Test Results for Prague

Phase II

Operational Benefit Evaluation by Testing an A-SMGCS

D22aII-TRP-Annex A, 1.0

J. Jakobi

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Test Results for Prague

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2002-09-30	0.1	Document Outline	
2002-10-23	0.2	Section 5.3, 6.3.2, 6.4.3.4.7 renewed, new section 6.4.2, new Chapter 7	New contributions by DLR, AUEB, NLR PAS provided “number of stops”

Contents

1. Scope of Document

The field tests performed in phase two within the BETA project are documented in one main document (D22II-TRP.doc) and three separate subsidiary documents (one for each test site). The herewith-presented volume (D22aII-TRP-1.0) covers the tests at Prague-Ruzyně Airport (PRG) performed between 2002-05-27 until 2002-06-07.

The outcome of the analysis of the measured data given here is presented and discussed in the WP6000 documents (D25, D26, and D32).

The functional and operational tests performed at the test site PRG are based on the BETA documents produced in WP2000 (D10-GTC-10.doc), WP4000 (D33-THE-03.doc) and WP5100 (D16aII-TPP-1.0)doc, “Test Plan and Test Procedures” and were adapted on site due to regulatory, operational or weather conditions. Further explanations follow in the respective chapters.

Document Structure

The document is structured in the following way:

- Chapter 1 this chapter
- Chapter 2 summarises the tests briefly
- Chapter 3 briefly describes the technical system used during the tests
- Chapter 4 summarises the test equipment
- Chapter 5 describes the functional tests
- Chapter 6 describes the operational tests
- Chapter 7 is the Annex

2. Brief Summary of Tests

2.1 General

The second test phase of BETA consisted of:

- The pilots training and proof of principles at Braunschweig (DLR);
- The controller training and proof of principles at Amsterdam (NLR);
- The field tests at Prague (ANS-CR/CSL).
- The field tests at Hamburg (DFS/FHGG);

Note: As short test site indication the IATA airport codes are used in this document: BWE for Braunschweig, HAM for Hamburg and PRG for Prague.

The main focus of the training in the labs laid on the improvements of the HMIs and the preparation of the field-testing. The outcome has been documented in D17.

The BETA system and the functions implemented in Prague were further improved and completed and were used fully operational. The active BETA controller, who could take over one of three control positions, worked with the BETA system and BETA procedures as responsible person for managing the regular air traffic at the airport. In addition further controllers worked with BETA in line with the active controller but not in charge for the regular traffic.

For safety reasons, full operational testing under heavy traffic conditions as well as bad weather situation was not permitted in Phase 2 again. Furthermore, the available space at the Control Tower was not sufficient to set up more than one active BETA Controller working position (CWP). These circumstances cause that BETA could not be proved under aggravated traffic conditions, and besides, synergy effects, evoked by more than one BETA CWP, were lost.

3. The BETA System in the 2nd Test Phase

The BETA system at PRG comprises surveillance sensor equipment and computers from different manufacturers, integrated with the existing airport and ATC equipment and infrastructure to provide the first full-scale implementation of A-SMGCS.

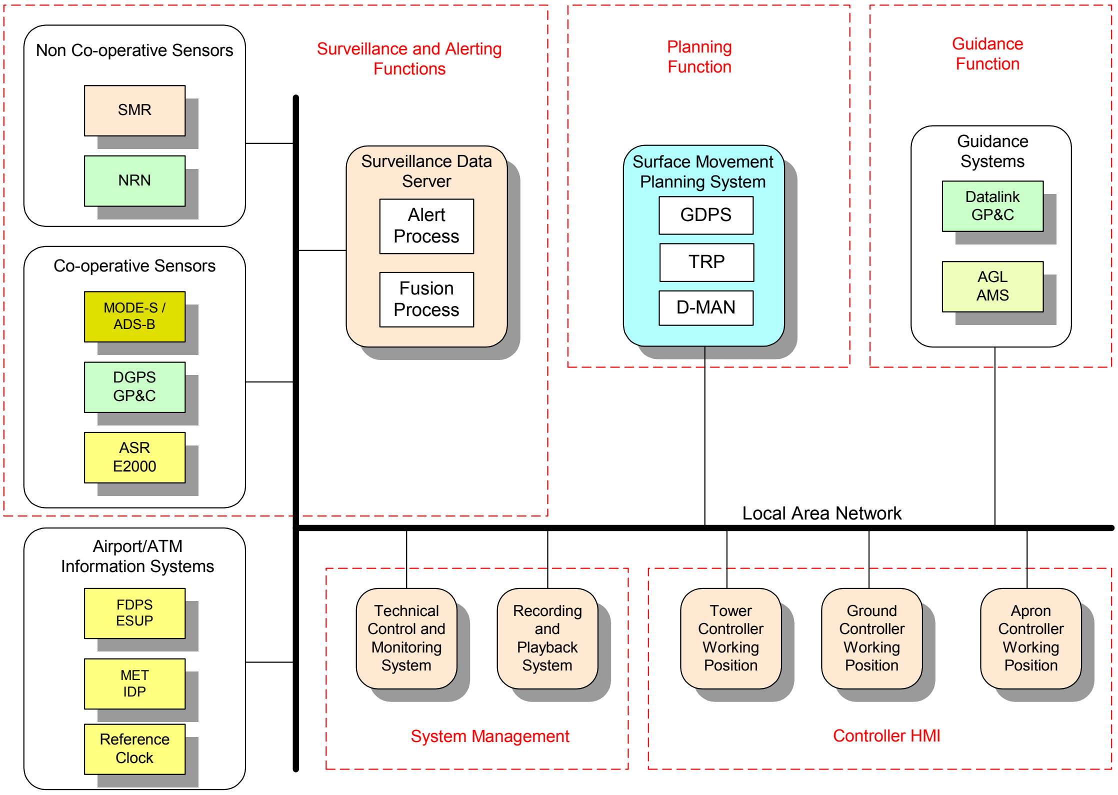

Figure 3-1 Overall System Block Diagram for Prague

<u>Sub- Systems</u>
To execute the tests at Prague the following subsystems are used (Partners responsible for the availability of the subsystems are shown in brackets):

Surveillance
Non-Co-operative Sensor Subsystems
SMR with digital extractor system (ANS-CR)
NRN, Near-range Radar Network (DLR)
Co-operative Sensor Subsystems
ASCS, Mode-S multilateration/ADS-B system (ERA-ASCS)
ASR E2000, Airport Surveillance Radar (ANS-CR)
GP&C, ADS-B based on differential GPS (DLR)
Sensor Data Processing
SDS, surveillance data server (PAS) including monitoring and alert (PAS)

Planning Subsystem
GDPS, ground plan data processing system (TATM)
TRP, taxi route process (TATM)
D-MAN, departure management process (NLR)

Controller Working Position
Active CWP in the upper Tower (PAS)
Non-active CWP in the Visual Control Room (PAS)
Display in the Gate Management (PAS)

Guidance/Communication
AGL-AMS, aerodrome ground lighting system (CSL)
Guidance Server (PAS)
DL, Data Link comprising GP&C (DLR)
AGL-AMS, guidance data processing (PAS)
Pilot HMI, on board HMI (DLR)

System Management
System Management (PAS)
Recording (DLR and PAS)

Following functions were realised by BETA in the 2nd Test Phase at Prague Airport:

Surveillance

- Detection and presentation of traffic objects and obstacles on the aerodrome movement area and approaches
- Automatic identification of suitably equipped co-operating traffic, including
- Arriving aircraft (SSR) except VFR
- Some departing aircraft, if equipped with active mode-S transponders
- Participating vehicles (GP&C and/or mode-S equipped test vans and service vehicles)
- Manual identification of other targets

Alerting

- Runway occupied/runway incursion alerting for arrivals and departures
- Restricted area intrusion alerting
- Crossed stop bar alerting
- Route deviation alerting

Planning

- Flight Plan Presentation
- Creation, modification, and editing of flight plans (including VFR and vehicles)
- Electronic flight strips (EFS)
- Handover of EFS
- Departure sequence proposal
- Presentation of the standard taxiway route

Guidance

- Stop bars
- On-board guidance
- Clearance delivery
- Route indication

Controller HMI

- Traffic Situation Display
- EFS Display

The BETA equipment has been provided in a non-redundant configuration. Although good engineering practices have been employed, the BETA system is a prototype. It is beyond the scope of BETA to evaluate the system reliability or availability. The focus has been on data integrity, accuracy and usability.

4. Test Equipment

The test equipment at the 2nd test phase used at Prague was:

• Test-Van	DLR Test Van Equipped with Mode-S Transponder, GP&C Transponder and Pilot –HMI.	DLR
• Test A/C	DLR Test A/C Mode-S Transponder; GP&C Transponder and Pilot –HMI equipped.	DLR
• 2 Test cars	Mode-S Transponder and GP&C Transponder equipped. Car 1 with the call sign CSL1 Car 2 with the call sign FIRE1	CSL
• 3 Test cars	Mode-S Transponder and GP&C Transponder equipped. Car 1 with the call sign FOLLOW1 Car 2 with the call sign FOLLOW2 Car 3 with the call sign FOLLOW3	ANS CR

Figure 4-1: DLR Test Van

Figure 4-2: DLR Test A/C

5. Functional Tests

5.1 Test Criteria and Parameters

5.1.1 Test Criteria

Index	Test Criteria
F1:	**Surveillance Accuracy and Timeliness (RPA, RVA, TRUR, TRL) Testing NRN and SDS**
F1A	Testing the NRN. Test Van on RWY24 and TWY Alpha and Bravo
F1B	Testing the Surveillance Accuracy of the SDS (RPA, RVA, TRUR) at normal speed with stops
F1C	Elk Test on apron north
F1D	Measuring Target Report Latency (TRL) of the CWP display TRL measured by stopwatch ON-F1D
F2	**Surveillance System Reliability (PD, PFD, PID, PFID, PCT, CV)**
F2	Normal Traffic Recording (no specific procedure needed) Multiple BETA Observers writes a protocol. No specific Scenario (ON-F2) PCT and CV will be tested by offline replay of CWP
F3	**Monitoring and Alert (PDAS, PFA, ART)**
F3A	Conflict alert situations (Alert Response Time, ART measured with stopwatch) ON-F3
~~F3B~~[1]	~~Restricted area alert (Alert Response Time, ART measured with stopwatch) ON-F3~~
F3C	Stop bar crossing (Alert Response Time, ART measured with stopwatch) ON-F3
F3D	Route deviation alert (Alert Response Time, ART measured with stopwatch) ON-F3
F4	**Planning Performance:**
~~F4A~~[2]	~~Test procedure outlined by NLR, TATM, PAS ON-F4~~
F4	Hand Over Test / Completeness of Electronic Flight Strip / Taxi Route generation and changing
F5	**Guidance Performance:**
F5A	On Board Guidance Test CDRT, GART, GACT measured with stopwatch ON-F5

Table 5-1: Test Criteria

[1] Not used in Prague due to closed RWY 13/31.
[2] Only Handover Test / Completeness of Electronic Flight Strip / Taxi Route generation and changing

5.1.2 Test Parameters

	Abbreviation	Test Parameters	
1.		**Surveillance Integrity Parameters for SDS**	
1.1	RPA	Reported Position Accuracy	SDS-Logger
1.2	RVA	Reported Velocity Accuracy	SDS-Logger
1.3	TRUR	Target Report Update Rate	SDS-Logger
1.4	TRL	Target Report Latency	ON-F1D
2.		**Surveillance Reliability Parameters for SDS**	
2.1	PD	Probability of Detection	ON-F2
2.2	PFD	Probability of FALS Detection	ON-F2
2.3	PID	Probability of Identification of co-operative targets	ON-F2
2.4	PFID	Probability of False Identification of co-operative targets	ON-F2
2.5	PCT	Continuity of target track (fast replay of the HMI)	HMI-Logger
2.6	CV	Coverage Volume	HMI-Logger
3		**Alert Parameters**	
3.1	PDAS	Probability of Detection of an Alert Situation	
3.2	PFA	Probability of False Alert	
3.3	ART	Alert Response Time	
		F3A Runway incursion	ON-F3
		F3B Restricted Area intrusion	ON-F3
		F3C Stop bar crossing	ON-F3
		F3D Route deviation	ON-F3
4.		**Planning Parameters**	
	TOTPA	Take Off Time Prediction Accuracy (NLR)	ON-F4-NLR
	DSRT	Departure Sequence Response Time (NLR)	ON-F4-NLR
	TPCR	Taxi Plan Computation Rate (PAS)	ON-F4-PAS
	TPCRT	Taxi Plan Computation Response Time (PAS)	ON-F4-PAS
		Clearance Control (TATM)	ON-F4-TATM
		Hand Over Test / Completeness Flight Strip / Taxi Route generation and changing	ON-F4
5.		**Guidance Performance Parameter**	
5.1	CDRT	Clearance Delivery Response Time	ON-F5
5.2	GART	Guidance Aid Response Time	ON-F5
5.3	GACT	Guidance Aid Confirmation Time	ON-F5

Table 5-2: Test Parameters

5.2 Times of Testing

Date	Time UTC	Index	Criteria	Remarks	Recordings
2002-05-21	11:00	Briefing			
2002-05-21	14:00 – 15:00	F1A	NRN-Surveillance	Test Van taxiing on A/B/24	S0020521-2.CSC
2002-05-21	15:00 – 16:00	F1B	SDS-Surveillance	Test Van stops at Stop Bars ASCS not transmitted from ERA	S0020521-3.CSC
2002-05-22	06:30	Briefing			
2002-05-22	07:50 – 08:15	F1D	SDS Latency	No Latency observed. TRL < 0,2 sec.	
2002-05-22	08:15 – 09:00	F1C	SDS Dynamic	FOLLOWIII on G-C-H-J	S0020522-02.CSC
2002-05-22	12:10 – 12:40	F3C-1	Alert Stop Bar	ART = <1 sec	S0020522-05.CSC
2002-05-22	12:45 – 12:55	F3A-1	RWY Incursion	FOLLOWIII TWY-D /RWY06	S0020522-05.CSC
2002-05-22	13:07 – 13:30	F3C-2	Alert Stop Bar	ART = <1 sec	S0020522-05.CSC
2002-05-22	13:40 – 15:33	F2	Reliability	42 a/c at 2 hours	
2002-05-22	13:40 – 15:33	F3D	Route Deviation	Not operating properly	
2002-05-22	16:20 – 16:40	F5-1	Guidance	Syntax false transmitted	
2002-05-23	06:30	Briefing			
2002-05-23	07:30 – 11:00	F3A-2/3	RWY Incursion	Tests observed during test run F4	
2002-05-23	07:30 – 09:45	F4-ARR-1/2	Hand Over Arr	All taxi plans are available and complete	
2002-05-23	09:45 – 11:30	F4-DEP	Hand Over Dep	All taxi plans are available and complete	
2002-05-23	12:30 – 14:15	F5-2	Guidance	Work around for Taxi Route Syntax	

Remarks:

RWY 06 / 24 used as active RWY.
RWY 13 / 31 closed due to construction work.

5.3 Results

5.3.1 Surveillance Accuracy and Timeliness

Calculation methods:

The 90% position accuracy, RPA, is given as follows:
For each position report calculate the error in the X position, Δx, and in the Y position, Δy.

Δx = (true X position - reported X position) in meters
Δy = (true Y position - reported Y position) in meters

mean deviation X, $m_x = 1/n \sum \Delta x_i$ = Pmx
mean deviation Y, $m_y = 1/n \sum \Delta y_i$ = Pmy
quadratic X, $q_x = 1/n \sum (\Delta x_i)^2$ = Pqx
quadratic Y, $q_y = 1/n \sum (\Delta y_i)^2$ = Pqy

n = Num

$$RMS_X = \sqrt{(q_x - m_x^2)} \qquad = Psigx$$

$$RMS_y = \sqrt{(q_y - m_y^2)} \qquad = Psigy$$

$$Rx = C \bullet RMS_X + ABS(m_x) \quad = PRx \quad \text{with} \quad C = 1.645 \quad (\text{for } 90\%)$$
$$Ry = C \bullet RMS_y + ABS(m_y) \quad = PRy \quad \text{with} \quad C = 1.645 \quad (\text{for } 90\%)$$

$$RPA = \sqrt{(Rx^2 + Ry^2)}$$

The 90% velocity accuracy, RVA, is given as follows:
For each position report calculate the error in the X position, Δvx, and in the Y position, Δvy.

Δvx = (true X velocity - reported X velocity) in m/s
Δvy = (true Y veloctity - reported Y velocity) in m/s

mean deviation X, $mv_x = 1/n \sum \Delta vx_i$ = Pmvx
mean deviation Y, $mv_y = 1/n \sum \Delta vy_i$ = Pmvy
quadratic X, $qv_x = 1/n \sum (\Delta vx_i)^2$ = Pqvx
quadratic Y, $qv_y = 1/n \sum (\Delta vy_i)^2$ = Pqvy

n = Num

$$RMSv_X = \sqrt{(qv_x - mv_x^2)} \qquad = Psigvx$$

$$RMSv_y = \sqrt{(qv_y - mv_y^2)} \qquad = Psigvy$$

$$Rvx = C \bullet RMSv_X + ABS(mv_x) \quad = PRvx \quad \text{with} \quad C = 1.645 \quad (\text{for } 90\%)$$
$$Rvy = C \bullet RMSv_y + ABS(mv_y) \quad = PRvy \quad \text{with} \quad C = 1.645 \quad (\text{for } 90\%)$$

$$RVA = \sqrt{(Rvx^2 + Rvy^2)}$$

The reference position (true position):
The reference position is given by the GP&C system. Due to the antenna replacement to a new position (at the NRN master station) a position offset of the new planned antenna position has to be calculated.

The calculation of the reference position is given by:

true X position = GP&C reported X position + X-Offset
true Y position = GP&C reported Y position + Y-Offset

The offset is given by:

X-Offset = plus 6,0 meter
Y-Offset = minus 2,0 meter

5.3.1.1 SDS and NRN Surveillance Accuracy, F1A, 2002-05-21

Test Protocol:
F1A, 2002-05-21

Staff:
Alan Gilbert (PAS)
Kurt Klein (DLR)
Klaus Werner (DLR)
Hans Peter Zenz (DLR)
Peter Horn (DLR)

Test Vehicle:
Test Van, DAZZZ (DLR)

Test Scenario:
The Test Van operates on RWY-24 and TWY-A-B.

Data Recording:
ASCS data was not transmitted by ERA.
Only GP&C and NRN data available.
CATS File: 20020521-02.CSC. (GP&C)
SDF Logger: TT-20020521-140723-sdf.log (NRN)
PAS Logger: 0205211430.cpt

5.3.1.2 NRN-Surveillance Accuracy, F1A, 2002-05-21

Results:
The 90% position accuracy is calculated to:
RPA = 8,6 meter and RVA = 2,8 m/s
This is calculated by 968 position reports with the GP&C as reference system

Calculations:
Transformation with Program CATS-ZW1.EXE
File 20020521-02.CSC -> 20020521.02.ASCII
EXCEL:
20020521-F1A-NRN-DAT.XLS
TT-20020521-140723-sdf.xls
TT-20020521-140723-sdf-z.xls

The Position Accuracy, RPA, is calculated with:

Num	Pmx	RMSx	Rx 90%	Pmy	RMSy	Ry 90%	RPA 90%
968	-0,7	3,2	6,1	-1,3	2,9	6,1	8,6

The 90% accuracy RPA = 8,6 meter.

The Velocity Accuracy, RVA, is calculated with:

Num	Pmvx	RMSvx	Rvx 90%	Pmvy	RMSvy	Rvy 90%	RVA 90%
968	0,0	1,1	1,8	-0,1	1,3	2,2	2,8

The 90% accuracy RVA = 2,8 m/s

The Figure 5-1 shows the track of the Test Van on RWY-06 and on TWY-B and TWY-A. The red line is the track detected by the NRN system and shows the coverage volume, CV, of the system.

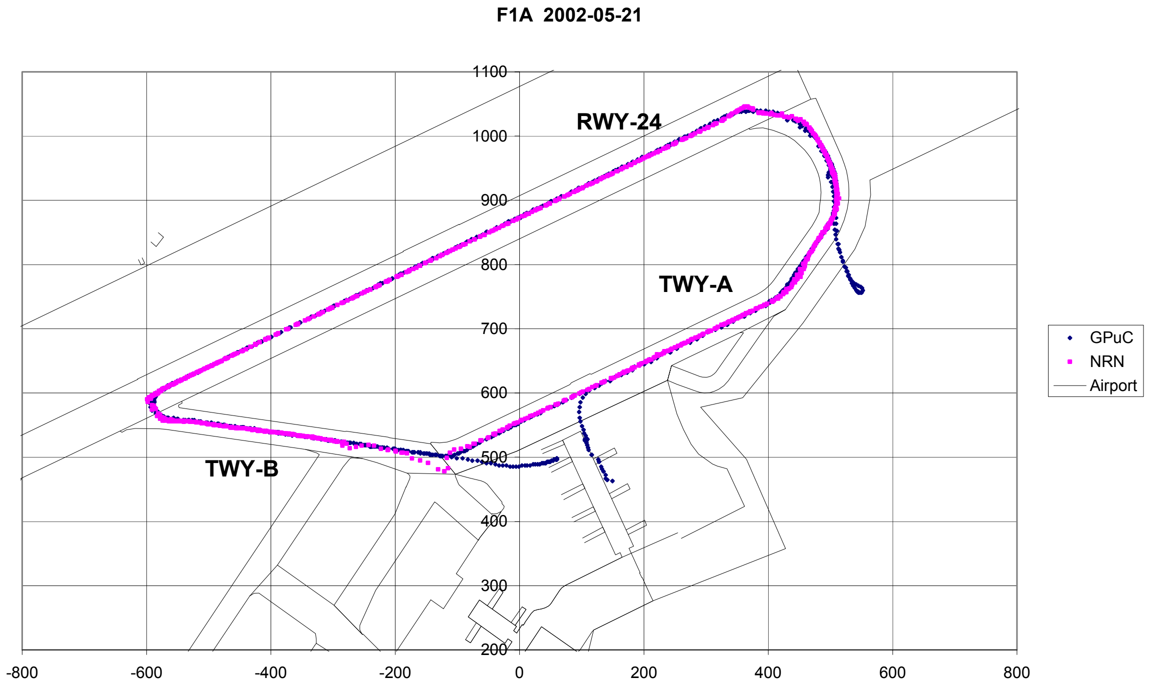

Figure 5-1: XY Plot of GP&C and NRN from F1A-2002-05-21

The Figure 5-2 shows the x position over time of the NRN and GP&C system. The gab from 1500 sec to 2500 sec indicates the test interrupt due to airport traffic. The test run starts at 14:16 UTC with displayed test time t=0 sec at the following figures.

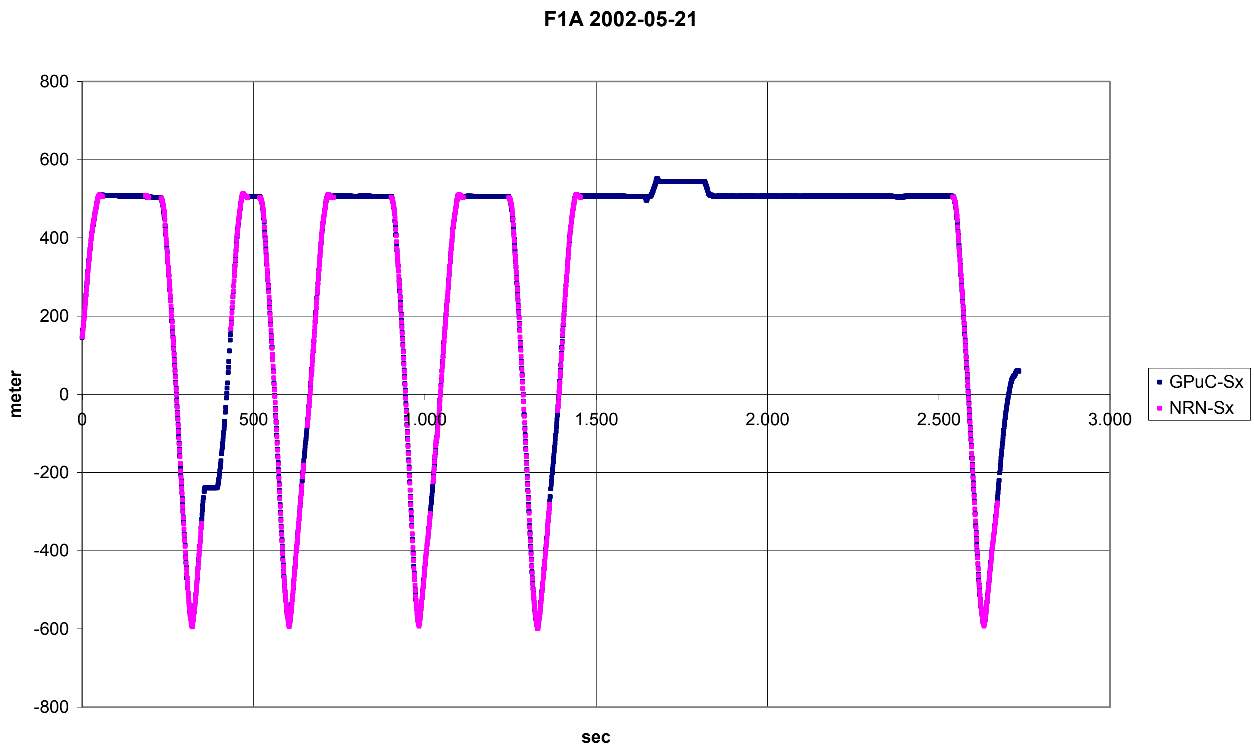

Figure 5-2: X Plot as function of time of GP&C and NRN from F1A-2002-05-21

The Figure 5-3 shows the position error, difference from GP&C to NRN system, over time.

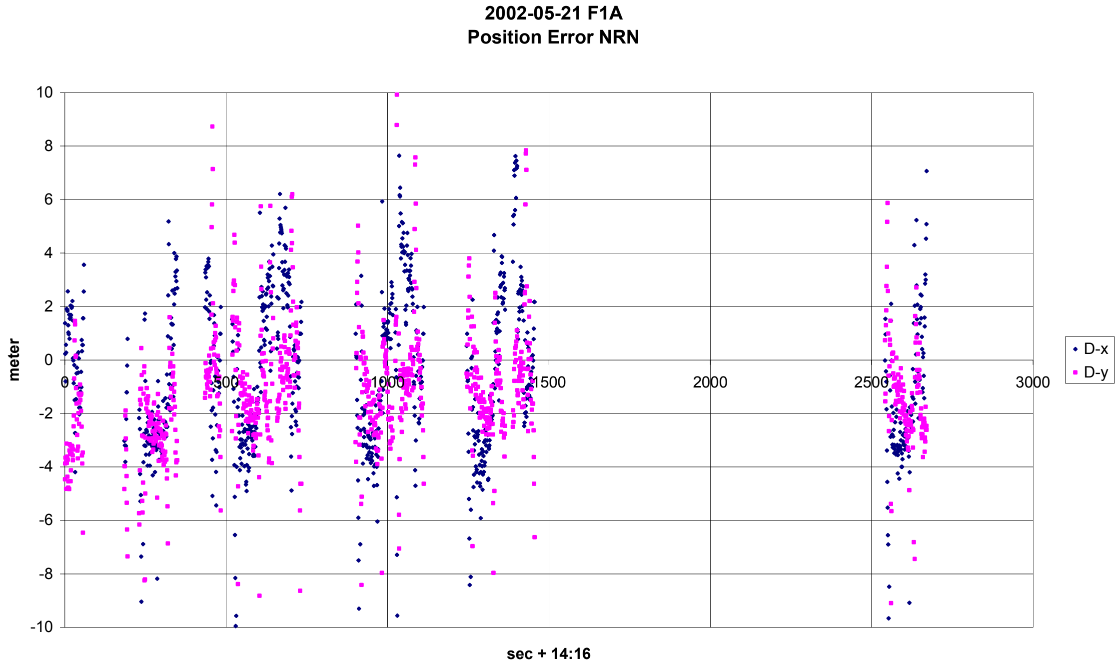

Figure 5-3: The NRN position error from F1A-2002-05-21

Figure 5-4 shows the velocity error, difference from GP&C to NRN system, over time.

