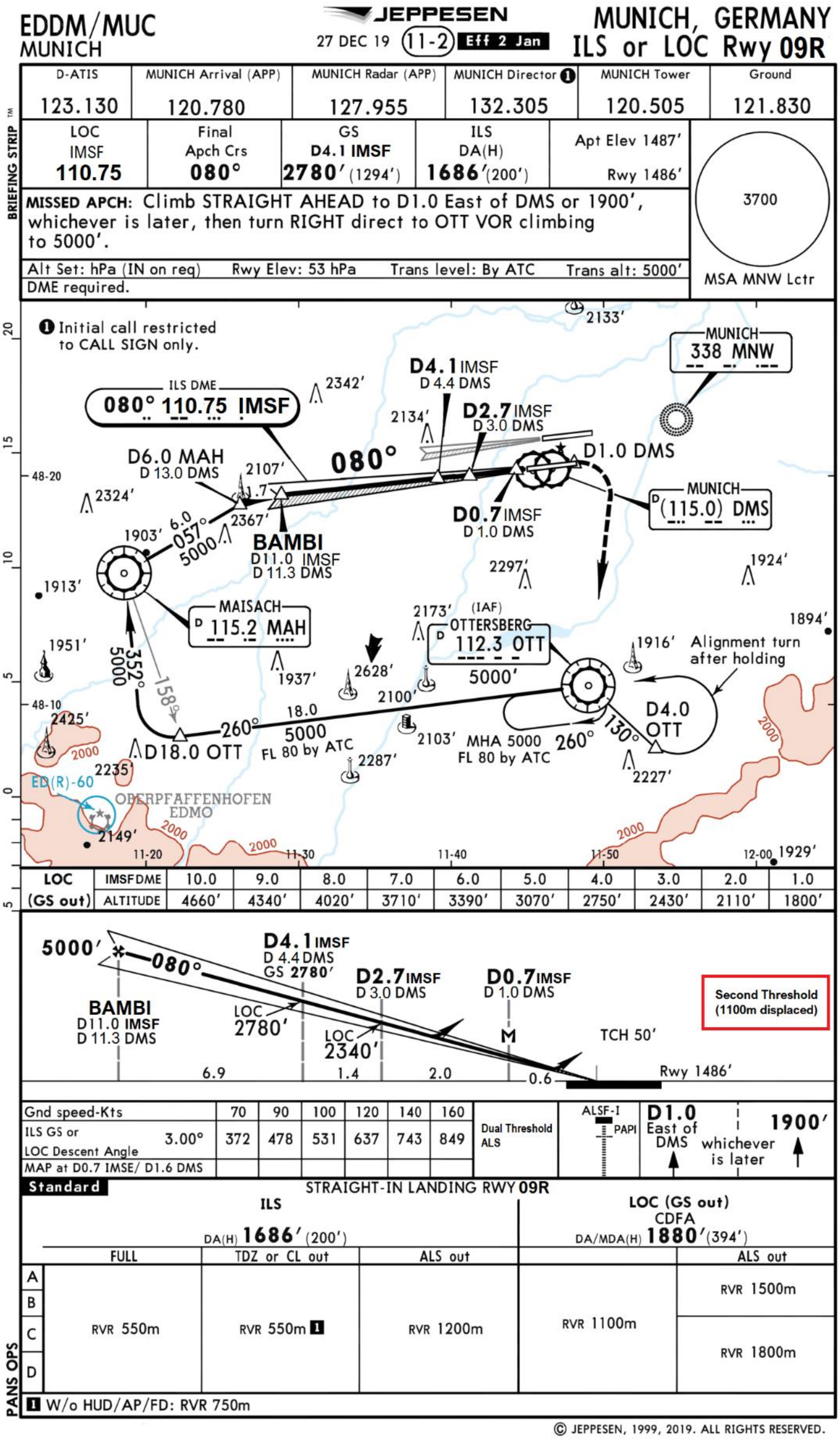

Figure 170: R25 chart for threshold 09R

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