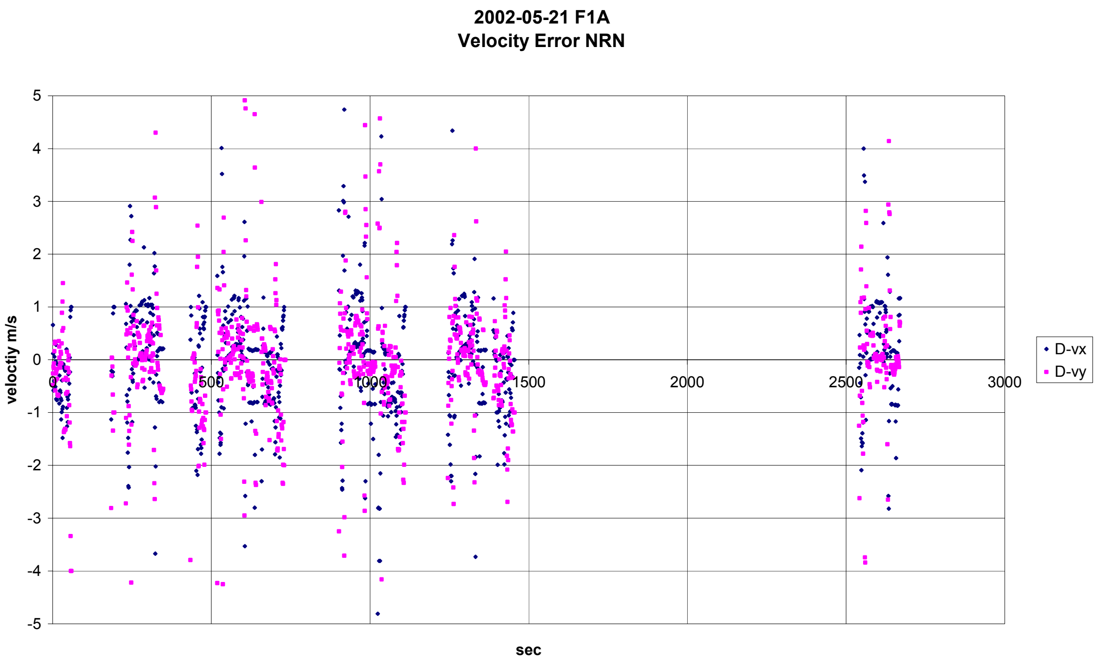

Figure 5-4 The NRN velocity error from F1A-2002-05-21

5.3.1.3 SDS- Surveillance Accuracy, F1A, 2002-05-21

Results:

The 90% position accuracy is calculated to:
RPA = 12,1 meter and RVA = 3,3 m/s only during movements.

(RPA = 7,2 meter and RVA = 1,4 m/s over the complete test run)
This is calculated by 819 (4384) position reports with the GP&C as reference system.
The test duration was 1797 sec. 2587 of 4384 position reports are multiple transmitted with different positions.

Calculations:
Transformation with Program CATS-ZW1.EXE
File 20020521-02.CSC -> 20020521.02.ASCII
EXCEL:
0205211430-CPT.XLS
20020521-F1A-SDS-DAT.XLS
20020521-F1A-SDS-DAT-V0.XLS

In fact of stops for a long time the accuracy is calculated twice. First for the complete test run and second only if the car was moving.

a) Over the complete test run.
The Position Accuracy, RPA, is calculated with:

Num	Pmx	RMSx	Rx 90%	Pmy	RMSy	Ry 90%	RPA 90%
4384	-1,2	2,7	5,6	-0,5	2,5	4,6	7,2

The 90% accuracy RPA = 7,2 meter.

The Velocity Accuracy, RVA, is calculated with:

Num	Pmvx	RMSvx	Rvx 90%	Pmvy	RMSvy	Rvy 90%	RVA 90%
4384	0,0	0,6	1,0	0,0	0,6	1,0	1,4

The 90% accuracy RVA = 1,4 m/s

b) Only if the velocity is nor equal 0.
The Position Accuracy, RPA, for v >< 0 is calculated with:

Num	Pmx	RMSx	Rx 90%	Pmy	RMSy	Ry 90%	RPA 90%
819	-0,1	5,6	9,3	-0,1	4,6	7,7	12,1

The 90% accuracy during movement RPA =12,1 meter.

The Velocity Accuracy, RVA, for v>< 0 is calculated with:

Num	Pmvx	RMSvx	Rvx 90%	Pmvy	RMSvy	Rvy 90%	RVA 90%
819	-0,1	1,4	2,4	0,1	1,3	2,3	3,3

The 90% accuracy during movement RVA = 3,3 m/s

Figure 5-5 shows the position error of the SDS. The SDS test starts at 843 sec and includes only two circles, the stop from 1500 sec to 2500 sec, and the last circles. The SDS logfile starts 843 sec and ends at 2640 sec and has a test duration of 1797 sec. Within this time 4384 position reports from the SDS are received. This means 2587 position reports are multiple transmitted with different positions.

Figure 5-6 shows the velocity error of the SDS. It shows the long time of no moving. While the target is moving the velocity and the position error increases.
For measuring the error only the part of moving should be used with RPA = 12 m and RVA = 3,3 m/s.

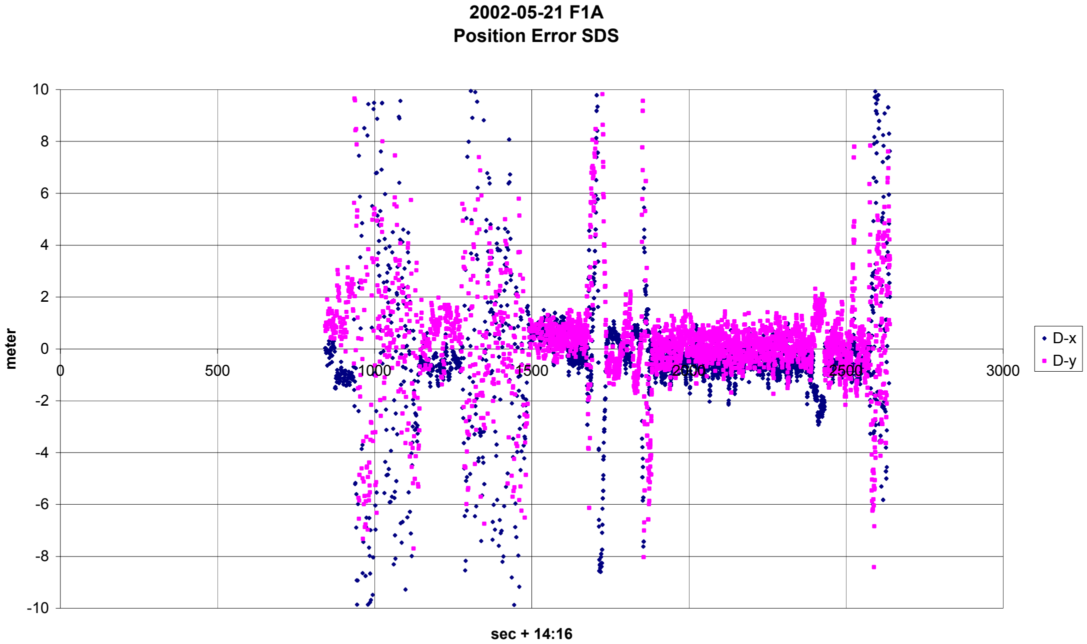

Figure 5-5 The SDS position error from F1A-2002-05-21

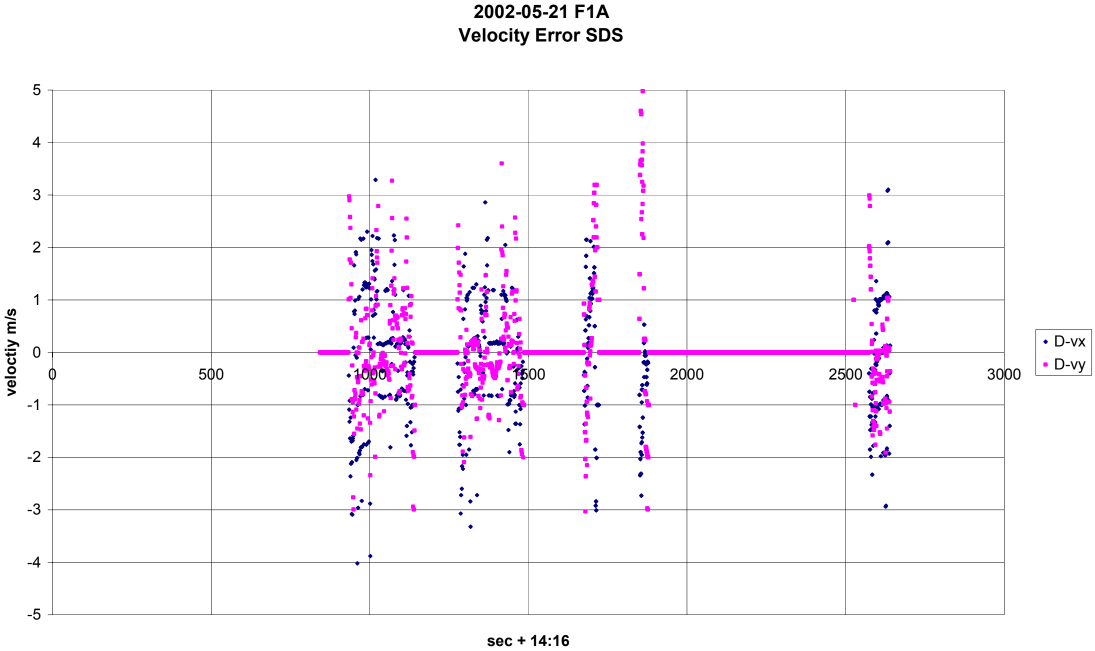

Figure 5-6 The SDS velocity error from F1A-2002-05-21

5.3.1.4 SDS-Surveillance, F1B, 2002-05-21

Test Protocol:

F1B, 2002-05-21

Staff:
Alan Gilbert (PAS)
Kurt Klein (DLR)
Klaus Werner (DLR)
Hans Peter Zenz (DLR)
Peter Horn (DLR)

Test Vehicle:
Test Van, DAZZZ (DLR)

Test Scenario:
The Test Van operates at all TWY' s and RWY' s and stops at all stop bars.

Data Recording:
ASCS data was not transmitted by ERA.
Only GP&C data available.
CATS File: 20020521-03.CSC.
SDF Logger: TT-20020521-150548-sdf.log
PAS Logger: 0205211500.CPT
PAS Logger: 0205211530.CPT

Result:
The GPS failed under the terminal at 15:07 for about 3 sec.
The 90% SDS position accuracy, RPA, is given with 20,7 m and
the 90% SDS velocity accuracy is given with 2,8 m/s. The test duration was 3250 sec.
3145 of 6395 position report are transmitted multiple with different position.

Calculation:
Transformation with Program CATS-ZW1.EXE
File 20020521-03.CSC ➔ 20020521-03.ASCII.
EXEL
20020521-F1A-SDS-DAT.XLS
20020521-F1A-SDS-DAT-V0.XLS
TT-20020521-150548-sdf.XLS
TT-20020521-150548-sdf.ASCII and 20020521-03.ASCII.

The Position Accuracy, RPA, is calculated with:

Num	Pmx	RMSx	Rx 90%	Pmy	RMSy	Ry 90%	RPA 90%
6395	-0,1	10,6	17,5	0,1	6,7	11,1	20,7

The 90% accuracy RPA = 20,7 meter.

The Velocity Accuracy, RVA, is calculated with:

Num	Pmvx	RMSvx	Rvx 90%	Pmvy	RMSvy	Rvy 90%	RVA 90%
6395	0,0	1,3	2,2	0,0	1,1	1,8	2,8

The 90% accuracy RVA = 2,8 m/s

Figure 5-7 shows the track during this test run. The GPS failed under the terminal about 3 sec.

Figure 5-8 shows the position over time. The test duration was 3250 sec. In this time 6395 position reports are received from the SDS. This means 3145 position report are transmitted multiple with different position.

Figure 5-9 shows the position error and

Figure 5-10 shows the velocity error over time.

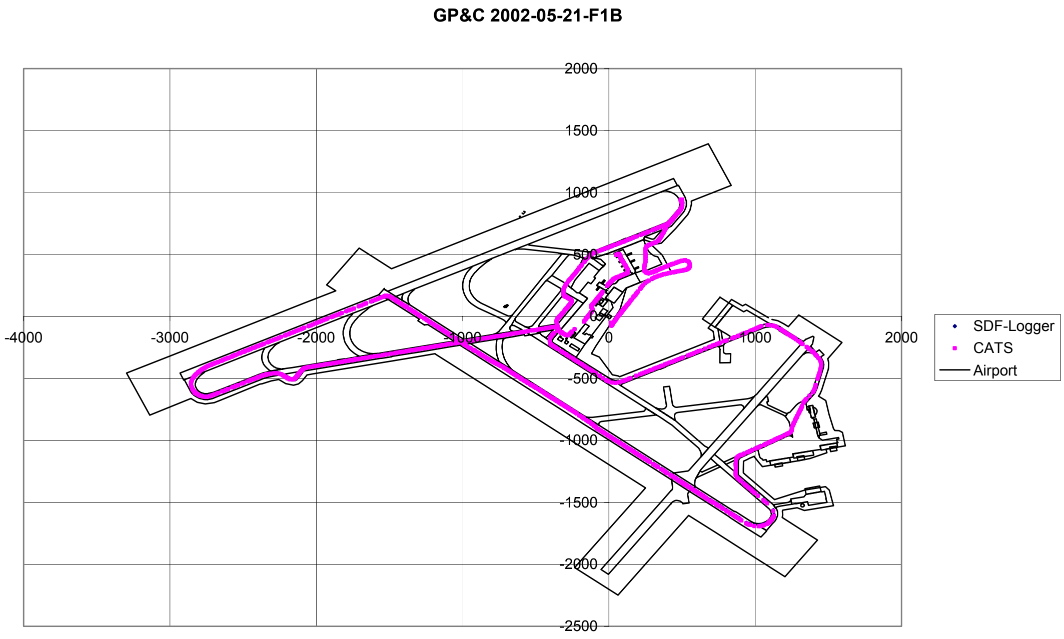

Figure 5-7: XY Plot of GP&C from F1B-2002-05-21

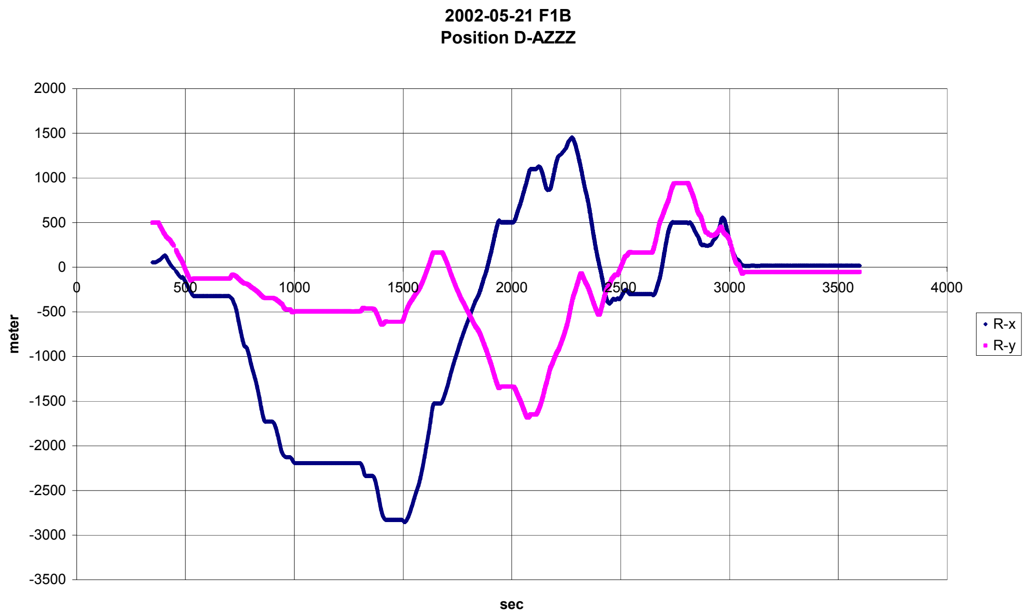

Figure 5-8: Sx/Sy = f(t) Plot of GP&C from F1B-2002-05-21

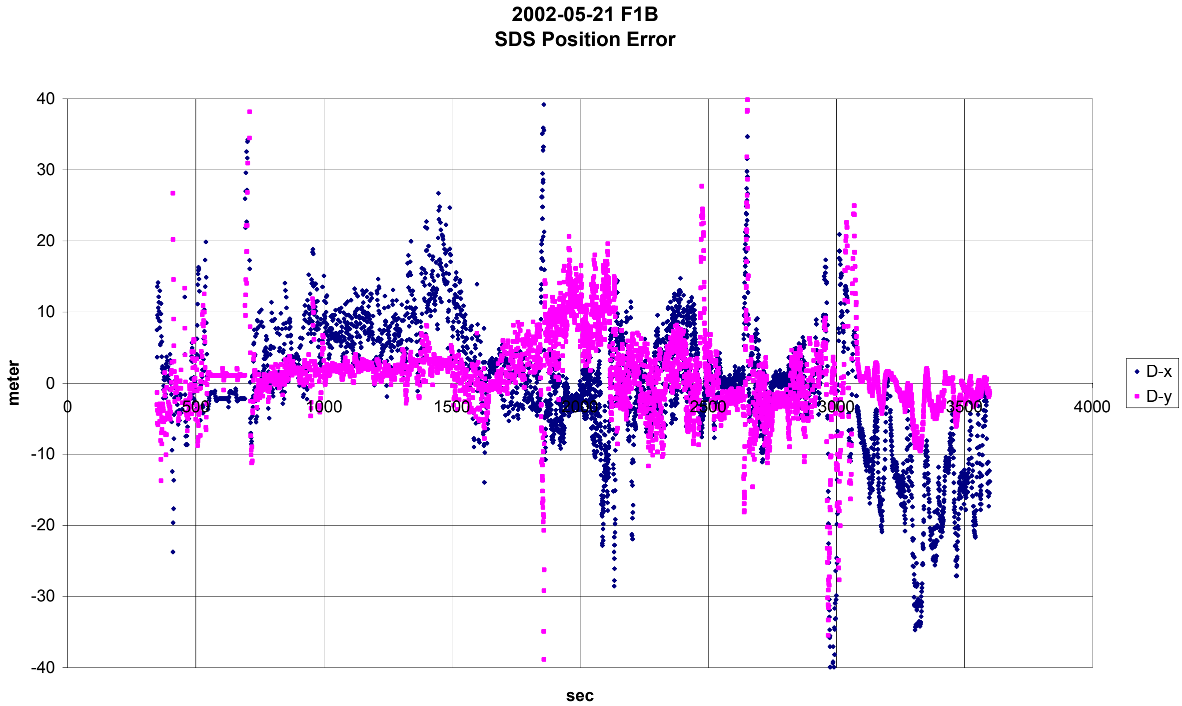

Figure 5-9 SDS position error from F1B-2002-05-21

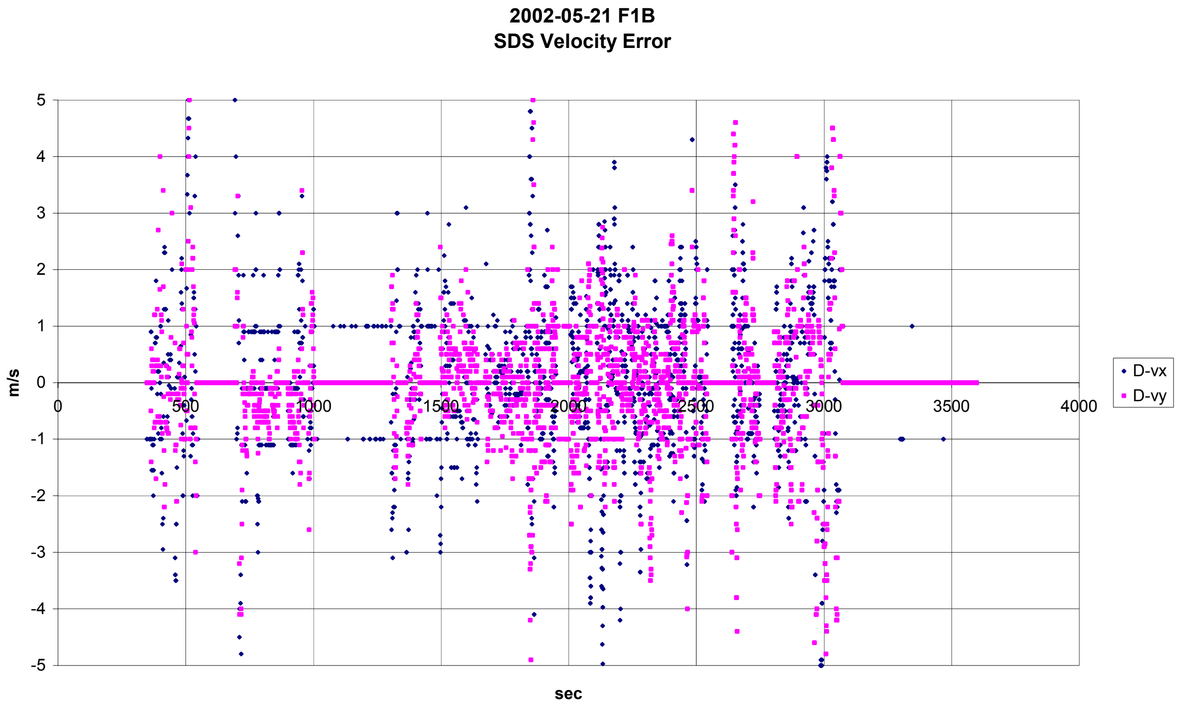

Figure 5-10 SDS velocity error from F1B-2002-05-21

5.3.1.5 CWP latency TRL, F1D, 2002-05-22

Test Protocol:
F1D, 2002-05-22

Staff:
Alan Gilbert (PAS)
Kurt Klein (DLR)
Klaus Werner (DLR)
Hans Peter Zenz (DLR)

Test Vehicle:
FOLLOW1 (ANS)

Test Scenario:
The test car, FOLLOW1, proceeds with constant speed on RWY-13/31 crossing TWY-F. The intersection, RWY-13/31 to TWY-F, is well seen from the window at the TWR and is marked on the CWP.
The CWP latency is measured
from crossing the TWY-F in reality
to crossing the TWY shown at the CWP.
This will be repeated for 11 times.

Data Recording:
CATS File: 20020522-01.CSC.

Results:
Measuring the Latency at the CWP < 0.2 sec.
The measured time seems to be the reaction time of the observer by pushing the start / stop button at the stopwatch.

5.3.1.6 SDS-Surveillance Dynamic Test, F1C, 2002-05-22

Test Protocol:
F1C, 2002-05-22

Staff:
Alan Gilbert (PAS)
Kurt Klein (DLR)
Klaus Werner (DLR)
Hans Peter Zenz (DLR)

Test Vehicle:
Test car, FOLLOW1 (ANS)

Test Scenario:
The test car FOLLOWS1 was proceeding at the apron on TWY G-J-K-C and TWY G-J-H-C.

Data Recording:

CATS File:	20020522-02.CSC	(GP&C)
GP&C-Logger:	BT-20020522-081357-GPC.log	(GP&C)
SDF-Logger:	TT-20020522-081340-sdf.log	(GP&C)
SDF-Logger:	TT-20020522-081346-sdf.log	(ASCS)
PAS Logger:	0205220800.CPT	
PAS Logger:	0205220830.CPT	

Calculations:

EXCEL:

TT-20020522-081340-SDF-ASCII.XLS

0205220800-CPT.XLS

Figure 5-11 shows the GP&C track of the test run and

Figure 5-12 shows the corresponding SDS track of the test run.

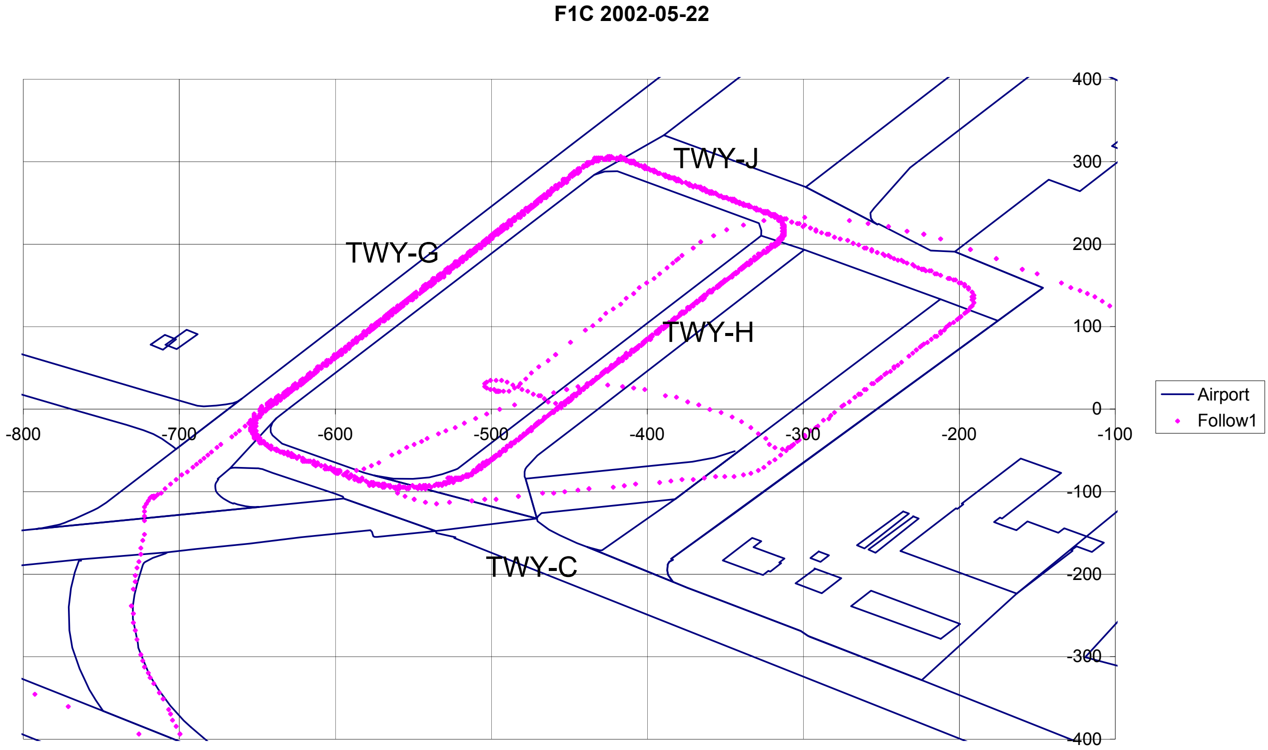

Figure 5-11: XY Plot of GP&C from F1C 2002-05-22

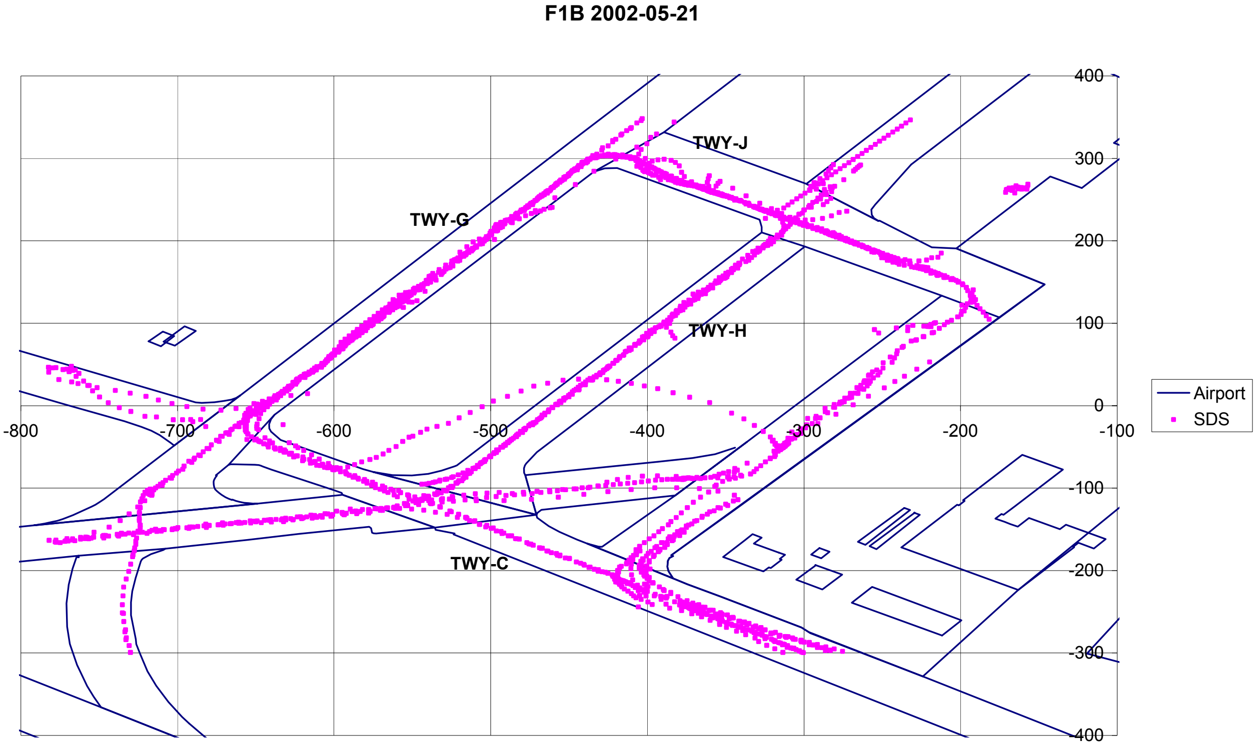

Figure 5-12 XY Plot of SDS from F1C 2002-05-22

5.3.2 Surveillance System Reliability

5.3.2.1 Surveillance Monitoring, F2, 2002-05-22

Test Protocol:

Observer Note: F2-a, observer Kurt Klein (DLR).
Observer Note: F2-b, observer H. Peter Zenz (DLR).

Staff:

Alan Gilbert (PAS)
Kurt Klein (DLR)
Hans Peter Zenz (DLR)

Test Scenario:

No specific scenery. The actual traffic was observed.

Data Recording:

No data recording.

Results:

Departing a/c.
All a/c are detected. Identification for all a/c after switched on the Mode-S system, in general prior before take off.
Arriving a/c:

All a/c are detected and identified. The identification was not lost after switching off the Mode-S or SSR system. The systems switched off normally after landing.

Continues track and false detection and identification:
Small a/c (< 2,5 t take off weight) are lost or indicated as two targets after landing with false identification.

5.3.3 Alert Performance Parameter

5.3.3.1 Alert Test, F3A-1/2/3 and F3D 2002-05-22 and 23

Testing Alert Performance Parameter, Runway Incursion F3A and Route Deviation F3D

- **F3A-1, RWY Incursion Alert, 2002-05-22**

Test Protocol:
F3A-1, 2002-05-22

Staff:
Alan Gilbert (PAS)
Kurt Klein (DLR)
H. Peter Zenz (DLR)

Test Vehicle:
FOLLOW1 (ANS)

Test Scenario and Test Configuration:
Test car, FOLLOW1, is located at CAT-I Holding Position RWY-06 on TWY-D.
The BETA system is configured for low visibility CAT-III conditions.

Data recording:
No data recording.

Results:
All landing and departing a/c on RWY24 generates an alarm.

- **F3A-2, RWY Incursion Alert, 2002-05-23**

Test Protocol:
F3A-2 / F4-ARR-1, 2002-05-23

Staff:
Alan Gilbert (PAS)
Kurt Klein (DLR)
H. Peter Zenz (DLR)

Test Scenario and Test Configuration:
No specific scenery. The actual traffic is observed while the BETA system is configured for low visibility CAT-III conditions.

Data recording:
No data recording.

Results:
All real alarm conflicts are shown on the CWP screen.

- **F3A-3, RWY Incursion Alert, 2002-05-23**

Test Protocol:
F3A-3 / F4-ARR-2, 2002-05-23

Staff:
Alan Gilbert (PAS)
Kurt Klein (DLR)
H. Peter Zenz (DLR)

Test Vehicle:
CSL1 (CSL)

Test Scenario and Test Configuration:
Test car CSL1 is located at CAT-I Holding Position RWY-06 on RWY-31.
The BETA system is configured for low visibility CAT-III conditions.

Data recording:
No data recording.

Results:
All landing and departing a/c on RWY24 generates an alarm.

5.3.3.2 Alert Test, F3C-1/2, 2002-05-22

Test Protocol:
F3C-1, 2002-05-22
F3C-2, 2002-05-22

Staff:
Alan Gilbert (PAS)
Kurt Klein (DLR)
H. Peter Zenz (DLR)

Test Vehicle:
FOLLOW1 (ANS)

Test Scenario and Test Configuration:
Definition of a Stop Bar at TWY-B Holding Point RWY24 CATIII position.
The test car is crossing the stop bar and generates an alarm.

Data Recording:
CATS File: 20020522-05.CSC (GP&C)

Results:
All stop bar crossings generates an alarm. The Alert Response Time was measured with ART < 1 sec.

5.3.3.3 F3D-1, Route Deviation Alert, 2002-05-22

Test Protocol:

No specific procedure and protocol. The Route Deviation Alert was observed during the Surveillance System Reliability test, F2.
Observer Note: F2-a, observer Kurt Klein (DLR).
Observer Note: F2-b, observer H. Peter Zenz (DLR).

Staff:

Alan Gilbert (PAS)
Kurt Klein (DLR)
H. Peter Zenz (DLR)

Test Scenario and Test Configuration:

No specific scenario. The real traffic was observed.

Results:

The taxi route generation was not running properly at this time. For landing a/c a taxi route via RWY 13/31 was generated. In fact of construction work the RWY-13/31 was closed and the a/c was leaving the RWY-06/24 on TWY-B, C and D. For all a/c a route deviation alert was generated. Some false alarm are generated while a/c was leaving on TWY-B in accordance with the given taxi route instruction.

5.3.4 Planning Performance Parameter

EFS Test, F4-ARR and F4-DEP, 2002-05-23

Test Protocol:

F4-ARR-1, 2002-05-23
F4-ARR-2, 2002-05-23
F4-DEP, 2002-05-23

Staff:

Alan Gilbert (PAS)
Kurt Klein (DLR)
H. Peter Zenz (DLR)

Test Scenario and Test Configuration:

No specific scenario. The real traffic was observed.
Testing the completeness of Electronic Flight Strip, EFS.

Results:

All flight plans are available and complete during this test period of about 4 hours. During this period 57 movements are observed.

Ground Plan Server Data Recording:

All automatic and operator operations on flight plans were traced and time-stamped (with a millisecond resolution). The records therefore enable the analysis of both the system performance and the operator behaviour.

groundPlanServer_020523_10:27:34.trc

Typical traces for a creation of a new flight plan are as follows. The trace file extract given below shows:

- the plan creation, and the notification of the creation to all the ground plan data processing server's clients,
- the allocation of a landing runway,
- the raising and notification of an alert concerning the missing runway,
- the computation of an optimal exit point (taking into account the shortest route to the stand),
- the assignment an notification of the route.

```
23/05/2002 10:27:58-625 >4>> Plan created: Plan CSA6175A |mvtType InboundFlight | qfu  |
destinationPark 6 | typeId B734 | ssrCode 3376 | callsign CSA6175 | airlinerId OKWGF |
airlineId  | propulsionMode UnknownPropulsion | wakeTurbulenceClass MediumWTC | colour  |
dataLink  | rnav  | departure LLBG | destination LKPR | terminal  | flrules RuleI | flstatus
InactiveFlight | flType FlightTypeS | flPriority 0 | star  | cta --:-- | eta 10:19 |
taxiDuration 0 min 0 sec  | entryExit  | viaJunctionIds  | bypassJunctionIds  | clrGiven
HoldForClearance | clrConditional FALSE | clrGivenTime --:-- | clrRequested HoldForClearance
| nextPossibleClearances :  LandingClearance - | handovers :  TEC=UnControlled -
GEC=UnControlled - | alerts :  | timeOfLastUpdate 10:27 | remarks  | simFlag FALSE |
 | timeOfStatusLastUpdate 10:27 | timeOfLastShot --:-- | lastClearanceActionIsRequest FALSE
| lastClearanceHasBeenExecuted FALSE | lastEvent unknownEvent | pushBackDelay 0 |
is_associated FALSE | entryExitJunction
23/05/2002 10:27:58-626 >3>> Server GdpsNotified_i::consider_groundPlanCreated
23/05/2002 10:27:58-641 >5>> compute_inboundRoute
23/05/2002 10:27:58-641 >5>> allocate_defaultLandingRunway
23/05/2002 10:27:58-654 >6>> found landing runway R06/24
23/05/2002 10:27:58-669 >6>> allocate default qfu 24
23/05/2002 10:27:58-673 >5>> set_alert 63 for CSA6175A
23/05/2002 10:27:58-673 >6>> alert level 1
23/05/2002 10:27:58-673 >5>> format_alertMessage for alertId 63
23/05/2002 10:27:58-674 >6>> formated alert reason :  Missing runway, default 24 used
23/05/2002 10:27:58-674 >3>> Server GdpsNotifier_i::consider_alertRaised
23/05/2002 10:27:58-922 >6>> Optimal exit junction JR13/31.0/IR06/24:R13/31.0
23/05/2002 10:27:58-991 >4>> route found  minTaxiDuration 2 min 2 sec  averageTaxiDuration 3
min 21 sec  -- areas R13/31.0  IR13/31:TF  TF.1  ITF:TG  TF.2  ITC:TF:TH:TL  TH.1  ITH:TJ
TH.0  ITA:TB:TH  TA  NorthC  6  -- junctions JR13/31.0/IR06/24:R13/31.0  JR13/31.0/IR13/31:TF
JTF.1/IR13/31:TF  JITF:TG/TF.1  JTF.2/ITF:TG  JITC:TF:TH:TL/TF.2  JTH.1/ITC:TF:TH:TL
JITH:TJ/TH.1  JTH.0/ITH:TJ  JTH.0/ITA:TB:TH  JTA/ITA:TB:TH  JNorthC/TA  J6
23/05/2002 10:27:58-997 >4>> Exit point R13/31
23/05/2002 10:27:58-997 >3>> Server GdpsNotifier_i::consider_routeChanged
```

Typical traces for a flight plan update are as follows. The trace file extract given below shows:

- an estimated time of departure update on a plan that was not yet sequenced for departure,
- the re-sequencing and notification of the corresponding new sequence numbers.

```
23/05/2002 10:39:46-415 >3>> change_etd for 10:48 of acId AFL142D
23/05/2002 10:39:46-415 >6>> plan AFL142D found in plan factory
23/05/2002 10:39:46-416 >3>> update_sequence for AFL142D etd 10:48 qfu 24
23/05/2002 10:39:46-416 >6>> not found in sequence acId AFL142D
23/05/2002 10:39:46-417 >6>> shifted to sequence number 3 for acId DLH3265D
23/05/2002 10:39:46-417 >3>> Server GdpsNotifier_i::consider_orderInSequenceChanged
23/05/2002 10:39:46-422 >6>> sequenced runways :
23/05/2002 10:39:46-423 >6>>    QFU 24 sequenced
23/05/2002 10:39:46-423 >6>>     1  acId DLH5253D etd 10:43  seconds 1022143410
23/05/2002 10:39:46-423 >6>>     2  acId AFL142D etd 10:48  seconds 1022143710
23/05/2002 10:39:46-424 >6>>     3  acId DLH3265D etd 10:58  seconds 1022144280
23/05/2002 10:39:46-424 >4>> new order in sequence 2
23/05/2002 10:39:46-424 >4>> new sequence number 2 for acId AFL142D
23/05/2002 10:39:46-424 >3>> Server GdpsNotifier_i::consider_orderInSequenceChanged
```

5.3.5 Guidance Performance Parameter

5.3.5.1 Guidance Test, F5-1, 2002-05-22

Test Protocol:

F5-1, 2002-05-22

Staff:

Klaus Werner (DLR)

Lutz Ehmke (DLR)
H. Peter Zenz (DLR)

Test Scenario and Test Configuration:

Ground system = CWP-Apron for clearance input and request indication.
Onboard system = HMI on board the Test Van, DAZZZ, for request input and clearance and route indication.
A data logger on ground is logging the incoming messages from the onboard system.

Data Recording:

DALICON Logger: BT-20020522-160425-DLK.LOG (Logger on ground station for departure)
DALICON Logger: BT-20020522-162209-DLK.LOG (Logger on ground station for arrival)

Testing departure F5-DEP. Log file = BT-20020522-160425

```
$ED-AZZZ□□ 0LB160556110160119REQ_DEP:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*44□ 16:05:14.19□
$FD-AZZZ□□ 0*04□ 16:05:20.20□
$ED-AZZZ□□ 0LB160624110190000WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*52□ 16:05:42.23□
$FD-AZZZ□□ 0*04□ 16:06:05.97□
$ED-AZZZ□□ 0LB160716110190000WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*52□ 16:06:33.71□
$ED-AZZZ□□ 0LB160748110162120REQ_START_UP:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*2A□ 16:07:05.75□
$FD-AZZZ□□ 0*04□ 16:07:14.26□
$ED-AZZZ□□ 0LB160804110190000WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*5E□ 16:07:22.38□
$ED-AZZZ□□ 0LB160830110163121REQ_PUSH_BACK:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*5A□ 16:07:47.51□
$FD-AZZZ□□ 0*04□ 16:07:52.32□
$ED-AZZZ□□ 0LB160840110190000WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*5E□ 16:07:57.63□
$ED-AZZZ□□ 0LB161102110164122REQ_TAXI:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*39□ 16:10:19.93□
$FD-AZZZ□□ 0*04□ 16:10:27.75□
$ED-AZZZ□□ 0LB161121110190000WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*51□ 16:10:38.65□
$ED-AZZZ□□ 0LB161201110166123REQ_LINE_UP:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*4A□ 16:11:19.11□
$FD-AZZZ□□ 0*04□ 16:11:25.73□
$ED-AZZZ□□ 0LB161216110190000WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*56□ 16:11:33.94□
$ED-AZZZ□□ 0LB161228110167124READY_FOR_TAKE_OFF:□□□□□□□□□□□□□□□□□□□□□□□□□□□*31□ 16:11:45.85□
$FD-AZZZ□□ 0*04□ 16:11:48.96□
$ED-AZZZ□□ 0LB161246110190000WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*53□ 16:12:04.28□
```

Testing arrival F5-ARR. Log file = BT-20020522-162209

```
$ED-AZZZ□□ 0LB162459110170125REQ_LAND:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*30□ 16:24:17.50□
$F--------4*72□ 16:26:09.97□
$ED-AZZZ□□ 0LB162930110170126REQ_LAND:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*31□ 16:28:48.78□
$FD-AZZZ□□ 0*04□ 16:28:56.00□
$ED-AZZZ□□ 0LB162950110190002WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*5E□ 16:29:08.42□
$ED-AZZZ□□ 0LB163000110164127REQ_TAXI:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*3D□ 16:29:18.54□
$FD-AZZZ□□ 0*04□ 16:29:23.34□
$ED-AZZZ□□ 0LB163015110190002WILCO:□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□*57□ 16:29:32.95□
```

Results:

- CDRT, Clearance Delivery Response Time measured with < 15 sec.
  Time from CWP-Apron delivery to receiving system acknowledge from onboard system.
- GACT, Guidance Aid confirmation Time measured with < 30 sec.
  Time from CWP-Apron delivery to receiving system acknowledge from onboard operator.

- Format descriptors tested:
  The Table 5-3 based on Table 7-8, Format Descriptors and Command Keywords DOCID "D08AI-SID-10.DOC"
  All format in Table 5-3 are tested. All other formats are not available by the CWP.

Format	Type of Message	Comment or Command Keyword	Tested
30	Departure clearance	DEP	OK
32	Start-up clearance	START_UP	OK

Format	Type of Message	Comment or Command Keyword	Tested
33	Pushback clearance	PUSH_BACK	OK
34	Taxi clearance	TAXI	Failed
36	Line-up clearance	LINE_UP	OK
37	Take-off clearance	TAKE_OFF	OK
40	Landing clearance	LAND	OK
60	Departure clearance request	REQ_DEP	OK
62	Start-up clearance request	REQ_START_UP	OK
63	Pushback clearance request	REQ_PUSH_BACK	OK
64	Taxi clearance request	REQ_TAXI	OK
67	Ready for Departure (indirect Take-off request)	REQ_TAKE_OFF	OK
70	Landing clearance request	REQ_LAND	OK
90	Affirm and Will Do	WILCO	OK

Table 5-3: Descriptor tested

- Taxi Route Transmission
  The transmitted taxi route is not conform with the specification in "D08AI-SID-10.DOC".

Specified	Given by the CWP
Taxi clearance and hold instruction TAXI_P_L_F//HOLD_RWY31:	TAXI_P_L_F:
Taxi clearance and park clearance TAXI_C_L_P//PARK_B12:	TAXI_C_L_P:

The destination //HOLD_RWY31 or //PARK_B12 is still missing In the CWP given Taxi Route Instruction.

For the Operational Test a **work around** was made by the DLR. In this work around the missing destination will added by the onboard HMI. To operate the guidance operations with the CWP a fixed RWY or parking position has to be used.

5.3.5.2 Guidance Test, F5-2, 2002-05-23

Test Protocol:
F5-2, 2002-05-23

Staff:
Klaus Werner (DLR)
Lutz Ehmke (DLR)
H. Peter Zenz (DLR)

Test Scenario and Test Configuration:
Ground system = CWP-Apron for clearance input and request indication.
Onboard system = HMI on board the Test Van, DAZZZ, for request input and clearance and route indication.
A data logger on ground and a second logger at the Test Van is logging the incoming messages. At the onboard HMI the work around for the taxi route was implemented.

Data Recording:
DALICON Logger: BT-20020523-135535-DLK.LOG (Logger on ground station)

DALICON Logger: BT-20020523-135648-DLK.LOG (Logger on Test Van, D-AZZZ)

Results:

The logged data are shown in Table 8-16. All transmitted data are received properly. The Taxi Route was indicated at the onboard HMI in a correct way. The work around was tested in a first way and must be completed for the operational tests.

6. Operational Tests

6.1 Participants

A total of six ANS-CR controllers and four CSA pilots participated in the BETA operational test trials. All participants were male. The table below outlines the sample size in a social-demographical way.

Subject	Age	Sex	Native Language	Current Employer	Trained as	Year of Training	Professional Experience (year)	Licence	Computer experience	Weekly time spent with computer (hours)
C1	48	male	Czech	ANS-CR	ATC	2	22	APP+TWR	10	5
C2	35	male	Czech	ANS-CR	ATC	1	8	APP+TWR	9	6
C3	34	male	Czech	ANS-CR	ATC	2	8	APP+TWR	11	8
C4	35	male	Czech	ANS-CR	ATC	2	5	APP+TWR	7	3
C5	30	male	Czech	ANS-CR	ATC	2	7	APP+TWR	9	14
C6	35	male	Czech	ANS-CR	ATC	2	7	APP+TWR	7	n.k.
P1	42	male	Czech	CSA	Pilot	n.k.	12	n.k.	n.k.	n.k.
P2	30	male	English	CSA	Pilot	n.k.	12	n.k.	n.k.	n.k.
P3	n.k.	male	Czech	CSA	Pilot	n.k.	n.k.	n.k.	n.k.	n.k.
P4	n.k.	male	Czech	CSA	Pilot	n.k.	n.k.	n.k.	n.k.	n.k.
C = Controller P = Pilot n.k. = Not known										

Table 6-1: Social-Demographic Data of the Test Subjects

6.2 Times of Testing and Traffic Amount

The following table (Table 6-2) outlines the times when the BETA and Baseline test runs were conducted and provides information about the associated traffic amount. Six BETA controllers participated in the operational test trials whereas they run through three different Control Positions (CEC, GEC, TEC).

In total 482 flights were handled by the BETA controllers under BETA operational procedures by an average traffic density of 21,5 flights per hour. The total operational test time in the BETA test condition amounts to 22,8 hours (1368 min), including the baseline test condition 40,3 hours (2418 min).

Control Position	Controller (index number)	BETA / Baseline	Date	Start Time (UTC)	End Time (UTC)	Total Test Time (min)	No. of Arrivals	No. of Departures	Total Amount of Traffic	Movements per hour
CEC	1	BETA	05-29	13:40	15:12	92	14	12	26	17
		Baseline	06-19	17:00	18:00	60	7	9	16	16
	2	BETA	05-30	10:02	11:02	60	10	22	32	32
		Baseline	06-24	16:00	17:00	60	6	12	18	18
	3	BETA	05-30	07:55	09:02	67	19	13	32	29
		Baseline	06-17	18:01	18:33	32	4	8	12	23
	4	BETA	05-29 06-05	09:30 09:32	10:45 10:28	131	16	37	53	24
		Baseline	06-26	08:00	09:00	60	14	12	26	26
	5	BETA	05-29	07:54	09:30	96	23	13	36	23
		Baseline	06-18	08:00	09:00	60	13	11	24	24
	6	BETA	06-06	07:35	08:54	79	22	15	37	28
		Baseline	06-24	08:00	09:00	60	15	10	25	25
GEC	1	BETA	06-06	13:03	14:08	65	12	5	17	16
		Baseline	06-19	11:57	12:55	58	1	6	7	7
	2	BETA	06-07	09:38	10:34	56	12	15	27	29
		Baseline	06-24	10:00	11:00	60	6	17	23	23
	3	BETA	06-04 06-05	13:09 12:38	14:15 13:59	66 81	25	8	33	13
		Baseline	06-17	16:56	18:01	65	7	13	20	18
	4	BETA	06-04	10:12	11:13	61	5	19	24	24
		Baseline	06-26	07:00	08:00	60	14	6	20	20
	5	BETA	06-03	12:06	13:30	84	5	5	10	7
		Baseline	06-18	09:05	09:59	54	15	9	24	27
	6	BETA	06-03	13:30	14:34	64	20	8	28	26
		Baseline	06-24	07:00	08:00	60	12	11	23	23
TEC	1	BETA	06-06	10:19	11:19	60	2	16	18	16
		Baseline	06-19	14:00	15:00	60	12	7	19	19
	2	BETA	05-28	13:28	14:03	35	7	3	10	17
		Baseline	06-24	08:00	09:00	60	15	10	25	25
	3	BETA	05-30	12:55	13:58	63	10	8	18	17
		Baseline	06-17	14:56	15:57	61	13	13	26	26
	4	BETA	05-28	09:40	10:45	65	9	18	27	25
		Baseline	06-26	11:00	12:00	60	5	9	14	14
	5	BETA	06-05	07:08 08:07	07:42 08:52	34 45	21	15	36	27
		Baseline	06-18	11:00	12:00	60	4	16	20	20
	6	BETA	06-04	07:03	08:07	64	11	7	18	17
		Baseline	06-24	11:00	12:00	60	2	14	16	16
BETA			**Sum:**			**1368**	**243**	**239**	**482**	**-**
			Mean (per test run):			**76**	**13,5**	**13,2**	**26,8**	**21,5**
BASELINE			**Sum:**			**1050**	**165**	**193**	**358**	**-**
			Mean (per test run):			**58**	**9,1**	**10,8**	**19,8**	**20,5**
TOTAL			**Sum:**			**2418**	**408**	**432**	**840**	**-**
			Mean (per test run):			**67**	**11,3**	**12,0**	**23,3**	**21,0**

Table 6-2: Test Times and Traffic Amount for all Test Runs

6.3 Results

In this section all operational raw data and results are reported. This includes objective as well subjective quantitative data and also qualitative data in terms of comments of the controllers and pilots. The results are listed in relation to the four main benefit criteria: Safety, Efficiency, Working Conditions, and Environmental Impacts (compare [5] p. 40)

6.3.1 Safety

6.3.1.1 Situation Awareness

Situation Awareness (SA) was measured by operators' subjective ratings in a post run questionnaire (SART) after each test run; BETA as well in the baseline phase. SART provides multi-dimensional SA rating scales. There are three primary SART rating dimensions, namely *Demand on attention resources (D)*, *Supply of attention resources (S)*, and *Understanding (U)*. In this tests phase II the 14-item SART version was used, comprising 4 items that relates to (D), 5 to (S), and 5 to (U), plus an item that simply rates SA. Rating scores were obtained by a seven point Likert scale reaching from 1 (low) to 7 (high). A unitary SA index was obtained by combining the dimension rating means, using the following simple algorithm:

14-item SART: $SA = \Gamma U/N_u - (\Gamma D/N_u - \Gamma S/N_u)$, or more uncomplicated:
SA = Understanding – Demand + Supply.

From there, the SART index comprises a range of –5 (min) to + 13 (max), whereas 4 correspond to a medium level of SA. In Table 5-1 all raw data including the D, S, and U scores, as well the overall SART index are put together.

BETA / Baseline	Position	Controller index	Items				Ø	Items					Ø	Items					Ø	Ø
			D1	D2	D3	D4	D	S1	S2	S3	S4	S5	S	U1	U2	U3	U4	U5	U	SA index
BETA	CEC	1	3	3	3	2	2,75	3	4	4	3	2	3,2	7	6	5	6	6	6,0	6,45
		2	4	4	3	4	3,75	3	3	5	4	3	3,6	6	6	5	6	5	5,6	5,45
		3	2	2	2	1	1,75	3	3	3	4	3	3,2	6	6	6	5	6	5,8	7,25
		4	2	2	5	2	2,75	2	2	3	4	2	2,6	5	5	5	6	5	5,2	5,05
		5	2	2	1	2	1,75	3	5	2	3	5	3,6	6	6	5	6	7	6,0	7,85
		6	4	3	2	4	3,25	5	5	6	5	4	5,0	6	5	5	6	6	5,6	7,35
	GEC	1	2	1	2	2	1,75	3	3	3	4	3	3,2	6	6	6	6	5	5,8	7,25
		2	4	4	5	4	4,25	5	5	5	5	5	5,0	6	6	5	5	6	5,6	6,35
		3	5	2	4	3	3,50	3	4	6	5	5	4,6	6	5	6	6	6	5,9	7,00
		4	4	6	5	5	5,00	5	5	5	5	5	5,0	6	5	5	5	5	5,2	5,20
		5	2	2	5	5	3,50	2	2	2	4	4	2,8	6	5	4	7	5	5,4	6,50
		6	5	5	4	5	4,75	5	3	5	5	5	4,6	7	6	4	7	7	6,2	6,05
	TEC	1	3	2	3	3	2,75	4	4	5	3	5	4,2	6	6	6	6	6	6,0	7,45
		2	-	4	5	3	4,00	5	3	5	5	4	4,4	7	6	4	6	5	5,6	6,00
		3	3	3	3	2	2,75	3	5	6	3	5	4,4	5	5	5	5	5	5,0	6,65
		4	4	3	3	4	3,50	3	4	5	4	3	3,8	6	6	4	5	4	5,0	5,30
		5	3	3	2	2	2,50	4	3	4	4	4	3,8	6	6	3	6	5	5,2	6,50
		6	4	4	2	4	3,50	6	6	6	5	5	5,6	7	6	5	7	7	6,4	8,50
BASELINE	CEC	1	3	2	3	3	2,75	3	4	4	3	4	3,6	5	3	5	7	6	5,2	6,05
		2	3	1	4	3	2,75	3	5	5	4	4	4,2	7	6	6	7	5	6,2	7,65
		3	2	1	1	1	1,25	1	1	2	1	2	1,4	6	7	6	6	6	6,2	6,35
		4	2	3	2	2	2,25	3	3	3	4	3	3,2	6	6	6	6	5	5,8	6,75
		5	2	3	4	3	3,00	4	3	3	3	4	3,4	4	3	3	4	2	3,2	3,60
		6	2	1	1	1	1,25	4	2	2	2	6	3,2	7	4	6	7	6	6,0	7,95
	GEC	1	2	2	3	2	2,25	2	2	2	2	2	2,0	6	6	6	6	6	6,0	5,75
		2	3	2	3	4	3,00	4	3	4	4	3	3,6	6	5	5	6	6	5,6	6,20
		3	2	2	2	3	2,25	3	2	4	4	3	3,2	6	6	7	6	6	6,2	7,15
		4	3	2	4	3	3,00	3	4	4	5	4	4,0	6	5	6	6	5	5,6	6,60
		5	3	3	2	2	2,50	3	5	4	4	3	3,8	6	6	5	6	6	5,8	7,10
		6	5	2	4	4	3,75	4	5	5	4	5	4,6	6	6	6	7	6	6,2	7,05
	TEC	1	4	6	4	4	4,50	5	5	5	6	4	5,0	6	5	5	6	6	5,6	6,10
		2	4	2	4	3	3,25	3	4	5	4	4	4,0	6	6	6	6	5	5,8	6,55
		3	5	3	5	3	4,00	3	5	5	2	6	4,2	6	7	7	6	6	6,4	6,60
		4	5	3	4	3	3,75	3	4	4	4	5	4,0	6	7	6	6	5	6,0	6,25
		5	4	2	2	3	2,75	3	3	4	3	3	3,2	6	6	3	6	6	5,4	5,85
		6	5	3	5	5	4,50	3	4	6	5	4	4,4	6	6	6	7	6	6,2	6,10

Table 6-3: SART raw data

Table 6-4 summarises the SA results in accordance to the 6 different cells of the two test conditions [1]. Figure 6-1 visualises the SART means depending on the control position and BETA / Baseline condition.

		B: Position			
		B_1: CEC	B_2: GEC	B_3: TEC	Main Effect "BETA"
A: BETA	A_1: BETA	6,57 (0,46)	6,39 (0,30)	6,73 (0,46)	6,56 (0,34)
	A_2: BASELINE	6,39 (0,63)	6,64 (0,23)	6,24 (0,12)	6,46 (0,23)
Main Effect "Position"		6,48 (0,29)	6,52 (0,17)	6,49 (0,22)	

Table 6-4: SART Means (Standard Error)

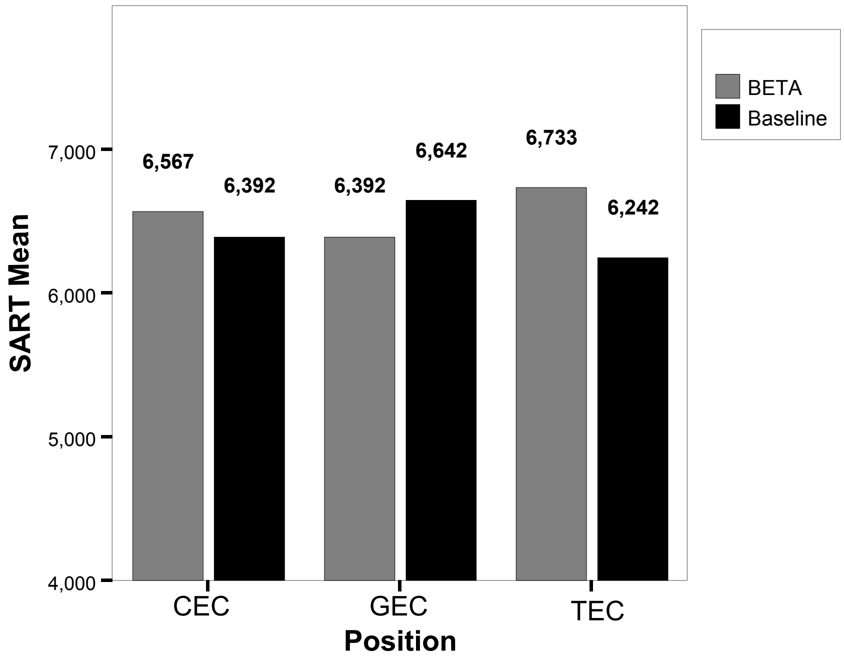

Figure 6-1: SART Means Bar Chart

A 2 (BETA) x 3 (Position) repeated-measures analysis of variance (ANOVA) revealed no effect, neither for BETA vs. Baseline nor for the Control Positions nor for their interactions (cf. Table 6-5). SART means are nearly distributed equally to the test conditions, i.e. they are influenced neither by BETA nor by the Control Position in the present test arrangement.

Source	df	F	Significance (two-tailed)
BETA	1	,099	,765
Error (BETA)	5		
POSITION	2	,015	,985
Error (POSITION)	10		
BETA x POSITION (Interaction)	2	,370	,700
Error (BETA*POSITION)	10		

Table 6-5: 2 (BETA) x 3 (Position) repeated-measures ANOVA of the SART Indices

6.3.1.2 Number of Misunderstandings

The 'number of misunderstandings' could not be measured because no adequate and practicable measuring instrument could be provided in good time.

6.3.2 Efficiency

Efficiency should be measured by a couple of objective traffic data and objective characteristics of the R/T communication.

6.3.2.1 Number and Duration of Stops

In total five different traffic recordings were used to extract the number and durations of stops of taxiing aircraft (cf. Table 6-6 and Table 6-8). Two of them were recorded during BETA operational test runs; three of them were recorded without operational influence of BETA. The stops do not include the pushback stop nor the stop at the runway entry point, only stops during taxiing.

BETA / Baseline	***Position controlled by BETA***	***Date***	***Test Times (UTC)***		***Total Test Time (hour)***	***Traffic Amount***		***Movements per hour*** *(traffic density)*	***Total Number of Stops***		***Number of Stops per a/c***	
			Start	***End***		***Arr***	***Dep***		***Arr***	***Dep***	***Arr***	***Dep***
BETA	GEC	06-03	13:30	14:34	1:04:00	20	8	26	**2**	**0**	**0,10**	**0**
BETA	CEC	06-06	07:35	08:54	1:19:00	22	15	28	**2**	**1**	**0,09**	**0,07**
Baseline	No	05-21	14:00	16:00	2:00:00	21	16	18	**2**	**10**	**0,10**	**0,63**
Baseline	No	05-22	07:00	09:00	2:00:00	28	16	22	**2**	**10**	**0,07**	**0,63**
Baseline	No	05-22	12:00	15:00	3:00:00	28	17	15	**2**	**13**	**0,07**	**0,77**

Table 6-6: Number of Stops during taxiing

BETA / Baseline	***Position controlled by BETA***	***Date***	***Test Times (UTC)***		***Total Test Time (hour)***	***Traffic Amount***		***Movements per hour*** *(traffic density)*	***Total Duration of Stops (min)***		***Duration of Stops (min) per a/c***	
			Start	***End***		***Arr***	***Dep***		***Arr***	***Dep***	***Arr***	***Dep***
BETA	GEC	06-03	13:30	14:34	1:04:00	20	8	26	**5:00**	**0:00**	**0:15**	**0:00**
BETA	CEC	06-06	07:35	08:54	1:19:00	22	15	28	**11:00**	**2:00**	**0:30**	**0:08**
Baseline	No	05-21	14:00	16:00	2:00:00	21	16	18	**2:00**	**22:00**	**0:06**	**1:23**
Baseline	No	05-22	07:00	09:00	2:00:00	28	16	22	**6:00**	**22:00**	**0:13**	**1:23**
Baseline	No	05-22	12:00	15:00	3:00:00	28	17	15	**1:00**	**31:00**	**0:02**	**1:49**

Table 6-7: Durations of Stops during taxiing

By a first view the data reveal enormous variations with the departures and a very small number of stops with the arrivals. Stops with departures vary from 0,00 to 0,77 per aircraft and stops with arrivals are hardly existent (0,07 – 0,10 per aircraft). These occur because firstly, Prague Ruzyne is not a highly congested airport, where numerous stops can be expected and secondly, stops of the taxiing traffic are influenced by a mass of permanently changing side conditions, e.g. changing runway configurations, dynamical traffic densities, changing timeliness of the aircraft, altered weather conditions, etc. To cope with those unpredictable conditions, recordings and evaluations over many weeks or even months are necessary to randomise all the influencing variables to be able to compare traffic data, which are solely affected by BETA or not. Further, the CEC position does not affect the moving traffic so that when the CEC position is realised by BETA, the BETA system is not able to influence the taxiing traffic. The BETA Ground (GEC) and Tower (TEC) were more in the position to reduce the number and durations of stops of taxiing aircraft. However, the BETA 'Planning' and 'Routing' function were not in this mature stage that the controller could use it applicably so that R/T communication effects caused by planning and routing can hardly be expected. Summarising, the intern and extern validity of the data are not sufficient to convey them into a statistical evaluation.

6.3.2.2 Number and Duration of R/T Communication

Table 6-8 outlines the recorded raw data of the number and the duration of R/T communication between the BETA controller and the pilots of the regular traffic. With respect to the control position the total number and duration as well the number and duration related to one aircraft are reported. Empty cells occur due to missing or corrupted recordings. To alleviate this negative impact, baseline data from phase one were added for the GEC and TEC position. At the end of the table the data for each position are summed up before it finishes with the total sum of communication for one aircraft, which was handled over all three control positions.

Control Position	Controller index	BETA / Baseline	Date	Start Time (UTC)	End Time (UTC)	Total Amount of Traffic[3]	Total Number of R/T	Total Duration of R/T (sec)	Number of R/T per a/c	Duration of R/T per a/c (sec)
CEC	1	BETA	05-29	13:40	15:12	12	83	539	6,9	44,9
		Baseline	06-19	17:00	18:00					
	2	BETA	05-30	10:02	11:02	22	121	788	10,1	35,8
		Baseline	06-24	16:00	17:00					
	3	BETA	05-30	07:55	09:02					
		Baseline	06-17	18:01	18:33	8	12	112	1,6	18,6
	4	BETA	05-29 06-05	09:30 09:32	10:45 10:28	37	212	1373	5,7	37,1
		Baseline	06-26	08:00	09:00					
	5	BETA	05-29	07:54	09:30	13	93	525	7,25	40,4
		Baseline	06-18	08:00	09:00	11	134	531	12,2	48,3
	6	BETA	06-06	07:35	08:54					
		Baseline	06-24	08:00	09:00					
GEC	1	BETA	06-06	13:03	14:08	17	184	663	10,8	39,0
		Baseline	06-19	11:57	12:55	7	100	347	14,3	49,6
	2	BETA	06-07	09:38	10:34	27	235	952	8,7	35,3
		Baseline	06-24	10:00	11:00					
	3	BETA	06-04 06-05	13:09 12:38	14:15 13:59	33	169	501	10,7	31,3
		Baseline	06-17	16:56	18:01	20	183	544	9,2	27,2
	4	BETA	06-04	10:12	11:13					
		Baseline	06-26	07:00	08:00					
	5	BETA	06-03	12:06	13:30	10	143	484	14,3	48,4
		Baseline	06-18	09:05	09:59					
	6	BETA	06-03	13:30	14:34	28	276	873	9,8	31,2
		Baseline	06-24	07:00	08:00					
	Baseline (Phase I)		09-13	09:05	13:58	105	947	3020	9,0	28,8
TEC	1	BETA	06-06	10:19	11:19	18	141	538	7,8	29,8
		Baseline	06-19	14:00	15:00					
	2	BETA	05-28	13:28	14:03	10	78	251	7,8	25,1
		Baseline	06-24	08:00	09:00					
	3	BETA	05-30	12:55	13:58	18	193	670	10,7	37,2
		Baseline	06-17	14:56	15:57	26	319	753	12,3	29,0
	4	BETA	05-28	09:40	10:45	27	213	670	7,8	24,8
		Baseline	06-26	11:00	12:00					
	5	BETA	06-05	07:08 08:07	07:42 08:52	36	388	1260	10,7	35,0
		Baseline	06-18	11:00	12:00					
	6	BETA	06-04	07:03	08:07					
		Baseline	06-24	11:00	12:00					
	Baseline (Phase I)		09-13	09:05	14:07	108	843	2830	7,8	26,2
CEC		**BETA**				**84**	**509**	**3225 sec**	**6,1**	**38,4 sec**
		BASELINE				**19**	**147**	**643 sec**	**7,7**	**33,8 sec**
GEC		**BETA**				**98**	**1007**	**3473 sec**	**10,3**	**35,4 sec**
		BASELINE				**132**	**1230**	**3911 sec**	**9,3**	**29,6 sec**
TEC		**BETA**				**109**	**1013**	**3389 sec**	**9,3**	**31,1 sec**
		BASELINE				**134**	**1162**	**3583 sec**	**8,7**	**26,7 sec**
SUM for one aircraft		**BETA**							**25,7**	**104,9 sec**
		BASELINE							**25,7**	**90,1 sec**

Table 6-8: Number and Duration of R/T Communication (Raw Data)

In order to prove the data for significant differences, they had to be transferred in this way that to be compared data base on the same amount of traffic. That is, one of the two R/T scores, which shall be compared, was extrapolate to the lesser amount of traffic of the two scores (compare Table 6-9).

[3] With the CEC control position only departures are reported because the CEC only interacts with outbound traffic.

Control Position	BETA / Baseline	Total Amount of Traffic	Number of R/T	Total Duration of R/T (sec)	Number of R/T per a/c	Duration of R/T per a/c (sec)
CEC	BETA	**19**	**115**	**729**	**6,1**	**38,4**
	BASELINE	**19**	**147**	**643**	**7,7**	**33,8**
GEC	BETA	**98**	**1007**	**3473**	**10,3**	**35,4**
	BASELINE	**98**	**913**	**2904**	**9,3**	**29,6**
TEC	BETA	**109**	**1013**	**3389**	**9,3**	**31,1**
	BASELINE	**109**	**945**	**2915**	**8,7**	**26,7**
SUM for one aircraft	BETA				**25,7**	**104,9**
	BASELINE				**25,7**	**90,1**

Table 6-9: Number and Duration of R/T Communication (data extrapolated referring the traffic amount)

After this extrapolation the total number and duration of the respective data could be compared by a chi square test, which is well suited for the proof of non-parametric data of frequencies. The chi square score for two frequencies is calculated by following term:

$$\chi^2 = (f_{b(1)} - f_e)^2 / f_e + (f_{b(2)} - f_e)^2 / f_e$$

f_b = Observed frequency
f_e = Expected frequency

The observed frequency is what was measured. The expected frequency is the mean of the two to be compared frequencies. The chi square scores are reported in Table 6-10 and Table 6-11.

Control Position	BETA / Baseline	Number of R/T	df	χ^2
CEC	BETA	**115**	1	**3,91***
	BASELINE	**147**		
GEC	BETA	**1007**	1	**2,3**
	BASELINE	**913**		
TEC	BETA	**1013**	1	**1,18**
	BASELINE	**945**		

Table 6-10: Chi Square Test for Comparisons of Number of R/T between BETA and Baseline

Control Position	BETA / Baseline	Duration of R/T (sec)	df	χ^2
CEC	BETA	**729**	1	**5,39***
	BASELINE	**643**		
GEC	BETA	**3473**	1	**50,77***
	BASELINE	**2904**		
TEC	BETA	**3389**	1	**35,64***
	BASELINE	**2915**		

Table 6-11: Chi Square Test for Comparisons of Number of R/T between BETA and Baseline

By a directed hypothesis and ∀ = 0.05 a critical Chi square score ($\chi^2_{crit\,(1;\,90\%)}$)[4] of 2,71 is calculated. Empiric chi squares scores higher than this critical score becomes significant (marked with a star in the tables above). Since the directed hypothesis expect lower number and duration of R/T communication within the BETA test condition, only the comparison of the number of communication at the CEC position revealed a significant effect as it was assumed. All other comparisons are either not significant or even support the baseline condition. But generally can be stated that controllers using BETA require the same number of messages

[4] With a directed hypothesis the critical chi square value correspond to the doubled ∀-level (5% → 10%).

with the pilot to control the aircraft. The duration of the RT messages per aircraft is systematically longer (constantly 5-6 seconds per control position) for BETA then for the Baseline. This is the case in all positions.

These unexpected results can be explained that just one aircraft was equipped and controlled via data link. Further, the number of communication within the BETA trials was very often superimposed by the controllers' announcement to the pilots to switch on their transponders whilst pushing back or commencing taxiing. Another reason might be that controllers require more time to find the information they want to communicate to the pilots on their unfamiliar BETA displays meanwhile they interact with the pilot. This additional "search-time" would extend the duration of communication.

6.3.2.3 Holding Time for each Aircraft holding for Line-up at the RWY Entry Point

This efficiency parameter should be mainly influenced by the use of a departure manager. The D-MAN should give the controller the right time of Off-Block and the ETD, as well the best departure sequence when more than one aircraft intents to depart nearly the same time. However, the controller could not use the D-MAN because it did not cope with the real life operational procedures at Prague airport. A more detailed D-MAN analysis can be found in section 6.4.2. Nevertheless some data are presented here. In the last column of Table 6-12 you can see the number of waiting aircraft in relation to all departing aircraft. In the next to last column the average waiting time of a waiting aircraft is represented.

BETA / Baseline	*Position controlled by BETA*	*Date*	*Test Times (UTC)*		*Total Test Time (min)*	*Traffic Amount*		*Movements per hour*	*Holding time at the RWY entry point (min)*	
			Start	*End*		*Arr*	*Dep*		*per waiting a/c*	*No. of waiting a/c*
BETA	GEC	06-03	13:30	14:34	1:04	20	8	26	**0:30**	**2/8**
BETA	CEC	06-06	07:35	08:54	1:19	22	15	28	**1:12**	**9/15**

Table 6-12: Average holding time of waiting aircraft at the RWY entry point

6.3.2.4 Usability Head Down

The usability of the BETA system working head down exclusively could not be proved. The controllers were requested to work head down but the confidence in the system (Surveillance function in this case) was not high enough that controller would trust it blind. The controllers said that even under low visibility and BETA use they would ask the pilot whether its aircraft has left the runway. Gazes outside the windows are also very influenced by the respective subject itself and the control position, and as well by the traffic density. A sophistic analysis is neglected at this stage because of the obvious result that working with BETA could not yet replace the standard behaviour 'looking outside the window' for controlling the airport traffic.

6.3.3 Working Conditions

6.3.3.1 Workload

Controllers' workload was measured once working with the BETA System, and once working with current system (baseline). The NASA-TLX rating scale was used as the measurement instrument. NASA TLX comprises six different workload dimensions (*Mental Demand [MD]*, *Physical Demand [PD]*, *Temporal Demand [TD]*, *Performance [P]*, *Effort [E]*, and *Frustration Level [FL]*), which require an answer on a rating scale from 0 (low) to 20 (high) each. For the BETA tests, the NASA TLX was administered without the weighting technique. This renders the questionnaire easier to comprehend and to fill in for the controllers, but still yields valid results. (For a discussion of using the NASA TLX without the weighting technique, see Nygren, 1991 [2]). By summing the answers to the six workload dimensions, an overall score ranging from 0 (lower end of the scale) to 120 (higher end of the scale) is attained. No scale had to be inverted for calculating an overall score from the separate scales.

Table 6-13 outlines all the NASA-TLX values gained from each BETA controller over three different control positions once with BETA and once without BETA (baseline). Also the sum of the six workload-dimensions (NASA-TLX index) is represented in the last column.

BETA / Baseline	Position	Controller index	Items						
			MD	PD	TD	P	E	FL	NASA-TLX Index
BETA	CEC	1	4	4	5	6	5	6	30
		2	9	7	7	11	6	3	43
		3	6	2	10	2	6	1	27
		4	3	3	11	3	3	3	26
		5	3	3	3	2	13	1	25
		6	5	5	5	7	10	1	33
	GEC	1	11	9	5	15	9	5	54
		2	13	13	13	9	11	5	64
		3	9	6	9	1	17	6	48
		4	15	15	11	11	14	13	79
		5	7	3	5	9	3	5	32
		6	10	4	10	7	9	2	42
	TEC	1	9	5	9	3	7	3	36
		2	12	11	9	11	6	5	54
		3	7	1	8	3	17	7	43
		4	9	5	9	7	5	5	40
		5	13	11	7	7	17	9	64
		6	12	6	10	4	12	0	44
BASELINE	CEC	1	13	5	13	3	9	3	46
		2	4	4	4	4	4	3	23
		3	1	1	1	0	1	0	4
		4	5	5	7	3	13	5	38
		5	5	5	3	1	5	3	22
		6	6	2	5	0	5	0	13
	GEC	1	3	3	3	3	3	1	16
		2[5]							
		3	4	3	10	1	10	5	33
		4	9	7	11	5	15	3	50
		5	7	7	13	1	9	7	44
		6	11	6	10	1	9	1	38
	TEC	1	15	7	11	5	15	11	64
		2	9	9	5	5	4	4	36
		3	15	6	18	2	16	12	69
		4	11	11	11	3	15	3	54
		5	9	9	13	1	7	5	44
		6	14	10	15	1	16	0	56

Table 6-13: NASA-TLX raw data

Table 6-14 summarises the workload (NASA-TLX) results in accordance to the 6 different cells gaining from the two test conditions. Also the means of the main effects are represented. Figure 6-2 visualises the NASA-TLX workload means depending on the control position and BETA / Baseline condition.

[5] No data available.

		B: Position B_1: CEC	B_2: GEC	B_3: TEC	Main Effect "BETA"
A: BETA	A_1: BETA	28,2 (1,46)	51,0 (7,89)	45,4 (4,85)	41,5 (1,71)
	A_2: BASELINE	24,6 (7,76)	36,2 (5,80)	57,4 (4,31)	39,4 (2,32)
Main Effect "Position"		26,4 (3,90)	43,6 (5,31)	51,4 (1,60)	

Table 6-14: NASA-TLX Means (Standard Error)

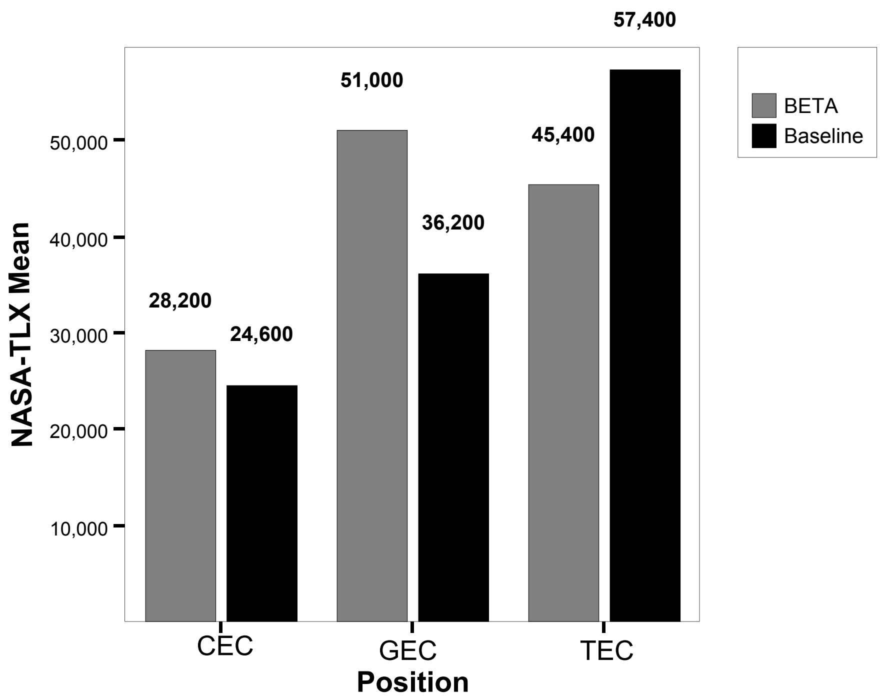

Figure 6-2: Bar Chart of the NASA-TLX Means

A 2 (BETA) x 3 (Position) repeated-measures analysis of variance (ANOVA) revealed a main effect of the 'Control Position', $F_{(2, 8)} = 9.452$, $p < 0,01$ (cf. Table 6-15). The TEC position gets the highest workload mean (51,4 [42,8 %]) followed by GEC (43,6 [36,3 %]) and the CEC Position (26,4 [22,0 %]). This is also underlined significantly by a contrast-test for proof of linearity, $F_{(1, 4)} = 22.999$, $p < 0,01$.

Between BETA and BASELINE no significant effect could be detected. Both BETA (41,5 [34,6 %]) and BASELINE (39,4 [32,8 %]) NASA-TLX indices are nearly equal and under-averaged low.

No significant interaction between BETA and the Control Position were found, means, that the workload becomes higher from CEC over GEC to TEC but independent on the controllers' use of BETA or not.

Source	df	F	Significance (two-tailed)
BETA	1	3,287	,144
Error (BETA)	4		
POSITION	2	9,452	,008*
Error (POSITION)	8		
BETA x POSITION (Interaction)	2	1,707	,241
Error (BETA*POSITION)	8		
** Marks statistic significance (p < .05)*			

Table 6-15: 2 (BETA) x 3 (Position) repeated-measures ANOVA of the NASA-TLX Indices

6.3.3.2 Acceptance of BETA System

After finalisation of all test runs all six controller were requested to give their opinion to following statements, which refer to the acceptance of the BETA system. The following table outlines the frequencies of the possible answers reaching from 1 (strongly disagree) to 6 (Strongly agree). The column 'Topic' represents different areas of BETA for what the controllers were interviewed.

Topic	Statements	Frequencies					
		Strongly Disagree 1	Disagree 2	Slightly Disagree 3	Slightly agree 4	Agree 5	Strongly Agree 6
General	1. The concept of operations for BETA is difficult to understand.		6				
	2. The BETA procedures were easy to work with.		1		2	3	
	3. It is easy to learn to work with BETA.			1		4	1
	4. The BETA system will not fundamentally change the way that controllers work.	1	1		1	3	
	5. The BETA system requires a re-distribution of tasks within the controller team.	1	2	1	2		
	6. Using BETA makes you think differently about the controller tasks.	1	1	2	1	1	
	7. The BETA system changes routine communication tasks.	1	2	2		1	
	8. This field test changed my attitude towards BETA.	2	3			1	
Stress	9. You had a good picture of the traffic under your control during the BETA field tests.					5	
	10. The BETA system makes the controller's job boring.	3	2		1		
Levels of Service	11. BETA enabled you to handle more traffic.		2		2	1	
	12. BETA enabled you to provide the pilots a better level of service.	2	2			2	
	13. BETA enabled you to execute your tasks more effectively.	1	3		1	1	
Safety	14. Working with BETA makes you feel safer.		2	1	1	2	
	15. The introduction of BETA will increase the potential of human error.		3	1	1		1
	16. The types of human error associated with BETA are different than those associated with normal work.		1		2	2	
Training	17. There was enough training to get familiar with the BETA procedures.		1	1	1	1	2
	18. There was enough training on the HMI, its rules and its mechanisms.			2	1	2	1
	19. The work environment (seating, lighting) was comfortable.			2	2	2	
	20. There were distractions/disturbances from other activities (e.g. visitors) during the tests.	1	3	2			

Table 6-16: System Acceptance (Frequencies of the Controllers' Judgements)

The following table puts together the average opinion of the six controllers to the different acceptance statements. It also marks means that are significant statistically.

Topic	Statements	N	Mean	SD	SD	Min	Max
General	1. The concept of operations for BETA is difficult to understand.	6	2,00*	,00 #	,00 #	2	2
	2. The BETA procedures were easy to work with.	6	4,17	,48	1,17	2	5
	3. It is easy to learn to work with BETA.	6	4,83*	,40	,98	3	6
	4. The BETA system will not fundamentally change the way that controllers work.	6	3,67	,71	1,75	1	5
	5. The BETA system requires a re-distribution of tasks within the controller team.	6	2,67	,49	1,21	1	4
	6. Using BETA makes you think differently about the controller tasks.	6	3,00	,58	1,41	1	5
	7. The BETA system changes routine communication tasks.	6	2,67	,56	1,37	1	5
	8. This field test changed my attitude towards BETA.	6	2,17	,60	1,47	1	5
Stress	9. You had a good picture of the traffic under your control during the BETA field tests.	5	5,00*	,00 #	,00 #	5	5
	10. The BETA system makes the controller's job boring.	6	1,83*	,48	1,17	1	4
Levels of Service	11. BETA enabled you to handle more traffic.	5	3,40	,60	1,34	2	5
	12. BETA enabled you to provide the pilots a better level of service.	6	2,67	,76	1,86	1	5
	13. BETA enabled you to execute your tasks more effectively.	6	2,67	,61	1,51	1	5
Safety	14. Working with BETA makes you feel safer.	6	3,50	,56	1,38	2	5
	15. The introduction of BETA will increase the potential of human error.	6	3,17	,65	1,60	2	6
	16. The types of human error associated with BETA are different than those associated with normal work.	5	4,00	,55	1,22	2	5
Training	17. There was enough training to get familiar with the BETA procedures.	6	4,33	,67	1,63	2	6
	18. There was enough training on the HMI, its rules and its mechanisms.	6	4,33	,49	1,21	3	6
	19. The work environment (seating, lighting) was comfortable.	6	4,00	,37	,89	3	5
	20. There were distractions/disturbances from other activities (e.g. visitors) during the tests.	6	2,17*	,31	,75	1	3

* *The mean values marked with a star deviate significantly from the expected test size '3.5' by a T-Test for one sample size and a one-tailed error probability of $\alpha = 0.05$.*

\# *Calculation of the SD and SE is not possible because the answers do not vary.*

Table 6-17: Means of the controllers' acceptance to the BETA System

At the end of the acceptance questionnaire the controllers were asked to give their opinion to the best and worst things, which they experienced during the BETA tests. The following table gives a summery of the frequencies of the controllers' answers and their valence:

Valence	Matter of Interest								
	Surveillance	Alerts	EFS	D-MAN	System Inputs	Location CWP	Data link	Discrepancy Planned / Real	Unknown aim of testing
positive	5	3	1	0	0	0	1	0	0
negative	0	0	1	1	1	1	0	1	1

Table 6-18: Frequencies of Controller experienced best and worst things whilst testing

6.3.3.3 Usability of BETA System

Usability was measured after each BETA test run. The Standard Usability Scale items vary from 1 – 10. The items listed in Table 6-19 correspond to the items in the SUS questionnaire. Items 2; 4; 6; 8 are already transformed in terms of 'good usability' is expressed by '5', poor usability by '1'. All six controllers performed three Control position (CEC, GEC, TEC) with support of BETA and gave their usability ratings after each test run. That is, each controller filled in the usability scale three times.

Position	Controller Index	Usability Items 1	2	3	4	5	6	7	8	9	10	Usability index
CEC	1	5	5	5	5	4	4	4	5	5	4	4,6
	2	3	3	3	4	2	3	4	4	2	4	3,2
	3	5	3	5	5	5	4	5	5	5	4	4,6
	4	3	3	4	4	2	2	4	4	3	4	3,3
	5	5	2	4	5	4	3	5	4	5	3	4
	6	4	4	4	3	3	3	4	5	4	4	3,8
GEC	1	4	4	4	4	3	4	4	4	4	4	3,9
	2	3	3	3	4	3	3	4	3	3	4	3,3
	3	3	3	5	2	4	5	4	4	4	4	3,8
	4	3	3	3	4	3	2	4	4	3	2	3,1
	5	4	4	4	5	3	2	4	4	4	5	3,9
	6	4	4	4	2	3	3	2	5	3	4	3,4
TEC	1	4	4	4	5	4	4	4	4	4	4	4,1
	2	3	4	3	4	3	4	4	4	3	4	3,6
	3	3	3	4	2	5	4	4	4	4	4	3,7
	4	4	3	4	4	4	4	4	4	4	4	3,9
	5	2	4	1	5	2	4	4	4	3	5	3,4
	6	4	5	4	3	4	4	4	5	4	4	4,1

Table 6-19: Controllers' ratings to each of the usability items and usability indices

Under all Control Position (CEC, GEC, TEC) the BETA system usability is estimated as high and becomes statistically significant each time ([CEC = $T_{5df} = 3{,}693$; $p < 0.05$], [GEC = $T_{5df} = 4{,}029$; $p < 0.05$], [TEC = $T_{5df} = 7{,}502$; $p < 0.05$], [cf. Table 6-20 and Table 6-21]).

Position	Number of Subjects	Mean	Standard Deviation	Standard Error of the Mean
CEC	6	3,9167	,6080	,2482
GEC	6	3,5667	,3445	,1406
TEC	6	3,7667	,2503	,1022

Table 6-20: Descriptive Statistic of the Usability Means of three Control Positions

Position	T-Score	df	Sig. (1-tailed)	Average Difference (Test Size = 3)	95% Confidence Interval of the Differences Lower	Upper
CEC	3,693	5	,007*	,9167	,2786	1,5547
GEC	4,029	5	,005*	,5667	,2052	,9282
TEC	7,502	5	,000*	,7667	,5040	1,0294
** = Marks statistical significance p < 0.05* *df = degree of freedom*						

Table 6-21: T-Statistic of the Usability Means of three Control Positions

With respect to the null hypothesis $H_{0,2}$ it was assumed that 'no significant differences in the effects of the use of the BETA system between the control positions' would occur. Indeed, referring the *usability* the $H_{0,2}$ could not rejected in this test trial with this sample size ($F_{(2, 10\,df)} = 1{,}391$; $p > 0.10$ [$\beta = 0.10$], cf. Table 6-22).

However, a decision cannot be made referring the validity of the null or alternative hypothesis, because a not-significant result is not an evidence of the validity of the null hypothesis.

	df	F	p (significance)
POSITION	2	1,391	,293
Error (POSITION)	10		

Table 6-22: Repeated-Measures ANOVA to the System Usability between the three Control Positions

Also the CSA Co-Pilots were asked to their perceived usability of BETA. The ratings and the respective mean values are put together in the following table. All usability indices, gained from the pilots, are over-averaged positive.

Position	Pilot Index	Usability Items 1	2	3	4	5	6	7	8	9	10	Usability index
Co-Pilot	1	5	4	5	5	4	3	4	5	4	5	4,4
	2	4	4	5	5	4	5	4	4	4	5	4,4
	3[6]											
	4	4	4	5	4	4	4	5	5	4	4	4,3

Table 6-23: Pilots' ratings of to each of the usability items and usability indices

6.3.4 Environmental Impacts

As above-mentioned the effects of BETA influencing movements or operations of the traffic are estimated as very low. However, the raw data of "fuel burn while taxiing" are available (outcome of the CSA aircraft QAR) and could be analysed.

6.4 Additional Results

6.4.1 Assessment of BETA A-SMGCS Benefits

After finalisation of all test runs all six controller were requested to give their opinion to following statements, which refer to the potential benefits that the controller would attribute to the BETA system.

Statements	Frequencies: 1 Strongly Disagree	2	3	4	5 Strongly agree
1. The control of aircraft in the test runs was very safe.			1	4	1
2. BETA A-SMGCS will reduce air pollution.	1	3	1	1	
3. BETA A-SMGCS will reduce costs for airports.		2	4		
4. BETA A-SMGCS will reduce costs for airlines.		2	3	1	
5. BETA A-SMGCS will reduce costs for ATC providers.		2	3	1	
6. BETA A-SMGCS will reduce costs for passengers.	1	1	2	1	
7. I think that the BETA A-SMGCS increases airport capacity.			2	4	
8. In my opinion, the use of the BETA system endangers safety at the airport.	2	2	2		
9. The control of aircraft with the BETA system was very efficient.		1	1	4	
10. I think that the BETA system helped me to maintain good situation awareness.		1	1	3	1
11. The use of the BETA system makes the controller's job more difficult.		4		1	1
12. The use of the BETA system makes the controller's job more boring.	2	3		1	
13. With the BETA system, it was easier to separate aircraft safely.	1	1		4	

[6] Questionnaire is still missing.

14. The BETA system made it easier to detect potential problematic situations.	1		1	4	
15. BETA A-SMGCS will not reduce waiting times for aircraft at the airport.			4	1	1

Table 6-24: Frequencies of the controllers' ratings to the benefit assessment statements

Statements	N	Mean	Standard Error	SD	Min	Max
1. The control of aircraft in the test runs was very safe.	6	4,00*	,26	,63	3	5
2. BETA A-SMGCS will reduce air pollution.	6	2,33	,42	1,03	1	4
3. BETA A-SMGCS will reduce costs for airports.	6	2,67	,21	,52	2	3
4. BETA A-SMGCS will reduce costs for airlines.	6	2,83	,31	,75	2	4
5. BETA A-SMGCS will reduce costs for ATC providers.	6	2,83	,31	,75	2	4
6. BETA A-SMGCS will reduce costs for passengers.	5	2,60	,51	1,14	1	4
7. I think that the BETA A-SMGCS increases airport capacity.	6	3,67*	,21	,52	3	4
8. In my opinion, the use of the BETA system endangers safety at the airport.	6	2,00*	,37	,89	1	3
9. The control of aircraft with the BETA system was very efficient.	6	3,50	,34	,84	2	4
10. I think that the BETA system helped me to maintain good situation awareness.	6	3,67	,42	1,03	2	5
11. The use of the BETA system makes the controller's job more difficult.	6	2,83	,54	1,33	2	5
12. The use of the BETA system makes the controller's job more boring.	6	2,00*	,45	1,10	1	4
13. With the BETA system, it was easier to separate aircraft safely.	6	3,17	,54	1,33	1	4
14. The BETA system made it easier to detect potential problematic situations.	6	3,33	,49	1,21	1	4
15. BETA A-SMGCS will not reduce waiting times for aircraft at the airport.	6	3,50	,34	,84	3	5
Mean:		**3,27**				
* *The means marked with a star deviate significantly from the expected test size '3' by a T-Test for one sample size and a one-tailed error probability of* $\alpha = 0.05$.						

Table 6-25: Means of the controllers' opinions to the benefit assessment statements

6.4.2 DMAN Evaluation

Introduction
DMAN (Departure Manager) is an advisory tool. The aim of the tool is to provide the ground controller with departure scheduling information, such as optimised off-block time, optimised time of departure and take-off sequence. From this information it is expected that the controller will be able to process the aircraft more efficiently, resulting in higher runway capacity, lower workload, safer operations and a reduction in fuel consumption.

DMAN Configuration
DMAN was configured to start planning when the departure clearance was issued and freeze planning when the start-up clearance was issued. The bullet on the PAT (Planned Action Timeline) represents the optimum time for issuing the start-up clearance (when the bullet reaches the UTC line). The horizontal line on the PAT includes time for start-up, pushback and taxiing (figure 1).

General Observations
The CEC (Clearance Executive Controller) gave the departure clearance and start-up clearance together. This resulted in DMAN planning on a first-come first-serve basis. Controllers preferred not to change their clearance procedures and delay the pilot's start-up clearance. Instead, it was agreed that the start-up clearance would be given verbally with the departure clearance, but the start-up clearance button would be pressed by the GEC (Ground Executive Controller) when the aircraft actually started its engines. This

procedure was in place for tests conducted during and after 3rd June, 2002. This had the effect of increasing the DMAN planning time before values were frozen with the start-up clearance.

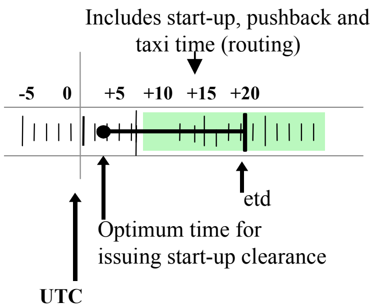

Figure 1: PAT at Prague Airport

Approximately 20% of the departing aircraft at Prague were issued CFMU slots from Brussels, the rest were without slots. Controllers tend to give preference to flights with a CFMU slot, as the take-off time window is more restrictive that aircraft without slots. If Brussels does not issue a slot, DMAN creates a 30 minutes slot for the aircraft. Sequence discrepancies were identified as a result of DMAN planning unslotted aircraft with tighter constraints than controllers.

Traffic density at Prague airport is very low. In general the traffic density is not great enough to enable one to measure any real capacity benefits of DMAN, or test whether the DMAN assignment of sequence numbers is the same as the controller's assignment.

Duplicate sequence numbers and missing sequence numbers were observed in the aircraft labels. For example, on occasions there was no number 1 and on other occasions there were multiple number 2's. This resulted in the controllers loosing confidence in the accuracy of the sequencing.

Observations seemed to indicate that there is a large variability in the time interval between when aircraft call in for start-up clearance and when they actually start their engines. Some aircraft seem to start-up soon after requesting the clearance while other does not start for another 15 minutes or more. It was suggested by a controller that this variability might be company dependent.

A CSA pilot was questioned about the pilot's perspective of the start-up clearance. He mentioned that it is a clearance that the pilot needs to get issued while at the gate, and basically serves as a tick in the box and enables them to start the engines and perform engine checks at the gate/stand. However, getting the clearance does not define the time at which the engines must start but allows the pilot to start the engines at his own discretion. This is different to the pushback clearance that must be executed immediately after the clearance has been given. The start-up clearance is not perceived as a time critical clearance.

6.4.3 Comments by the Operators

The following comments and observations were gained <u>during</u> the test trials. They are related to the test subject and its position and are chronologically listed and in a raw form, that is, they are neither appraised nor further explained. They shall give a first idea of the operator's impression of the system. From there, it is most likely that not all comments can be comprehended completely at this stage. Detailed explanations and a summery of these comments will follow in document D22 and D25.

6.4.3.1 Controller Comments whilst testing

Controller index	Control Position	Comments during the BETA Test Run	Observations by the BETA Observer
4	TEC	Arriving VFR flight gets TWY F_L_R, what is not correct, because Light aircraft vacate via C when RWY 24 is active. With one aircraft at TWY B and one at TWY A waiting for take off the faster aircraft gets clearance first. D-MAN does not consider this.	A lot of route deviation alerts occur, because aircraft do not behave as planned. TEC looks out of the window with every clearance he gives. One wrong RWY incursion alert.
2	TEC	Target of TYR708T was missing for 20 sec after Departure what is not acceptable. Auditory alert is missed when RWY incursion.	3 times RWY incursion alert caused by a CSL car crossing the CAT II/III bar. 1st good – both targets red 2nd just a/c was red 3rd good – from orange to red colour
5	CEC	Approaching window shall be extended beginning with 4 miles out. DEST, SID, SSR are in right sequence in EFS – very good. The SID consists of two information that should be splitted (e.g. BANAS2A – BANAS 2A). VFR are not in the EFS because pilot calls in for the flight plan via phone – must be generated in the system – works good. Orange alarms are too much and the meaning is often unclear.	
4	CEC	Handover TRANSACTION FAILS alert between CEC and GEC arises too early.	CSA822 wrong “+30 alert”. CSA 894 wrong SID.
1	CEC		5 times orange alerts, which could be identified neither by the controller nor by the observer.
3	CEC	When a flight plan was updated regarding the EOBT by the Airport database, the ‘+30 alert’ is not updated. TOO EARLY alert is confusing. Outbound aircraft might be quicker than 10 min from Gate 6 to RWY 24 as calculated by D-MAN.	CSA670 with CTOT calls in very early and requests an earlier CTOT but in vain (no earlier slot by CFMU) - BETA CEC gives Start up clearance in accordance to D_MAN proposal TOO EARLY alert arises
2	CEC	Turbo-Prop like ATR42 gets often SU-clearance long before slot time because it can wait at the RWY holding point TWY B – what is easier for the TEC to sequence different departures from TWA A and B. ‘+30 alerts’ are wrong. Controller must have the possibility to overrule the D-MAN.	CSA894 has wrong SID: HOCAN9A instead of LAGAR9A. When aircraft calls in later than EOBT D-MAN does not consider this flight.
3	TEC	‘Approach window’ with 4 miles out is better. When RWY incursion under low vis, it shall already be alerted when arriving aircraft is 4 miles out instead of 2 miles out. (*done*) ‘Undo’ for the clearance button is desired. Wind indication is missing.	Wrong target on TWY G in front of TWY B Wind indication is hard recognisable when sun is shining because the display is too far away. CSL1 is always shown as ‘7777’ on surveillance display.
5	GEC		RWY change 2 min after start of testing. DLR aircraft with data link was used but just taxiing 1st trial - data link clearances without

			moving of the aircraft - 2nd trial - aircraft taxies in accordance to data link clearances. CSA pilot is co-pilot, which does the R/T com – controller says 'Follow data link instructions. DLR vacates via TWY B and route **A**_H_L_P is transmitted by pressing the clearance button - Route update to **B**_G_C_L_P happens not before pressing the taxi clearance button so that wrong route is transmitted to aircraft.
6	GEC	It is difficult to find the stand in the 'EFS all arrival' window to pre-announce the stand of an arriving a/c to the Follow-Me driver.	
6	TEC		BETA controller does not use 'Flight data Messages' window – it was minimised by him. He detected a deviation of the SSR code indicated in the EFS and on the surveillance display – pilot had switched on wrong transponder code and was informed via the BETA controller.
4	GEC	The BETA EFS AFR1683 is displayed with CTOT although there is no CTOT for this flight.	DLR aircraft is controlled via data link but it is just taxiing. Co-ordination problems with the timing of handover of the EFS and the R/T com - EFS arrives to late at the BETA GEC CWP. DLR aircraft vacates via TWY C but route 13/31_F_L_P is transmitted, what is wrong. Some departures are not labelled. BC stands up to be able to look outside. Has to look outside in order to give the right taxi clearance because the heading of the aircraft at the stands cannot be seen via the BETA display.
3	GEC		DLR aircraft is controlled via data link and performs a complete airport circuit. 'Ready for departure' is indicated as 'Take off' request in the EFS, what is wrong. From there, also the 'Line up' clearance button is skipped. Two labels for one target are generated what often causes 'RWY incursion' alerts.
5	TEC	Clicking on the Clearance button increases controllers' workload. Wrong sequencing of the clearances (once).	
6	CEC	'Exit' point as 2nd SID is desired by the CEC to be able to decide whether the departing aircraft shall do a left or right turn after reaching the first SID - Additional column is needed in the EFS. 2 clicks for handover could be done by one click.	BC has to change a lot of SIDs manually from VOZVLM to VLM1J manually. Hardly gazes outside.
1	TEC	EFS Column 'REMARK' can be used for additional information, which shall be passed on between the control positions, e.g. input	Again wrong RWY alert due to double targets.

		of the TWY using for take off, which are already negotiated with CEC and GEC earlier. Too many clicks for updating the clearance status. Surveillance works very well when Pilots are requested for switching on their transponder codes. When RWY incursion under low vis, it shall already be alerted when arriving aircraft is 4 miles out instead of 2 miles out. (*done*) Different altitudes indicated between BETA INSET 1 window and track view display. 'Flight data Messages' information are too complicated.	
1	GEC	In future times it will be sufficient, when the transponder will be switched on by the pilot during pushback.	DLR aircraft is controlled via data link and performs a complete airport circuit. Data link trial was performed errorless. When RWY 06 stand 04 - 13 gets wrong route (TWY B_A instead of just TWY A).
2	GEC	I have no time for manual labelling. Difficult to find the stand of an arrival in the 'ALL Arrival' window to announce it to the Follow Me driver.	DLR aircraft is controlled via data link but just taxiing.

Table 6-26: Comments and Observations during the BETA Test Trials

6.4.3.2 Controller Comments at the non-active control Position whilst testing

Controller index	Non-active Control Position	Comments during the BETA Test Run	Observations by the BETA Observer
4	GEC	Normally the faster traffic gets priority on departure due to shorter time blocking the departure sector. The graphic display of the slots is helpful very much but control according to the D-MAN advices is not possible.	
5	GEC	Heading of aircraft on stands between 38 and 30 depend on wind very often (aircraft nose towards the wind when parking)	CTOT was not cancelled in the BETA system (interface problem?)
2	GEC	Discussion on D-MAN – Sequence should be generated when taxi starts. EFS is not removed when aircraft has departed.	

6.4.3.3 CSA Co-Pilot Comments

CSA Pilots performed a BETA test run by a flight in the BETA test aircraft. They had a guidance display fixed on their knee and sat behind the crew to get outside view and to monitor the R/T communication between the Crew and the BETA controller. Afterwards the CSA test pilots could give useful comments to the onboard guidance and estimated its usability.

Pilot index	Position	Comments during the BETA Test Run	Observations by the BETA Observer
1a	Co-Pilot	The Runway markings should be shown in their true colour. This is usually white. This will reinforce the difference between Runways and Taxiways. Yellow Runway markings may be used in countries with snow problems. Data link taxi clearance message should have a more appropriate clearance limit. Not stand B1 TO RUNWAY 06 HOLD but 1) STAND B1 TO HOLD 04-22; 2) CROSS 04-22; 3) TAXI TO HOLD 13-31; 4) CROSS 13-31; 5) TAXI TO CAT III/CAT I VISUAL HOLDING POINT RUNWAY 06. There should be a STAND PARKED/ SHUT DOWN Message. This would de-activate a flight strip but is also required in low visibility for the Ground Controller. The CAT I or VISUAL HOLD was shown with a Pseudo-Stop bar. There is no real stop bar at this location at Prague. A red route line of similar thickness to the green approved route should be used. In 3D mode, data link message box writes over the current position. It should be closer to the top of the screen. The size of the aircraft and picture size appears to be different. This is confusing and adds to apparent delay of updates. Follow Me and Fire Trucks shown as aircraft.	Time lag appears to be around 1 sec to 3 sec.
2		An aural warning of an incoming clearance would be helpful; otherwise all the time is consumed by watching the screen.	
3			The aircraft was parked on the B1 centreline at the start of the test as usual. However, today the aircraft position display showed a 1/3 of a semi-span displacement to the right of centreline. This was effectively a 1/6 wingspan error in the position. The same accuracy problem occurred on parking for the middle of the test and then at shutdown. This was a constant error and appeared to be held through taxiing. At holding point F, short of Runway 13/31 when approached from the East, the aircraft was parked nose at the holding position line. However, the aircraft was shown as having the start of the wings over the line. This appeared to be a constant error and was again representative of the zero velocity error at other positions, such as the parking positions used in the test. It may be concluded from points 1 and 2 that the DGPS positions were out by about 4 metres. SAFETY ISSUE. At the holding position F a statement that the aircraft was "Ready for departure"

			was sent. A reply "Cleared for take-off Runway 13, wind 000-000" was received. The wind error is normal. However, there was an aircraft (Cessna twin engine, probably a 340) on short finals to land on Runway 13 at the time that the clearance was received. Had the crew proceeded then it would have been very interesting! L/RR/R/B6 for the first test was not consistent with a reasonable route. The requirement to use RR appeared to be unnecessary. We did not use RR. Did a route deviation alert activate? When we were taxiing on L then the green line showing the route When taxiing on some routes, no green line was shown. This was for the return to the parking position after the first landing and the same for the second landing. The taxi route suggested after landing of Runway 13, vacated via P then overwrote the taxiway designation letter L. The green route line, which had for the Runway 06 hold been stopped at the relevant holding position with a red line across the route, did not appear on the Runway 13 Foxtrot entry route. There were two items to note here. Firstly that there was no red line across the route. Secondly, that the green line did not stop at the holding position but continued to the edge of the runway. THIS FUNCTIONAL ELELMENT OF THE TEST FAILED IN MY OPINION.
4		Zoom function is ok. The stand by time of the menu should be extended from 3 to min 6 sec before it disappears by itself.	

6.4.3.4 Controller Comments to single BETA Functions

In the debriefing session after each test run the controllers were asked to single BETA functions they experienced during the previous test run.

6.4.3.4.1 Comments to 'Surveillance Display'

Control Position	Controller index	Surveillance Display
CEC	1	-
	2	-
	3	-
	4	-
	5	-
	6	Not needed at CEC position.
GEC	1	Very good surveillance.
	2	Ok – but Mode s must be switched on.
	3	Ok, no comments.
	4	A lot of manual labelling.
	5	I want to have the possibility to rotate the label by the mouse.
	6	Ok.

TEC	1	Surveillance display is ok.
	2	One target disappeared after departure for about 20-30 seconds.
	3	Once label switched from an arrival to departure. More improvements necessary.
	4	S.D. is ok. Better than we have in deal traffic.
	5	Not suitable for TEC position, even under low visibility we would ask pilot to report 'Out of RWY', thus not simply trust the display
	6	No comments

6.4.3.4.2 Comments to 'Electronic Flight Strips'

Control Position	Controller index	Electronic Flight Strips
CEC	1	Without problems.
	2	SID was wrong.
	3	Quite well.
	4	Once SID wrong.
	5	In EFS DEP: Split SID in two information; example: Banas 2A. Updating of CTOT's. No update now!
	6	I would appreciate that the exit point would be written at the EFS to be able to give the aircraft the appropriate clearance – there is some variability especially in case of westbound departures from RWY 06
GEC	1	For daily use it would be useful to simplify the EFS.
	2	Ok.
	3	Ok – but lots of windows, it is difficult to find stand after (before) landing.
	4	No comment.
	5	Divide the SID in two words.
	6	I missed the possibility to quickly find the number of parking position (shortly before landing) to be able to inform Follow Me I missed the possibility to create new EFS quickly (VFR flights, rescue flights etc.)
TEC	1	CLR buttons are not connected to other functions → they are not necessary at this stage.
	2	-
	3	2x missing (although IFR)
	4	Once runway for landing missing. ALL EFS were there.
	5	Wrong sequence in 'Status' column.
	6	I have been missing a possibility to change the order of the strips (departures)

6.4.3.4.3 Comments to 'Handover Procedures'

Control Position	Controller index	Handover Procedures
CEC	1	Ok.
	2	-
	3	Easy.
	4	Good.
	5	-
	6	It has been working – no comments.
GEC	1	O.k. – no comment.
	2	O.k.
	3	Easy.
	4	Easy learn- and practicable handover procedures
	5	-
	6	-

TEC	1	No comment – it is ok.
	2	-
	3	Easy. Ok.
	4	Ok – all EFS arrived right in time.
	5	-
	6	It has been working properly.

6.4.3.4.4 Comments to 'Clearance Monitoring Alerts'

Control Position	Controller index	Clearance Monitoring Alerts
CEC	1	-
	2	-
	3	Don't know.
	4	'TRANS FAILED' 1x but not useful
	5	-
	6	-
GEC	1	-
	2	In situation of high traffic – too much 'clicks' – ATC doesn't have the time to do that.
	3	-
	4	-
	5	-
	6	-
TEC	1	-
	2	-
	3	-
	4	Did not happen but could be good
	5	-
	6	-

6.4.3.4.5 Comments to 'Routing Function'

There are no comments of the Clearance Executive Controller, because the CEC is not involved in taxiing traffic.

Control Position	Controller index	Routing Function
GEC	1	-
	2	-
	3	Not versatile enough.
	4	No comment – no way to change.
	5	-
	6	Useless – at present condition
TEC	1	
	2	80% wrong
	3	I did not pay attention to it.
	4	No update possible.
	5	-
	6	-

6.4.3.4.6 Comments to ‘Data Link Function’

Only the comments Ground Executive Controller are reported here, because only this BETA position was confronted with data link clearances to the DLR test aircraft.

Control Position	Controller index	Data Link Function
GEC	1	Too experimental
	2	It could be useful to have ‘electronic confirmation’ – for ATC.
	3	Easy, but not possible to vary during cleared action.
	4	Did not work properly.
	5	The clearance sequence did not correspond with the reality.
	6	It would help, but only if 100% working.

6.4.3.4.7 Comments to ‘Departure Manager Function’

The Tower Executive Controller did not use the sequence proposal of D-MAN, because the real departure traffic, which was controlled by the real CEC and GEC who did not use D-MAN information, did not behave to the calculated sequence of D-MAN. From there, no useful comments of the TEC were gained.

Control Position	Controller index	Departure Manager Function
CEC	1	Does not fit to our procedures.
	2	-
	3	-
	4	D-MAN is not useable in this way to the real traffic. No information about exact start up time of aircraft for counting departure sequence. Green slot bar is good. Dot for EOBT is good.
	5	Can become useful.
	6	
GEC	1	
	2	
	3	
	4	
	5	The sequencing does not correspond to the real traffic.
	6	

Separate interviews was conducted in order to get controllers’ impressions regarding the DMAN in more detail:

Questions to the Departure Manager	Controller index	Answers
1. Are the sequence numbers helpful and accurate?	1	Sequence numbers have the potential to be helpful in peak hours. Sequence numbers should be seen as a recommendation rather a rule.
	2	Sequence numbers are helpful but not accurate.
	3	Sequence numbers are not accurate. If the sequence numbers worked they would be useful. Sequence numbers have been designed more for the simulator than real-life. In real life pilots call in late and early, not all aircraft have slots and slots can change (aircraft can send a ready message and request an earlier slot). Controllers first give priority to aircraft with a slot, then ETD/EOBT. Sequencing if often performed on a first-come first-serve basis. Sequencing also depends on the readiness of the crew.

	4	Sequence numbers were not helpful and not accurate. The logic behind the software is so complicated. I do not understand the output. Don't want sequence numbers, just need good surveillance. Prefer not to see any sequence numbers at all.
	5	
	6	
2. Is DMAN flexible enough to be a useful tool during normal airport operations? (E.g. when aircraft are delayed, miss CFMU slot etc.). Describe any situations that would require the system to be more flexible.	1	Sequencing seems to be theoretical. I would like to be able to simply manually change the sequence number of the aircraft. Edit function for changing sequence number is too complicated. I would like to be able to change the order of flight strips in the active departure window by dragging and dropping the strips. I would like to see the sequence numbers in the flight strips of the active departures and the process of dragging and dropping the flight strips changes the sequence number. Controllers should be able to change the sequence number right up until take-off. DMAN needs to take account of non-standard conditions such as variable weather conditions, de-icing procedures and blocked taxiway.
	2	I would like to have the possibility to change sequence numbers manually at all times. DMAN is not flexible enough. I would like to see sequence numbers in the flight strips. I would like to be able to move flight strips and the sequence number changes with it (in active departures bay only). Introduce an 'on hold' window where flights that are delayed can be put and the sequence number in the depending departures adjusts accordingly.
	3	
	4	DMAN is not flexible enough. DMAN needs to take account of real time changes.
	5	
	6	
3. Does DMAN make you operate differently from normal practice? For example, with regard to: issuing clearance, maintaining wake vortex separation times, queuing aircraft at runway holding, communication with pilots and other controllers.	1	Controllers do not question the pilot's decision when they request start-up. Controllers issue start-up clearance at the pilot's request. Start-up clearance does not necessarily mean that the engines start immediately. The behaviour of pilots is company dependent. For example, Czech airlines call in when they are ready for departure clearance, start-up clearance and pushback clearance, whereas British Airways calls in 15 minutes before they are ready to request start-up clearance.
	2	Pilots decide when to go and ATC give permission. DMAN did not affect communication with pilots and other controllers. Controllers cannot give a delay to the pilot because of DMAN.
	3	Pilots may call in for start-up clearance much earlier than the EOBT, it does not mean that they are ready for actual start-up. Controllers issue start-up at the pilot's discretion - No change in working practices.
	4	No effect on communication with pilots and controllers
	5	
	6	
4. DMAN starts planning when the departure clearance button is pressed and freezes planning when the start-up button is pressed. Do you think it is appropriate to use these clearances to start and stop the planning of DMAN? Please describe other events/times that could be used to start and freeze the planning.	1	The departure clearance and the start-up clearance are given together at Prague
	2	Start planning at pushback clearance when the aircraft starts moving.
	3	Freeze sequencing before taxiing. Pushback means that the aircraft is actually ready to go.
	4	
	5	
	6	

5. What aspects of the current version of DMAN would prevent the system from being accepted by controllers?	1	Depends on personal opinions. Older controllers tend to reject computers. Acceptance depends on age and flexibility of using any systems. Prefer paper, pen and radar. Computer increases workload if it is not working properly. Can only accept systems that work properly. Need to keep the system as simple as possible.
	2	eobt bullet is too restrictive.
	3	Sequencing is wrong. Flight data messages such as too early are inconsistent
	4	Only accept the planned action timeline display showing CFMU slot, UTC and electronic flight strips.
	5	
	6	
6. What did you particularly like about DMAN?	1	
	2	The planned action timeline is very good, don't have to check the clock
	3	Planned action timeline. Sequencing, if it worked.
	4	
	5	
	6	
7. Please add any additional comments!	1	
	2	
	3	
	4	Need to be trained from the beginning to use sequence numbers, difficult to switch, as controllers are too deep into their trained procedures. Why should pilot standby for start-up if the pilot prefers to start his engines.
	5	
	6	

6.4.3.4.8 Comments to 'Route Deviation Alerts'

There are no comments of the Clearance Executive Controller, because the CEC is not involved in taxiing traffic. Also, the Route deviation alert function was switched off due to too many wrong alerts caused by deviation between the predicted and the real route.

Control Position	Controller index	Route Deviation Alerts
GEC	1	-
	2	It is necessary to have possibility to change the route.
	3	I did not take care about it
	4	-
	5	-
	6	-
TEC	1	
	2	70% - 80% wrong
	3	-
	4	Not needed for vacating aircraft. Good for aircraft that miss the right exit.
	5	-
	6	-

6.4.3.4.9 Comments to 'Runway Incursion Alerts'

Only the comments Ground Executive Controller are reported here, because only this BETA position was confronted with data link clearances to the DLR test aircraft.

Control Position	Controller index	Runway Incursion Alerts
TEC	1	-
	2	Ok.
	3	Worked perfectly Under good visibility with 2miles out the label should switch to orange Under low visibility already with 4miles out the label should switch to orange
	4	2x wrong
	5	-
	6	We are tested only breaking of the sensitive zone – pretending the LVP conditions – worked properly.

6.4.3.4.10 Comments to 'Planning Alerts'

Control Position	Controller index	Planning Alerts
CEC	1	I have not paid attention to '+30' alerts
	2	-
	3	'+30' alert wrong when EFS was updated
	4	'+30' alert can be useful when it will be displayed just 5 min before
	5	'+30' alert is not understood – better would be –10! –9! –8! etc.
	6	No comments.
GEC	1	-
	2	There are too much factors, which do influence planning.
	3	I did not pay attention to this alert.
	4	-
	5	-
	6	-
TEC	1	-
	2	-
	3	Too much "No RWY" alert
	4	-
	5	-
	6	-

7. Comparative assessment of the overall performance of the BETA System

7.1 Introduction

The objective of this section is to present the results of the second phase of the comparative assessment of the BETA system. More specifically, this section: i) provides a comparative assessment of the BETA system against the BASELINE system during the second evaluation phase, ii) compares the results of the comparative assessment and the actual measurements of the operational characteristics of the BETA system and the BASELINE system as they were measured during the second operational test phase, iii) compares the results of the comparative assessment during the first phase with the result during the second phase, and iv) compares the performance of the BETA system during the first and the second evaluation phase.

The objective of the second phase of the comparative assessment of the BETA system involves the:

- Evaluation of the estimated performance of the BETA system as compared to the BASELINE system.
- Assessment of the estimated performance of the BETA system between the first and the second evaluation phase.

To achieve the above mentioned tasks some modifications of the initial methodological approach were required. In the next section the modified methodological approached in presented, as well as any information related to its operationalization.

7.2 Methodological Approach

In order to perform the comparative assessment of the BETA system during the second evaluation phase, the evaluation approach developed and implemented during the first evaluation phase of the system was used, i.e. the Analytical Hierarch Process (AHP). However, there are some differences between the first and the second evaluation phases that can be summarized as follows:

- The set of performance indicators used is different
- The panel of experts used for conducting the assessment is different
- A time dimension in the evaluation of the BETA system was introduced, i.e. the comparative assessment of the BETA system performance during the first ad the second evaluation phase.

Table 7-1 that follows presents the indicators considered at each evaluation phase. According to this table, there are substantial differences between the two phases.

Indicator	1st Phase	2nd Phase
Situation Awareness	✓	✓
Number of Misunderstandings	✓	✓
Safety on taxi instructions execution	✓	-
Response time in case of conflict	✓	-
Time required by the controller in handling each a/	✓	-
Traffic delays	✓	-
RWY occupancy time	✓	-
RWY throughput	✓	-
Number of movements	✓	-
Number of follow-me cars	✓	-
Length of cues at the RWY threshold	✓	-
Number of 'wrong route taken'	✓	-
Number of R/T Communication	-	✓
Duration of R/T Communication	-	✓
Number of stops of a/c during taxiing	-	✓
Duration of stops during taxiing	-	✓
Holding time for a/c holding for line up at the RWY entry point	-	✓
Usability Head Down	-	✓
Level of workload	✓	✓
Usability	✓	✓
Acceptance	✓	✓
Idling time at the gate	✓	-
Lower fuel burn while taxiing	-	✓
Transition Cost	✓	✓
Development Cost	✓	✓
Operational Cost	✓	✓
Maintenance Cost	✓	✓
Training Cost	✓	✓

Table 7-1 Indicators Used for the Comparative Assessment of the BETA System in the two Evaluation Phase

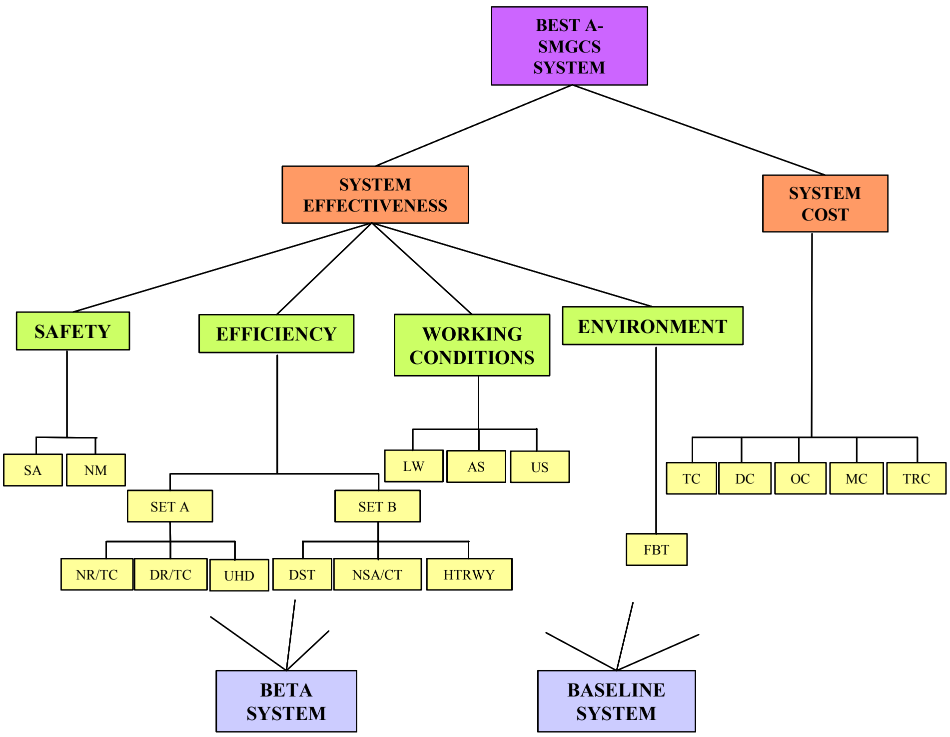

Figure 7-1 Hierarchical Decomposition of the Assessment of the Performance of the BETA system against the BASELINE

In the sections that follows information on the panel of experts used during the assessment and the results of the analysis performed are presents.

7.3 Results of the Comparative Assessment of BETA against BASELINE

Nine experts were participated at the comparative assessment of the BETA system during its second evaluation phase. These experts, were representing the following groups of stakeholders:

1. Pilots
2. Air Traffic Controllers
3. Airport Authority

The members of the expert panel were asked to self -rate their expertise in relation to the issues they were called upon to provide their opinion. The self -rated expertise was expressed on a scale from one to five where one stands for minimal expertise and five for very high expertise. Figure 7-2, presents a summary of the self rated expertise of the panel members.

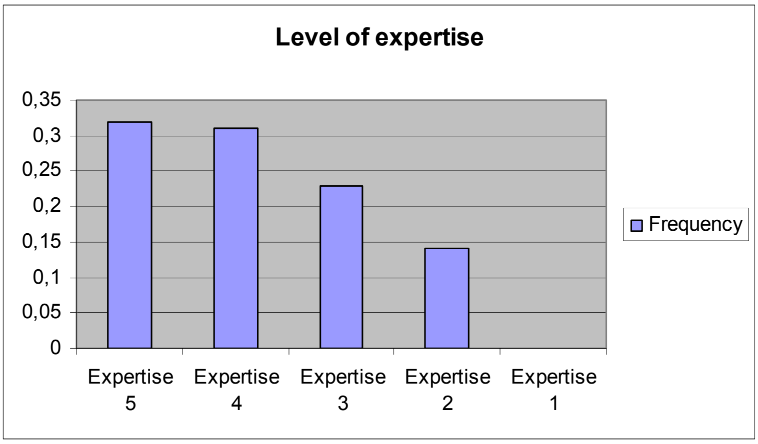

Figure 7-2 Level of Expertise of the Panel of experts in the Two Evaluation Phases

As it can be seen in Figure 7-2, the overwhelming majority of the panel participants, i.e. over 80%, have substantial self-rated expertise.

Regarding the estimation of the A-SMGCS system performance the experts were asked to provide their judgment in the form of pair-wise comparisons regarding the relative importance of each element located at a given level of the hierarchy of Figure 7-1 in influencing each element of the hierarchy located at the next higher level.

Number	Relative Importance
1	Equal importance
3	Moderate importance of one over another
5	Essential or strong importance of one over another
7	Very strong importance of one over another
9	Extreme importance of one over another
2,4,6,8	Intermediate values between the two adjacent judgments

Table 7-2 Composition of the Expert Panel

A software package was used for the analysis of the data collected, i.e. Expert Choice (Expert Choice Inc. 1998). Two types of graphs are used in order to summarize the results of the analysis. The first one is a bar chart, i.e. see for instance Figure 7-3, indicating the overall performance of the alternative A-SMGCS systems. The second type of chart (see for instance Figure 7-4), presents, the performance of the alternative systems in relation to the relative importance of the assessment criteria. The vertical axis on the right of this graph represents the ranking of the two alternative systems in terms of their overall performance. The horizontal axis of the graph represents the assessment criteria against which the performance of the alternative systems is assessed. The height of the vertical bars along the horizontal axis represents the relative importance of each criterion as these are expressed by the units indicated on the vertical axis in the left side of the graph. The two lines i.e. a solid, and a dashed line, indicate the fluctuation of the performance of each alternative system under consideration as a function of the relative importance of the assessment criteria.

The results of the analysis performed revealed that the BETA system is by far more preferable than the BASELINE system in terms of their overall performance. As Figure 7-3 suggests the BETA system outperforms the BASELINE system by more than a two to one ratio. Furthermore, the overall inconsistency of the expert judgements regarding the ranking of the two systems was very low, i.e. 9%, which suggests that the ranking of the two alternative systems is valid in terms of the logical consistency of the pair wise comparisons provided by the participating experts.

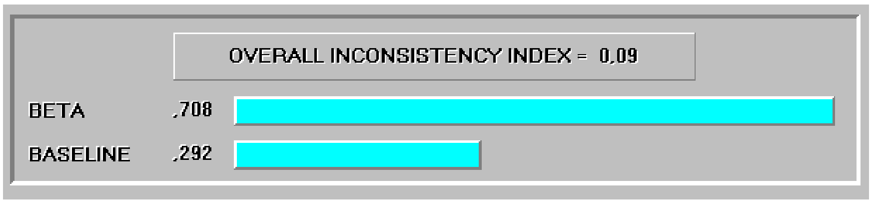

Figure 7-3 Comparative Assessment Results of the BETA system against the BASELINE system

The results of the sensitivity analysis are presented in Figure 7-4. The first result emerging from this analysis is that the BETA system outperforms by far the BASELINE not only in terms of their overall performance, i.e. 71% for BETA vs. 29% for the BASELINE, but also in terms of the system effectiveness criterion. However, as it was expected in the cost criterion the BASELINE system outperforms the BETA system since it costs less, i.e. there is no development or transition cost. Nevertheless, according to the figure the provided ranking is rather robust, since in order to have a rank reversal a substantial increase in the relative importance of the cost criterion is required (i.e. more than 56%).

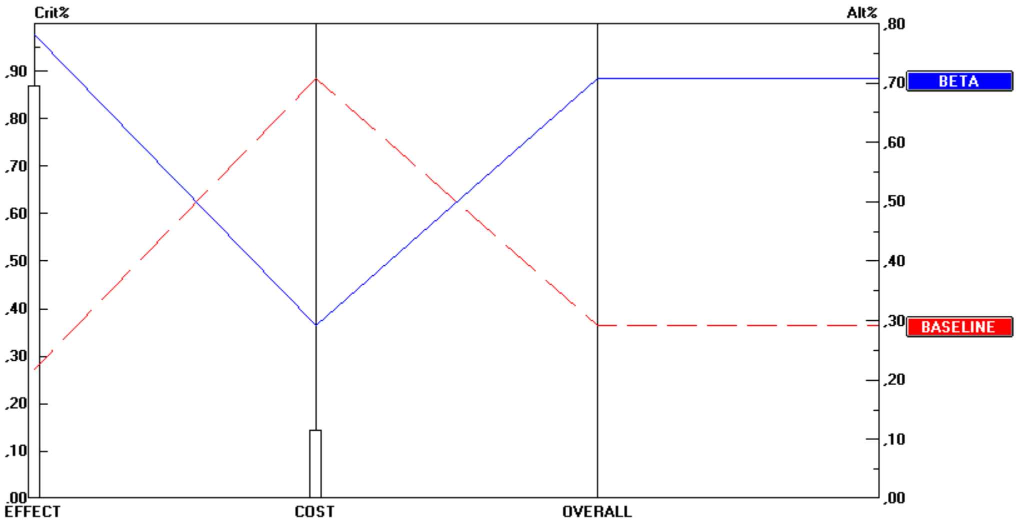

Figure 7-4 Sensitivity Analysis of the Comparative assessment Results

The importance for characterizing the overall performance of an A SMGCS, of the effectiveness and cost criterion is also illustrated in figure 7-6. According to the figure the effectiveness criterion outperforms the cost criterion with a more than four to one ratio. The logical consistency of the provided answers is perfectly consistent (i.e. the inconsistency ratio is zero)

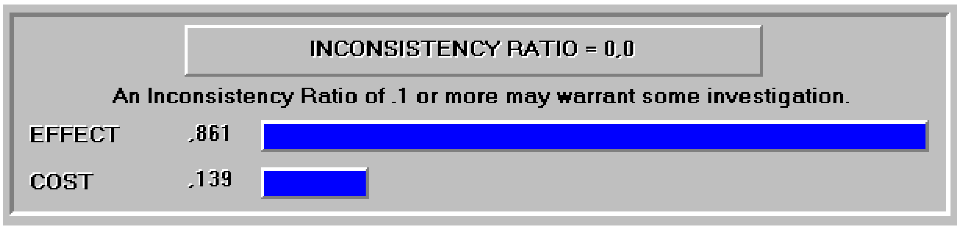

Figure 7-5 Ranking of the Assessment Criteria

In the table that follows the importance assigned to the various indicators measuring the effectiveness of an A SMGCS system, during the second evaluation phase of BETA is presented.

BETA Performance Indicator	Importance
Situation Awareness	0,56
Number of misunderstandings	0,13
Number of R/T Communication	0,06
Duration of R/T Communication	0,03
Number of stops of a/c during taxiing	0,02
Duration of stops during taxiing	0,02
Holding time for each aircraft holding for line up at the RWY entry point	0,02
Usability Head Down	0,02
Level of workload	0,04
Usability of the system	0,03
Acceptance of the system	0,02
Fuel burn while taxiing	0,05

Table 7-3 Relative importance of the effectiveness indicators

The analysis of the relative importance of the sub-criteria measuring the effectiveness of the BETA and BASELINE system suggests that safety was considered to be the most important criterion for the ranking of the two systems. As Figure 7-6 suggests safety accounts for about 69% of the impacts followed by efficiency, which accounts for almost 16%. Finally, environmental impacts and working conditions account for 5% and 10% respectively.

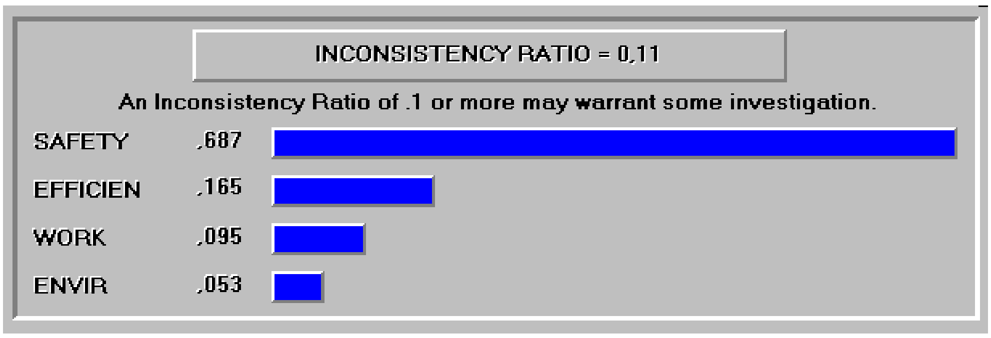

Figure 7-6 Ranking of the Effectiveness Criteria

Finally, according to Figure 7-7 among the indicators measuring the cost criterion the one with the highest relative importance is the development cost (DE) accounting for almost 44% to the system cost, followed by the operational (OPC) and maintenance costs (MAC), which account for 19% and 15% respectively. Then training cost (TRAC) and transition cost (TRC) is following with a contribution of 11% to the total cost each.

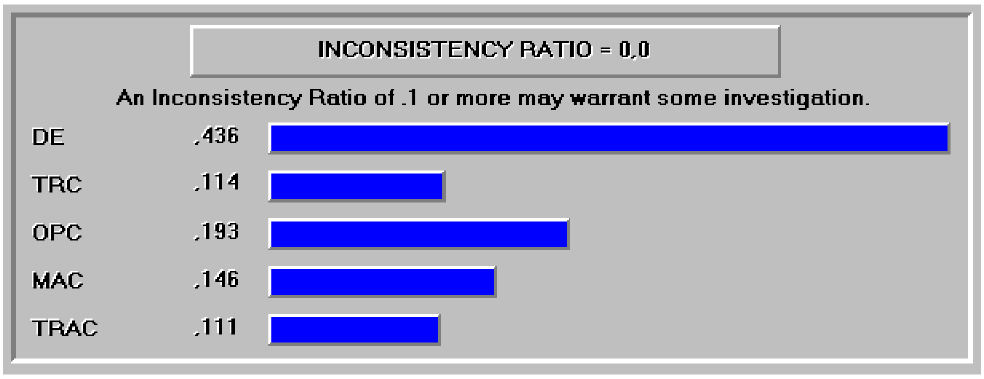

Figure 7-7 Ranking of the Cost Criteria

Despite the differences mentioned between the process deployed in conducting the comparative assessment between the first and the second evaluation phase, it may be useful to make an overview of the results of the comparative assessment between them, and therefore some interesting points are presented in the following section.

7.4 Comparison with the Results of the First Evaluation Phase

There are substantial differences between the comparative assessment developed during the first evaluation phase and the comparative assessment developed during the second evaluation phase. These differences involve both the expert panel composition, as well as the evaluation attributes considered, i.e. indicators. However, if the appropriate importance will be allocated to these differences, the results of the two phases can be critically discussed in order to identify commonalities.

The expert panel of the two phases varied both in composition and size. More specifically, at the first stage 11 experts were participated as compared to nine experts participated in the second phase. The majority of the experts used during the second phase were Air Traffic Controllers, with the exception of one Pilot and one representative of the Airport Authority, while at the first stage there were representatives from ASM ATFM Organization, Research Centres, and Systems Consultants. Figure 7-8 that follows presents the level of expertise of the persons involved at the two phases. According to Figure 7-8 the overall percentage of experts that have substantial self-rated expertise in both panels is around 80%. However, during the first phase the majority considered themselves to have substantial knowledge, while at the second phase to have expert knowledge. This difference can be attributed to the fact that the majority of the panel at the second phase is Air Traffic Controllers, i.e. the stakeholder group that has extensive experience in dealing with issues related to the effectiveness of traffic flow.

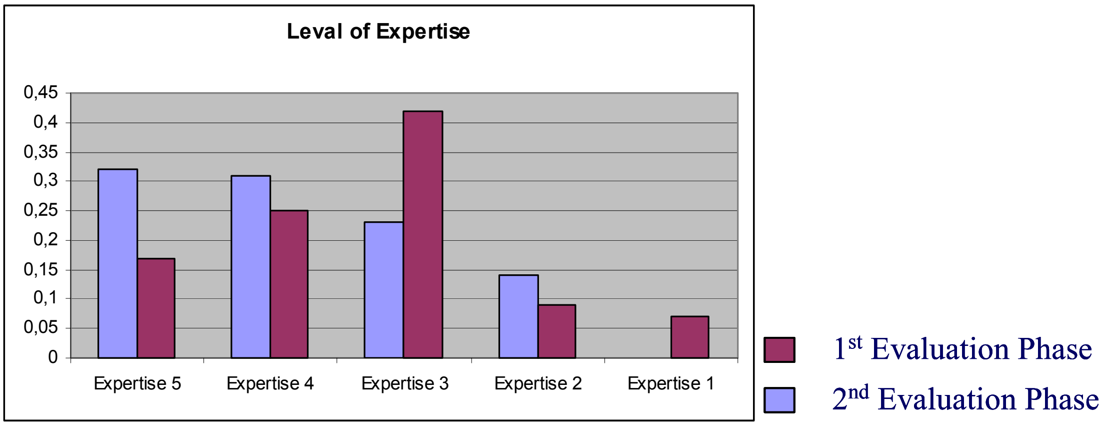

Figure 7-8 Level of Expertise of the Panel of experts in the Two Evaluation Phases

The BETA system was found to be much most preferable than the BASELINE system in terms of its overall performance during both evaluation phases. According to Table 7-4 in both cases BETA outperformed the BASELINE with almost a two to one ratio. The difference became slightly larger during the second phase and can be attributed to: i) the composition of the second panel, due to the fact that they are the immediate users of the BETA system has a better understanding of the potential benefits of the BETA system, and ii) that BETA system has been improved since the first evaluation phase. Also as can be seen from Table 7-5 during the second phase less importance has been attributed to the cost criterion and therefore effectiveness that is the competitive advantage of BETA over the BASELINE system has a more pronounced impact on the overall performance of the system.

A SM GCS Systems	1st Phase	2nd Phase
BETA	66,9%	70,8%
BASELINE	33,1%	29,2%

Table 7-4 Ranking of the two systems during the two evaluation phases

Criteria	1st Phase	2nd Phase
Effectiveness	0,839	0,861
Cost	0,161	0,139

Table 7-5 Relative importance of assessment criteria during the two evaluation phases

Table 7-6 presents the importance attributed to the various sub-criteria for the two evaluation phases. The following remarks can be made in reviewing the relative importance of these assessment attributes:

The importance allocated to safety has been increased; this can be attributed to the fact that the majority of the experts at the second phase are Air Traffic Controllers.
The importance of efficiency and environment has been substantially decreased possibly due to the same reason mentioned above.
The importance allocated to the development cost has been substantially increased as opposed to the recurrent cost items, i.e. operational and maintenance cost. This can be also attributed to the panel composition in the sense that Air Traffic Controllers can mainly realize large fixed costs outside their tasks. Express it differently, they are focused on their core system and not on the total airport system, i.e. they do not have a point of reference related to overall airport costs.

Sub-criteria	1st Phase	2nd Phase
Safety	0,558	0,687
Efficiency	0,227	0,165
Working Conditions	0,112	0,095
Environment	0,102	0,053

Development Cost	0,108	0,436
Transition Cost	0,099	0,114
Operational Cost	0,386	0,193
Maintenance Cost	0,272	0,146
Training Cost	0,135	0,135

Table 7-6 Relative importance of assessment sub-criteria during the two evaluation phases

Table 7-7 presents the performance of the BETA and the BASELINE system over the various indicators. According to the information provided at this table among the commonly considered indicators in the two evaluation phases there is a substantial increase in the performance of the BETA system over the BASELINE in the Usability and Acceptance indicators. This increase can be attributed to the improvements developed in the BETA system since the first phase, as well as to the new composition of the panel. More specifically, since these indicators are mainly related to Air Traffic Controllers the identified increase in the BETA performance can be also attributed to the following facts: i) the panel consists of more controllers than during the first phase, ii) they had the opportunity to use more the BETA system identify its usability and therefore accepted in a greater extent.

BETA Performance Indicator	1st Phase		2nd Phase	
	BETA	BASELINE	BETA	BASELINE
Situation Awareness	0,837	0,163	0,827	0,173
Number of misunderstandings	0,781	0,219	0,769	0,231
Number of R/T Communication	-	-	0,672	0,328
Duration of R/T Communication	-	-	0,669	0,331
Number of stops of a/c during taxiing	0,741	0,259	0,682	0,318
Duration of stops during taxiing	-	-	0,694	0,306
Holding time for each aircraft holding for line up at the RWY entry point	-	-	0,699	0,301
Usability Head Down	-	-	0,816	0,184
Level of workload	0,611	0,389	0,682	0,318
Usability of the system	0,682	0,318	0,810	0,190
Acceptance of the system	0,655	0,345	0,818	0,192
Fuel burn while taxiing	-	-	0,723	0,272
Development Cost	0,228	0,772	0,240	0,760
Transition Cost	0,249	0,751	0,252	0,748
Operational Cost	0,313	0,687	0,323	0,677
Maintenance Cost	0,357	0,643	0,407	0,593
Training Cost	0,431	0,569	0,289	0,711

Table 7-7 Relative performance of the BETA and the BASELINE system in terms of the various indicators during the two evaluation phases

Based on the above identified issues it can be claimed that especially in terms of effectiveness BETA system has been considered to have a superior performance, as compared to the BASELINE system, at both evaluation phases and for a variety of stakeholder groups of the Prague Airport. To make this conclusion more reliable within the next section a critical discussion of the results of the comparative assessment of the BETA system performance and of the results of other operational performance tests of the BETA system conducted within the second evaluation phase is presented.

7.5 Results of the Comparative Assessment of BETA System Performance during the Two Evaluation Phases

The results of the analysis performed found that the performance of the BETA system is by far more preferable during the second evaluation phase. As Figure 7-9 suggests the BETA system during the second phase is much more preferable as compared to the first phase by more than a two to one ratio.

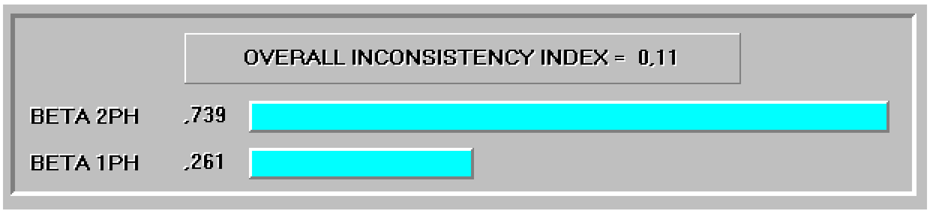

Figure 7-9 Ranking of the BETA system in terms of its performance between the two evaluation phases

The results of the sensitivity analysis revealed that the provided ranking is robust since, as illustrated in the Figure 7-10 the ranking of BETA system during the two phases is not affected by the weight assigned to the effectiveness criteria considered.

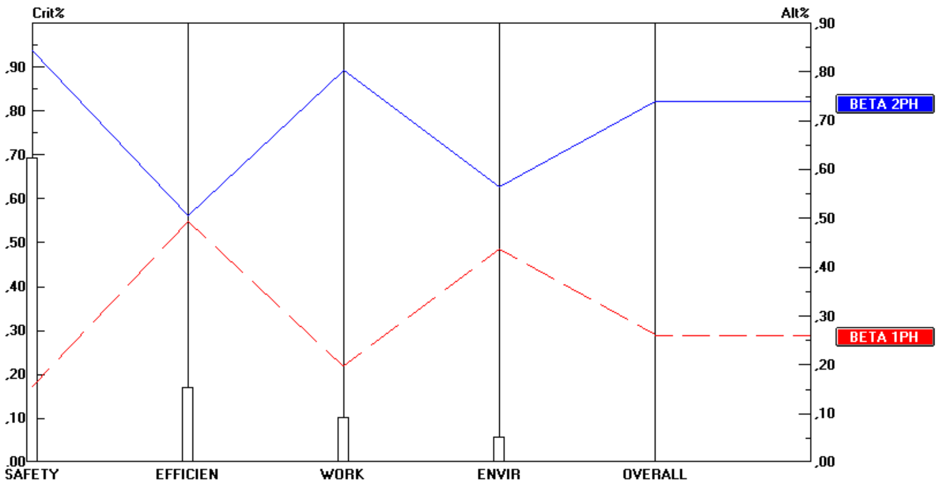

Figure 7-10 Sensitivity analysis for the ranking of the performance of the BETA system between the two evaluation phases

At this point it should mentioned that the experts were called to assess the performance of BETA during the two evaluation phases with respect to their perception of its performance on the attributes considered during the second evaluation phases, which as mentioned before are different than those considered in the first evaluation phase. Therefore, this outcome should not be compared without consideration to the results of the assessment between the two evaluation phases.

8. Annex

8.1 Test Protocol

List of Protocols:

2002-05-21

F1A	Surveillance Accuracy					CS	Version 1.0	
Title	Test Surveillance Integrity Parameter of NRN Test Van on RWY-24 and TWY-Alpha and Bravo					✔	**Remarks**	
Scenario	1. Test Van starts at apron North 2. It requests to taxi to RWY-24 via TWY-Alpha 3. BGEC clears Test Van to taxi rwy 24 via A 4. Test Van requests for taxi RWY-24, leaving via TWY-B, to RWY-24 via TWY-A 5. BGEC clears Test Van DLR for taxi RWY-24 – B and A This test will be repeated for at least 5 times						Test can be interrupted at all time.	
Aim	Measure Surveillance performance parameters of NRN							
Success Criteria	1. The movement of the car is recorded successfully 2. Continuity of the track at HMI							
Duration	60 minutes estimated							
Meteo	Good visibility							
Traffic	No other traffic at used area							
Active Sensors	**SMR**	yes	**ASR**	yes	**Mode S** yes		All Active Sensors have to be recorded	
	NRN	yes	**GP&C**	yes				
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND** **121,900**		**Tech. Freq.**	**130.100**
Special Mns	**Voice Button**	no	**SART**	no				
	Stop Watches	no	**NASA TLX**	no				
	Blind Shield	no	**Usability Quest.**	no				
			Debriefing Note	yes				

Actual Data

Date	2002-05-21	Test Van i.d.	D-AZZZ, P. Horn		
Time UTC	14:00	**BOB**	A. Gilbert, K. Klein, K. Werner, H. P. Zenz		
Record i. d.	20020521-03.CSC (GP&C) 20020521-140723-sdf.log (NRN)				
Time UTC	**Observation**				
14:15	Start with 1 Run				
14:44	Test Van waits on apron south of TWY A for about 2 min				
15:00	End of Test				

Table 8-1 F1A, 2002-05-21, NRN Surveillance

2002-05-21

F1B	Surveillance Accuracy	CS	Version 1.0
Title	Test Surveillance Integrity Parameter of SDS Test Van on RWY' s and TWY' s	✔	**Remarks**
Scenario	1. Test Van starts at apron North and requests to taxi apron north F-RWY06-RWY13-L-RR-R-N-M-L-K-A-RWY24-A 2. BGEC clears Test Van to taxi The Test Van proceeds on TWY' s with 30km/h and on RWY' s with maximum speed		If necessary the test run can be interrupted at all position.
Aim	Measure Surveillance performance parameters		
Success Criteria	1. The movement of the car is recorded successfully 2. The car dynamics approaches real aircraft behaviour 3. Continuity of the track at HMI		
Duration	90 minutes estimated		
Meteo	Good visibility		
Traffic	Low density or no other traffic		

Active Sensors	**SMR**	Yes	**ASR**	yes	**ModeS**	yes		All Active Sensors have to be recorded	
	NRN	Yes	**GP&C**	yes					
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**		**Tech.Freq.**	**130.100**

Special Mns	**Voice Button**	no	**SART**	no		
	Stop Watches	no	**NASA TLX**	no		
	Blind Shield	no	**Usability Quest.**	no		
			Debriefing Note	yes		

Actual Data

Date	2002-05-21	**Test Van i.d.**	D-AZZZ, P. Horn
Time UTC	15:00	**BOB**	A. Gilbert, K. Klein, K. Werner, H. P. Zenz
Record i.d.	20020521-03.CSC (GP&C) 20020521-150548-sdf.log (GP&C)		

Time UTC	Observation		
15:10	Test Van Start Taxi		
15:13	Test Van stops at F/RWY13 for 3 sec		
15:14	Test Van stops at F/D for 30 sec		
15:22	Test Van stops at F/E for 30 sec		
15:24	Test Van stops at F/RWY06 CATIII for 30 sec		
15:27	Test Van stops at RWY06/RWY13 for 30 sec		
15:32	Test Van stops at RWY13/RWY04 for 30 sec		
15:35	Test Van stops at L/RWY31 CATIII for 30 sec		
15:46	Test Van stops at A/RWY24 CATIII for 30 sec		
17:50	Test end		

Table 8-2 F1B, 2002-05-21, SDS Surveillance Accuracy

2002-05-22

F1D	**Surveillance accuracy TRL**						**CS**	Version 1.0	
Title	CWP Performance Measuring the Target Report Latency (TRL) of the CWP							**Remark**	
Scenario	1. Define a marked position on the RWY at the airport. Position: Crossing RWY13/31 with TWY-F 2. The test vehicle drives with a constant high speed passing the marked position 3. Start the stopwatch if a target is passing the marked position at the RWY. 4. Stop the stopwatch if the target is passing the marked position at the screen. Repeat this test for at least 10 times							If necessary locate the Test Van for defining the marked position	
Aim	Measuring the Target Report Latency								
Duration	60 minutes								
Meteo									
Traffic	Normal traffic								
Active sensors	**SMR** **NRN**	Yes yes	**ASR** **GP&C**	Yes Yes	**ModeS**	yes			
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**		**Tech.Freq.**	**TBD**
Special mns	**Voice Button**	no	**SART**			no			
	Stop Watches	**yes**	**NASA TLX**			no			
	Blind Shield	no	**Test Report**			**yes**			
			Debriefing note			**yes**			
Actual data									
Date	2002-05-22		**Test van id.**		FOLLOW1				
Time	07:50 UTC		**BOB**		A. Gilbert, K. Klein, K. Werner, H. P. Zenz				
Record id.	20020522-01.CSC								
	Observation								
Time UTC	Crossing RWY13 TWY-F								
07:55	1.	TRL = 0.7 sec RWY31							
	2.	TRL = 0.3 sec RWY13							
	3.	TRL = 0.1 sec RWY31							
	4.	TRL = 0.3 sec RWY13							
	5.	TRL = 0.1 sec RWY31							
	6.	TRL = 0.2 sec RWY13							
	7.	TRL = 0.1 sec RWY31							
	8.	TRL = 0.2 sec RWY13							
	9.	TRL = 0.2 sec RWY31							
	10.	TRL = 0.2 sec RWY13							
	11.	TRL = 0.1 sec RWY31							
08:20		Test End							

Table 8-3 F1D, 2002-05-22, SDS Surveillance Accuracy TRL

2002-05-22

F1C-ELK	Surveillance accuracy					CS	Version 1.0
Title	Test Surveillance Integrity Parameter of SDS Elk test with Test Van					✔	**Remark**
Scenario	The Test Van (TV) make a sharp turn with the highest possible velocity						
	1. The Test Van requests to taxi on TWY-G-J-K-L 2. After clearance the TV makes sharp turn TWY' s This procedure will be repeated for at least 5 times						If necessary the test run can be interrupted at all position.
Aim	to test track drop in sharp turns						
Success criteria	1. the track is recorded successfully 2. the procedure is done without interruption						
Duration	45 minutes estimated						
Meteo	Good visibility						
Traffic	No other traffic						
Active sensors	**SMR** **NRN**	Yes Yes	**ASR** **GP&C**	yes yes	**ModeS**	yes	All Active Sensors have to be recorded
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**	**Tech.Freq.**
Special mns	**Voice Button**	no	**SART**		no		
	Stop Watches	no	**NASA TLX**		no		
	Blind Shield	no	**Usability Quest.**		no		
			Debriefing note		yes		
Actual data							
Date	2002-05-22	**Test van id.**	FOLLOW1				
Time	08:15 UTC	**BOB**	A. Gilbert, K. Klein, K. Werner, H.P. Zenz				
Record id.	20020522-02.CSC (GP&C) BT-20020522-081357-GPC.log (GP&C) TT-20020522-081340-sdf.log (GP&C) TT-20020522-081346-sdf.log (ASCS)						
Time	**Observation**						
08:17	Start Test						
	7Kts G-J-K-L						
	8Kts G-J-K-L						
08:57	End Test						

Table 8-4 F1C, 2002-05-22, SDS Surveillance Accuracy (Elk Test)

2002-05-22

F3C-1	Alerting Performance Test						CS	Version 1.0	
Title	Stop bar crossing						✔	Remark	
Scenario	1. Define a restricted stop bar 2. Test vehicle is passing this stop bar and generates an alarm							This test will be done only for few of alerts to check the proper working of the alarm.	
Aim	Checking if the special code alerts are indicated on CWP								
Success Criteria	Alerting functions are working								
Duration	90 minutes								
Meteo	Good visibility								
Traffic	Normal traffic								
Active sensors	SMR NRN	Yes Yes	ASR GP&C	Yes Yes	ModeS	Yes			
Comm.	TWR	118,100	DEL	119,700	GRND	121,900		Tech.Freq.	TBD
Special mns	Voice Button	no	SART			no			
	Stop Watches	yes	NASA TLX			no			
	Blind Shield	no	Test Report			yes			
			Debriefing note			yes			
Actual data									
Date	2002-05-22		Test van id.						
Time	12:10 Local		BOB		A. Gilbert, K. Klein, H. P. Zenz				
Record id.	20020522-05.CSC								
	Observation								
Time Local									
	Stop bar definition = B/RWY24 CATII								
12:10	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
	3	Alert response Time 2.5 sec					ART	measured	
	Stop bar definition =								
	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
	3	Alert response Time Ok					ART	measured	
	Stop bar definition =								
	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
	3	Alert response Time 2,4 sec / 0,8 sec					ART	measured	
	Stop bar definition =								
	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
	3	Alert response Time					ART	measured	
12:35		Test End							

Table 8-5 F3C-1, 2002-05-22, Alert Performance Test

2002-05-22

F3A-1	**Alerting Performance Test**						**CS**	Version 1.0
Title	Runway Incursion						✔	**Remark**
Scenario	1. BETA System in low visibility conditions 2. Locate the test vehicle at “CAT I” Stop bar 3. Landing and departing a/c generates an alarm							This test will be done only for few of alerts to check the proper working of the alarm.
Aim	Checking if the special code alerts are indicated on CWP							
Success Criteria	Alerting functions are working							
Duration	90 minutes							
Meteo	Good visibility							
Traffic	Normal traffic							
Active sensors	**SMR** **NRN**	Yes Yes	**ASR** **GP&C**	Yes Yes	**ModeS**	Yes		
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**		**Tech.Freq.** **TBD**
Special mns	**Voice Button**	no	**SART**			No		
	Stop Watches	yes	**NASA TLX**			No		
	Blind Shield	no	**Test Report**			**Yes**		
			Debriefing note			Yes		
Actual data								
Date	2002-05-22		**Test van id.**		FOLLOW1			
Time	12:45		**BOB**		A. Gilbert, K. Klein, H. P. Zenz			
Record id.	20020522-05.CSC							
	Observation							
Time								
12:45	Position of test vehicle = TWY D / RWY06							
	Take Off a/c							
	1.	Probability of Detection					PDAS	Checked
	2	Probability of False Alert					PFA	Checked
	3	Alert response Time					ART	
	Landing a/c							
	1.	Probability of Detection					PDAS	Checked
	2	Probability of False Alert					PFA	Checked
	3	Alert response Time					ART	
13:30		Test End						

Table 8-6 F3A-1, 2002-05-22, Alert Performance Test

2002-05-22

F3C-2	**Alerting Performance Test**						**CS**	Version 1.0	
Title	Stop bar crossing						✔	**Remark**	
Scenario	3. Define a restricted stop bar 4. Test vehicle is passing this stop bar and generates an alarm Taxi B-RWY24-C-H							This test will be done only for few of alerts to check the proper working of the alarm.	
Aim	Checking if the special code alerts are indicated on CWP								
Success Criteria	Alerting functions are working								
Duration	90 minutes								
Meteo	Good visibility								
Traffic	Normal traffic								
Active sensors	**SMR** **NRN**	Yes Yes	**ASR** **GP&C**	Yes Yes	**ModeS**	Yes			
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**		**Tech.Freq.**	**TBD**
Special mns	**Voice Button**	no	**SART**			no			
	Stop Watches	**yes**	**NASA TLX**			no			
	Blind Shield	no	**Test Report**			**yes**			
			Debriefing note			yes			
Actual data									
Date	2002-05-22	**Test van id.**		FOLLOW1					
Time	13:04 Local	**BOB**		A. Gilbert, K. Klein, K. Werner,H. P. Zenz					
Record id.	20020522-05.CSC								
	Observation								
Time Local									
	Stop bar definition = B/RWY24								
	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
13:07	3	Alert response Time 1.3 sec					ART	measured	
	Stop bar definition =								
	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
13:13	3	Alert response Time 0.7 sec					ART	measured	
	Stop bar definition =								
	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
13:17	3	Alert response Time 0.96 sec					ART	measured	
	Stop bar definition =								
	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
13:29	3	Alert response Time 1.0 sec					ART	measured	
	Stop bar definition =								
	1.	Probability of Detection					PDAS	Checked	
	2	Probability of False Alert					PFA	Checked	
13:35	3	Alert response Time 0.97 sec					ART	measured	
13:45		Test End							

Table 8-7 F3C-2, 2002-05-22, Alert Performance Test

2002-05-22

Observation time from 13:42 to 15:45 UTC. Observer: H.-P. Zenz, K. Klein, A. Gilbert
RWY 06 in use, RWY 13/31 closed due to construction work

A/D	Call Sign	Detected	Identified	Taxi	Remark
D	TYR708T	13:44	13:48	H-F-06	
A	DAT67H	13:45	13:45	06-B-P9	
A	CSA039	13:47	13:47	06-stand	No loss
A	CSA829	13:53	13:53	06-P36C	No loss
A	CSA973	13:55	13:55	06-stand	No loss
A	CBA40	14:01	14:01	06-C-L-R-parking on R	Losses while parking
A	CSA881	14:05	14:05	06-B-Stand	No loss
D	CSA536	14:06	14:12	Stand-push back-H-F-E-06 t/o 14:15	
A	CSA823	14:08	14:08	06-C-G-P3A	No loss
A	CSA735	14:11	14:11	06-C-stand	No loss
D	CSA026	14:12			False target at crossing RWY 13/06 for 10 seconds
D	KLM356	14:18	14:26	P11-H-F-06 t/o 14:28	
A	AFR3442	14:20	14:20	06-B-G-P32	No loss (ghost target in Approach picture due to ASR)
A	CSA857	14:26	14:26	06-B-P7	No loss
D	GOE152		14:37	Stand-H-F-06	
D	S94	14:24	14:35	04/22-P-L-06 t/o 14:36	No loss (Air Force 2)
D	DAT67R	14:29	14:40	P9-H-F-06 t/o 14:41	No loss
A	CSA559	14:30	14:30	06-C-H-Stand	No loss
A	CBA41	14:33	14:33	06-C-L-P-04/22 parking 14:40	
D	FFR3307	14:36	14:44	P10-H-F-06 t/o 14:45	
A	CSA917	14:39	14:39	06-B-P12	No loss
D	CSA766	14:40	14:50	Stand-A-H-F-E-06 t/o 14:51	On H track loss due to pier B
A	OKLAB	14:44	14:44	06-C-L-?	
A	OKPRA			06-C-L-P-Stand	2 targets over RWY due to slow a/c, ID loss at 14:51
A	AZA516	15:01	15:01	06-B-A-P1	No loss
D	CSA508	14:59	15:07	P5-H-F-06 t/o 15:07	No loss
A	AFR2282	15:04	15:04	06-B-P6	At 15:06 SQ to 2000
D	CSA526	15:08	15:10	P4-H-F-E-06 t/o 15:17	No loss
D	CSA560			Stand-06 t/o 15:09	
D	AFR344		15:15	P32-H-F-D-06 t/o 15:15	
D	CSA778		15:23	Stand-H- F-E-06 t/o 15:21	
D	DLH3225		15:23	P25-F-E-06 t/o 15:23	
A	CSA725	15:19	15:19	06-B-A-stand	No loss
D	CSA7322	15:24	15:34	Stand-L-F-D-06 t/o 15:35	
D	CSA544		15:32	Stand-06 t/o 15:29	
D	CSA788				
D	CSA388	15:26	15:29	P3-A-G-F-06 t/o 15:39	
A	CSA491	15:26	15:26	06-B-stand	No loss
A	N938H	15:28	15:28	06-C-L-stand	No loss
A	CSA433	15:31	15:31	06-B-P2	No loss
D	CSA618		15:37	?-F-E-06 t/o 15:37	
A	DLH3310	15:36	15:36	06-B-G-J-P16	No loss

Table 8-8 F2-a, 2002-05-22, Surveillance Monitoring, Observer K. Klein

2002-05-22
Observation time from 13:42 to 15:45 UTC. Observer: H.-P. Zenz, K. Klein, A. Gilbert
RWY 06 in use, RWY 13/31 closed due to construction work

A/D	Call Sign	Detected	Identified	Taxi	Remark
D	TYR708T	13:44	Taxiing		Labelled while taxiing
L	DAT67H	13:45	13:45	B to Stand 10	
L	CSA039	13:48	13:48	B to Stand 36A	
L	CSA829	13:53	13:53	B Stand 37?	
L	CSA973	13:55	13:55	B Stand 37A	
D	KLM1536	14:14	TKOF	Stand 12 B-H-F	Labelled at TKOF
L	CBA40	14:01	14:01	C-L-P Stand B1	
D	CSA026	14:08	TKOF	D	Labelled at TKOF
D	CSA536	14:08	TKOF	D	Labelled at TKOF
L	CSA881	14:05	14:05	B-G-J Stand 16	Lost track on TWY-J
L	CSA826	14:10	14:10	B-G Stand 37A	
L	CSA735	14:11	14:11	B-G Stand 38B	
D	FFR3307	14:35	14:45	Stand 10 B-H-F	Labelled at TKOF
D	GOE152	14:24			Labelled at TKOF
L	AFR3442	14:22	14:22	B-G Stand 32	
D	S94	14:25	14:35		Labelled at TKOF
L	CSA857	14:27	14:27	B-A Stand 7	
D	DAT67R	14:31		Stand 9 B-H-F	Labelled at TKOF
L	CSA559	14:30	14:30	B-H Stand 23	
L	CSA41	14:31	14:31	B-G-C-L-P Stand B4	
D	CSA766	14:41		Stand 2 A-H-F	Labelled at TKOF
L	CSA917	14:40	14:40	B Stand 12	
L	OKLAB	14:45	14:45	B-G-C-L-P Stand B3	
L	OKPRA	14:51	14:51	B-G-C-L-P Stand B4	
D	CSA508	14:59		Stand 5 A-H-F	Labelled at TKOF
L	AZA516	15:01	15:01	B-A Stand 1	
D	CSA560	15:02		Stand 35B H-F	Labelled at TKOF
L	AFR2282	15:05	15:05	B-A Stand 6	
D	CSA526	15:10	15:11	Stand 4 H-B	Labelled while taxiing
D	CSA778	15:12		Stand 35A H-F	Not labelled
D	AFR344Q	15:08		Stand 32 H-F	Labelled at TKOF
D	DLH3225	15:16		Stand 25 K-F	Labelled after TKOF
L	CSA725	15:20	15:20	B-A Stand 3	
D	CSA788	15:25		Stand 13 B-H-F	Not labelled
D	CSA544	15:24		Stand 38B H-F	Labelled after TKOF
D	CSA7322	15:33		Stand B16 P-L-F	Labelled at TKOF
D	CSA388	15:30		Stand 3 A-H-F	Labelled while taxiing
L	CSA491	15:27	15:27	B-A Stand 4	
L	N938H	15:28	15:28	B-G-C-L-P Stand B3	
L	CSA433	15:31	15:31	B-A Stand 2	
L	DLH3310	15:35	15:35	B-G-J Stand 16	
D	CSA618	15:33		Stand 7 A-H-F	Labelled at TKOF

Table 8-9 F2-b, 2002-05-22, Surveillance Monitoring, Observer H. P. Zenz

2002-05-22

F5-TKOF	Testing Guidance Performance Parameters							**CS**	Version 1.0
Title	Check Onboard HMI and data link with CWP Take Off Procedure							✔	**Remark**
Scenario	1. Place the Test Van with the onboard HMI at an a/c parking place. 2. Start data link procedure by request at the Test Van								Test procedures will be outlined by PAS and NLR
Aim	Checking the functionality of the CWP input and data-link indication								
Success criteria	1. Request and acknowledge of the Test Van are displayed immediately 2. Clearances are transmitted and display at the onboard HMI immediately Taxi routes are displayed at the onboard HMI in a proper way								
Active sensors	**SMR** **NRN**	Yes Yes	**ASR** **GP&C**	Yes Yes	**ModeS**	Yes			
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**			**Tech.Freq.**
Special mns	**Voice Button**		no	**SART**		no			
	Stop Watches		no	**NASA TLX**		no			
	Blind Shield		no	**Test Report**		**yes**			
	DALICON Record		**Yes**	**Debriefing note**		yes			
Actual data									
Date	2002-05-22		**Test van id.**		D-AZZZ, K. Werner, L. Ehmke				
Time	16:05		**BOB**		H. P. Zenz				
Record id.	**BT-20020522-160425-DLK.LOG**								
	Observation								

Remarks		**Procedure**	**Operator at the Test Van**	**Operator at the CWP**	**Check**
	1	Initial call			
OK	1.1		Request Departure		CWP received
OK	1.2			Cleared Departure	HMI clearance received
OK	1.3		WILCO		CWP WILCO received
	2	Start Up			
OK	2.1		Request Start Up		CWP received
OK	2.2			Cleared Start Up	HMI clearance received
OK	2.3		WILCO		CWP WILCO received
	3	Push Back			
OK	3.1		Request Push Back		CWP received
OK	3.2			Cleared Push Back	HMI clearance received
OK	3.3		WILCO		CWP WILCO received
	4	Request Taxi			
OK	4.1		Request Taxi		CWP received
Not correct	4.2			Transmit Taxi Routing	HMI Taxi routing shown
OK	4.3		WILCO		CWP WILCO received
	5	Lining Up			
OK	5.1		Request Line Up		CWP received
OK	5.2			Cleared for Line UP	HMI clearance received
OK	5.3		WILCO		CWP WILCO received
	6	Take Off			
OK	6.1		Request Take Off		CWP received
OK	6.2			Cleared for Take Of	HMI clearance received
OK	6.3		WILCO		CWP WILCO received

The syntax of the transmitted taxi routing was wrong!

Table 8-10 F5-TKOF, 2002-05-22 Testing Guidance Performance Parameters

2002-05-22

F5-LDG	Testing Guidance Performance Parameters					**CS**	Version 1.0
Title	Check Onboard HMI and data link with CWP Landing Procedure					✔	**Remark**
Scenario	1. Place the Test Van with the onboard HMI at an a/c parking place. 2. Start data link procedure by request at the Test Van						Test procedures will be outlined by PAS and NLR
Aim	Checking the functionality of the CWP input and data-link indication						
Success criteria	1. Request and acknowledge of the Test Van are displayed immediately 2. Clearances are transmitted and display at the onboard HMI immediately 3. Taxi routes are displayed at the onboard HMI in a proper way						
Duration	15 minutes						
Meteo							
Traffic	Normal traffic						
Active sensors	**SMR** **NRN**	Yes Yes	**ASR** **GP&C**	Yes Yes	**ModeS**	Yes	
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**	**Tech.Freq.** **TBD**
Special mns	**Voice Button**	no	**SART**		no		
	Stop Watches	no	**NASA TLX**		no		
	Blind Shield	no	**Test Report**		**yes**		
	DALICON Record	**Yes**	**Debriefing note**		yes		
Actual data							
Date	2002-05-22	**Test van id.**	D-AZZZ, K. Werner, L. Ehmke				
Time	16:20 to 16:30	**BOB**	H. P. Zenz				
Record id.	**BT-20020522-162209-DLK.LOG**						
	Observation						

Remarks		**Procedure**	**Operator at the Test Van**	**Operator at the CWP**	**Check**
	1	Landing			
OK	1.1		Request to land		CWP received
OK	1.2			Cleared to land	HMI clearance received
OK	1.3		WILCO		CWP WILCO received
	2	Taxiing			
OK	2.1		Request Taxi		CWP received
Not correct	2.2			Transmit Taxi Routing	HMI Taxi routing shown
OK	2.3		WILCO		CWP WILCO received

The syntax of the transmitted taxi routing was wrong!

Table 8-11 F5-LDG, 2002-05-22 Testing Guidance Performance Parameters

2002-05-23

F4-ARR-1 / F3A-2	**Testing Electronic Flight Strips, EFS, on arrival Alerting Performance Test**						**CS**	Version 1.0
Title	EFS Test and Runway Incursion Alert Test							**Remark**
F3A-2 / F4-ARR-1	**Alerting Performance Test**						**CS**	Version 1.0
Title	Runway Incursion							**Remark**
Scenario	No specific scenario.Observing the actual traffic.							
Aim	Checking if all flight strips are available and complete. Checking if the special code alerts are indicated on CWP							
Success criteria	Alerting functions are working							
Traffic	Normal traffic							
Active sensors	All Sensors are working							
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**		
Special mns				**Debriefing note**		Yes		
Actual data								
Date	2002-05-23	**Test van id.**						
Time UTC	7:20 to 09:30	**BOB**	K. Klein, H. P. Zenz					
	Observation							

Time UTC	Call Sign		Remark	Alarm OK / False		
07:20			RWY06 in use			
07:28	CSA604	Dep	Hold on RWY06 CAT-I			
07:29	CSA769	Arrival	LDG on RWY06	RWY-Incurs	Ok	
07:30	CSA591	Arrival	LDG on RWY06	RWY-Incurs	OK	
07:35	CSA733	Arrival	LDG on RWY06, Taxiing via C	Route Deviation	OK	
07:35	MDL777	Arrival	LDG on RWY06, Taxiing via B	Route Deviation		False
07:42	CSA555	Arrival	LDG on RWY06, Taxiing via B	Route Deviation		False
07:48	GES311 CEF6041	Dep.	1 target with two different call-signs	RWY Conflict	OK	
08:04	CSL1	Dep	Hold on TWY-E/RWY06			
08:05	CSA1633	Arrival	LDG on RWY06	RWY-Incurs	Ok	
08:06	CSA1633	Arrival	Stop on TWY-B			
08:07	KLM1351	Dep	TKOF RWY06	RWY-Incurs	Ok	
08:17			RWY changed from 06 to 24			
08:38	CSA764	Dep.	Hold on RWY24 - A			
08:38	TVS413	Arrival	LDG RWY24	RWY-Incurs	OK	
09:00	DLH653	Dep.	Hold on RWY24 - A			
09:00	CSA653	Arrival	LDG RWY24	RWY-Incurs	OK	
09:08	GOE285	Arrival	2 Targets generated	RWY Conflict	OK	

Remark:
Taxi plan, EFS:
All taxi plans available and complete for arrival.
Alarms:
Route deviation depending on taxi plan generation. In general false.
All other alarms OK. False alarms by generating a second false target on the CWP.
Light a/c are generating two targets on the CWP in general.

Table 8-12 F3A-2 / F4-ARR-1, 2002-05-23, Alerting Performance and EFS Test

2002-05-23

F4-ARR-2 / F3A-3	**Testing Electronic Flight Strips, EFS, on arrival Alerting Performance Test**						**CS**	Version 1.0
Title	EFS Test and Runway Incursion Alert Test						✔	**Remark**
Scenario	• BETA System in low visibility conditions • Locate the test vehicle at "CAT I" Stop bar • Landing and departing a/c generates an alarm							This test will be done only for few of alerts to check the proper working of the alarm.
Aim	Checking if all flight strips are available and complete. Checking if the special code alerts are indicated on CWP							
Success Criteria	Alerting functions are working							
Duration	15 minutes							
Meteo	Good visibility							
Traffic	Normal traffic							
Active sensors	**SMR** **NRN**	Yes Yes	**ASR** **GP&C**	Yes Yes	**ModeS**	Yes		
Comm.	**TWR**	**118,100**	**DEL**	**119,700**	**GRND**	**121,900**		**Tech.Freq.** | **TBD**
Special mns	**Voice Button**	no	**SART**			No		
	Stop Watches	yes	**NASA TLX**			No		
	Blind Shield	no	**Test Report**			**Yes**		
			Debriefing note			Yes		
Actual data								
Date	2002-05-23		**Test van id.**		CSL1			
Time UTC	09:40 to 09:57		**BOB**		A. Gilbert, K. Klein, H. P. Zenz			
Record id.								
	Observation							
Time UTC								
09:43	Position of test vehicle, CSL1, at RWY06 holding point on RWY12							
09:44	CSA614	Landing. Alert Ok						
09:46	TVS555	Landing. Alert Ok						
09:48	CSA605	Landing. Alert Ok						
09:48	JAT1714	Departing Alert Ok						
09:53	CSA767	Landing. Alert Ok						
09:53	SLD8015	Departing. Alert Ok						
09:57	TAR228	Landing. Alert Ok						

Remark:
Taxi plan, EFS:
All taxi plans available and complete for arrival.
Alarms:
All Runway Incursion Alarms OK

Table 8-13 F3A-3 / F4-ARR-2, 2002-05-23, Alerting Performance and EFS Test

2002-05-23

F4-DEP	Testing Electronic Flight Strips, EFS, at departure			**CS**	Version 1.0
Title	Testing EFS				**Remark**
Scenario	No specific scenario. Observing the actual traffic.				
Aim	Checking if all flight strips are available and complete				
Success criteria	All flight strips are available and complete				
Traffic	Normal traffic				
Active sensors	All Sensors are working				
Special mns		**Debriefing note**	Yes		
Actual data					
Date	2002-05-23	**Test van id.**			
Time UTC	09:40 to 11:30	**BOB**	H. P. Zenz		
	Observation				
	RWY in use = RWY24				

Time UTC	Call Sign	TKOF on	**Time UTC**	Call Sign	TKOF on
09:48	JAT1714	RWY24	10:34	CSA972	RWY24-B
09:53	SLD8015	RWY24	10:38	CSA872	RWY24-B
09:59	CSA8944	RWY24	10:40	MDL778	RWY24-B
10:04	TYR706Q3	RWY24	10:51	CSA962	RWY24-B
10:06	CSA658	RWY24	10:53	CSA024	RWY24-B
10:07	GOE286	RWY24	10:55	CSA050	RWY24-A
10:12	CSA916	RWY24	11:00	CSA886	RWY24-A
10:16	CSA880	RWY24	11:02	DLH3229	RWY24-A
10:19	DAT67N	RWY24	11:06	BAW855	RWY24-B
10:20	CRX1487	RWY24	11:03	CSA558	RWY24-A
10:22	CSA490	RWY24	11:08	CSA742	RWY24-A
10:23	FIN716W	RWY24	11:10	TVS102	RWY24-A
10:26	AFR3441	Track lost 2x	11:16	CSA650	RWY24-A
10:27	CSA734	RWY24	11:18	TAR229	RWY24-A
10:30	CEF02	RWY24	11:20	CSA496	RWY24-B
10:32	CSA768	RWY24	11:23	CSA102	RWY24-A
			11:25	FFR1407	RWY24-A
			11:27	AFR1607	RWY24-A

Remark:
Taxi plan, EFS:
All taxi plans available and complete for arrival.

Table 8-14 F4-DEP, 2002-05-23, Testing available of taxi plans at EFS

2002-05-23

F5-2	Testing Guidance Performance Parameters	**CS**	Version 1.0
Title	Check Onboard HMI and data link with CWP-Apron **Test with work around for taxi instructions**	✔	**Remark**
Scenario	• Place the Test Van with the onboard HMI at an a/c parking place. • Start data link procedure by request at the Test Van		Test procedures will be outlined by PAS and NLR
Aim	Checking the functionality of the CWP input and data-link indication at onboard HMI		
Success Criteria	• Request and acknowledge of the Test Van are displayed immediately • Clearances are transmitted and display at the onboard HMI immediately • Taxi routes are displayed at the onboard HMI in a proper way		
Active sensors	**GP&C** Yes		
Special mns	DALICON Record **Yes**		
Actual data			
Date	2002-05-23 **Test van id.** D-AZZZ, K. Werner, L. Ehmke		
Time	14:00 **BOB** H. P. Zenz		
Record id.	BT-20020523-135535-DLK.LOG (Logger on ground station) BT-20020523-135648-DLK.LOG (Logger on Test Van, D-AZZZ)		
	Observation		

Remarks		**Procedure**	**Operator at the Test Van**	**Operator at the CWP**	**Check**
		Initial call			
OK	1		Request Departure		CWP received
OK	2			Cleared Departure	HMI clearance received
OK	3		WILCO		CWP WILCO received
		Start Up			
OK	4		Request Start Up		CWP received
OK	5			Cleared Start Up	HMI clearance received
OK	6		WILCO		CWP WILCO received
		Push Back			
OK	7		Request Push Back		CWP received
OK	8			Cleared Push Back	HMI clearance received
OK	9		WILCO		CWP WILCO received
		Request Taxi			
OK	10		Request Taxi		CWP received
OK	11			Transmit Taxi Routing	HMI Taxi routing shown
OK	12		WILCO		CWP WILCO received
		Lining Up			
OK	13		Request Line Up		CWP received
OK	14			Cleared for Line UP	HMI clearance received
OK	15		WILCO		CWP WILCO received
		Take Off			
OK	16		Request Take Off		CWP received
OK	17			Cleared for Take Of	HMI clearance received
OK	18		WILCO		CWP WILCO received
		Landing			
	19		Request to Land		CWP received
	20		Request to Land		CWP received
	21			Cleared to land	HMI clearance given
	22		WILCO		CWP WILCO received
OK	23		Request Taxi		CWP received
OK	24			Transmit Taxi Routing	HMI Taxi routing shown
OK	25		WILCO		CWP WILCO received

Table 8-15 F5-2, 2002-05-23 Testing Guidance Performance Parameters

	TWR: Receiving from Mobile, D-AZZZ, (On board system SS=11)											Mobile: Recieving from CWP-Apron, @LKPRB01, (CWP-Apron SS=01)										
	Ty	ID	O	MS	Time	SS	DD	ff	nnn	t	CS	Ty	ID	O	MS	Time	SS	DD	ff	nnn	t	CHS
1	$E	D-AZZZ	0	LB	140111	11	01	60	114	REQ_DEP:	*4C	$F	@LKPRB01	0								*70
2	$F	D-AZZZ	0								*04	$E	@LKPRB01	0	LB	140036	01	11	30	004	DEP_RWY24_BANAS2A_ETD_XXXX_SQK_XXXX:	*4A
3	$E	D-AZZZ	0	LB	140143	11	01	90	004	WILCO:	*52	$F	@LKPRB01	0								*70
4	$E	D-AZZZ	0	LB	140156	11	01	62	115	REQ_START_UP:	*27	$F	@LKPRB01	0								*70
5	$F	D-AZZZ	0								*04	$E	@LKPRB01	0	LB	140118	01	11	32	004	START_UP:	*64
6	$E	D-AZZZ	0	LB	140212	11	01	90	004	WILCO:	*55	$F	@LKPRB01	0								*70
7	$E	D-AZZZ	0	LB	140229	11	01	63	116	REQ_PUSH_BACK:	*5E	$F	@LKPRB01	0								*70
8	$F	D-AZZZ	0								*04	$E	@LKPRB01	0	LB	140151	01	11	33	004	PUSH_BACK:	*38
9	$E	D-AZZZ	0	LB	140243	11	01	90	004	WILCO:	*51	$F	@LKPRB01	0								*70
10	$E	D-AZZZ	0	LB	140253	11	01	64	117	REQ_TAXI:	*3B	$F	@LKPRB01	0								*70
11	$F	D-AZZZ	0								*04	$E	@LKPRB01	0	LB	140213	01	11	34	004	TAXI_H_A:	*7D
12	$E	D-AZZZ	0	LB	140311	11	01	90	004	WILCO:	*57	$F	@LKPRB01	0								*70
13	$E	D-AZZZ	0	LB	140339	11	01	66	118	REQ_LINE_UP:	*4B	$F	@LKPRB01	0								*70
14	$F	D-AZZZ	0								*04	$E	@LKPRB01	0	LB	140304	01	11	36	004	LINE_UP_RWY24:	*24
15	$E	D-AZZZ	0	LB	140357	11	01	90	004	WILCO:	*55	$F	@LKPRB01	0								*70
16	$E	D-AZZZ	0	LB	140428	11	01	67	119	READY_FOR_TAKE_OFF:	*3A	$F	@LKPRB01	0								*70
17	$F	D-AZZZ	0								*04	$E	@LKPRB01	0	LB	140347	01	11	37	004	TAKE_OFF_RWY24_WIND_000_000_KT:	*76
18	$E	D-AZZZ	0	LB	140441	11	01	90	004	WILCO:	*55	$F	@LKPRB01	0								*70
19	$E	D-AZZZ	0	LB	140500	11	01	70	120	REQ_LAND:	*38	$F	@LKPRB01	0								*70
20	$E	D-AZZZ	0	LB	140619	11	01	70	121	REQ_LAND:	*32	$F	@LKPRB01	0								*70
21	$F	D-AZZZ	0								*04	$E	@LKPRB01	0	LB	140536	01	11	40	005	LAND_RWY24_WIND_000_000_KT:	*7B
22	$E	D-AZZZ	0	LB	140628	11	01	90	005	WILCO:	*59	$F	@LKPRB01	0								*70
23	$E	D-AZZZ	0	LB	140641	11	01	64	122	REQ_TAXI:	*3A	$F	@LKPRB01	0								*70
24	$F	D-AZZZ	0								*04	$E	@LKPRB01	0	LB	140602	01	11	34	005	TAXI_13/31_F_G:	*00
25	$E	D-AZZZ	0	LB	140701	11	01	90	005	WILCO:	*53	$F	@LKPRB01	0								*70

Data Link Test after completing the work around for reduced taxi instruction.

Table 8-16 Data Link Monitoring, TWR and Mobile

8.2 References

[1] BETA
OPERATIONAL TEST CONCEPT
BETA DELIVERABLE D03-OCD-10, BRAUNSCHWEIG, DLR, 2000

[2] BETA
GENERAL TEST CONCEPT.
BETA DELIVERABLE D10-GTC-04, AMSTERDAM, NLR 2001

[3] BETA
TEST HANDBOOK
BETA DELIVERABLE D33-THE-03, BRAUNSCHWEIG, DLR 2001

[4] EUROCAE WORKING GROUP 41
MASPS FOR A-SMGCS, **ED-87A**, 2001 JANUARY

[5] BETA
TEST PLAN AND TEST PROCEDURES DOCUMENT PRAGUE (PHASE II)
BETA DELIVERABLE D16AII-TPP-10, BRAUNSCHWEIG, DLR 2002

[6] BETA
TEST PPROCEDURES FOR PRAGUE
BETA DRAFT VERSION PRG-SCENARIOS03, AMSTERDAM, NLR 2001

[7] BETA
BETA TEST AT BRAUNSCHWEIG, TEST REPORT FOR BWE, PHASE I
BETA DELIVERABLE D22CI-TRP-021.DOC, BRAUNSCHWEIG, DLR 2002

8.3 List of Figures

8.4 List of Tables

8.5 Acronyms and Abbreviations

A	
A/C	Aircraft
ACC	Area Control Centre
ANS-CR	Air Navigation Services of the Czech Republik
APN	Apron Control (responsible for the apron areas)
APP	Approach Control
AS	A-SMGCS Airborne System
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASR	Airport Surveillance Radar
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATM	Air Traffic Management
ATOPS	A-SMGCS Testing of Operational Procedures by Simulation (EC project of 4th Framework Programme)
ATS	Air Traffic Services Authority
B	
BETA	Operational Benefit Evaluation by Testing an A-SMGCS
BWE	Research Airport Braunschweig
C	
CD	Clearance Delivery
CEC	Clearance Executive Controller
CFMU	Central Flow Management Unit
CNS	Communication, Navigation, Surveillance
CTOT	Calculated Take-Off Time
CV	Coverage Volume
CWP	Controller Working Position
D	
DAS	Daten-Anzeige-System (Data Display System)
DEFAMM	Demonstration Facilities for Airport Movement Management (EC project of 4th Framework Programme)
df	Degree of freedom
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DMAN	Departure Manager
E	
EFPS	Electronic Flight Progress Strip
EFS	Electronic Flight Strip
EOBT	Estimated Off Block Time
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
F	
F	F-Statistic Score
FP	Flight Plan
FPS	Flight Progress Strip

G	
GEC	Executive Controller
GND	Ground Control (normally: ATC responsible for Start-up clearance and outbound traffic)
GP&C	Global Positioning and Communication System
H	
H	Hypothesis
HAM	Hamburg Airport
HMI	Human Machine Interface
I	
IATA	International Air Traffic Association
ICAO	International Civil Aviation Organisation
ID	Identification Code (e.g. Registration Mark, 24Bit Aircraft Address, Flight No.)
IFR	Instrument Flight Rules
M	
MASPS	Minimum Aviation System Performance Standards
MTOW	Maximum Take-off Weight
N	Number of Subjects
O	
OC	Operational Concept
P	
p	Error probality
PAS	Park Air Systems
PD	Probability of Detection
PFD	Probability of False Detection
PFID	Probability of False Identification
PR	Position Report
PRG	Airport Prague Ruzyně
PRUR xx sec	Position Report with Update Rate of xx sec
PSR	Primary Surveillance Radar
R	
R/T	Radio Telephony
RVA	Reported Velocity Accuracy
RWY	Runway
S	
SA	Situational Awareness
SD	Standard Deviation
SDF	Sensor Data Fusion
SDS	Surveillance Data Server
SE	Standard Error of the Mean
SID	Standard Instrumental Departure
SMPS	Surface Movement Planning System
SMR	Surface Movement Radar
Squawk	Transponder Mode A/C Code
SSR	Secondary Surveillance Radar
STDMA	Self organised Time Division Multiple Access (here: the experimental data link based on GPS, predecessor of VDL Mode 4)
SUC	Start-Up controller/Clearance Delivery
T	
T	T-Statistic Score
TATM	Thales ATM
TEC	Executive Controller
TRL	Target Report Latency
TRUR	Target Report Update Rate

TWR	Tower Control (normally: ATC for RWY and inbound traffic)
TWY	Taxiway
U	
UTC	Universal Time Co-ordinated
V	
VDL	VHF Data Link
VFR	Visual Flight Rules
VHF	Very High Frequency
VIP	Very Important Person
W	
Wilco	Will comply – used for R/T communication
WP	Work package

Table 8-17 Acronyms and Abbreviations of Surveillance Parameter