Test Plan and Test Procedures Document

PRAGUE (Phase II)

Operational Benefit Evaluation by Testing an A-SMGCS

D16AII-TPP-1.0

J. Jakobi

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Test Plan and Test Procedures Document

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Date	Issue	Changed Items/Chapters	Comment
2002-05-07	0.1	Complete update of D16aI	Based on D16-working paper
2002-05-24	0.2	• Updated Functional Test Plan • Updated Op. Test Plan • Reviewed Evaluation Methodology	Comments from DLR, PAS, QuinetiQ, AUEB
2002-09-19	0.3	Final Revision	DLR
2003-02-16	1.0	Formal Changes	Document as approved by the EC

Contents

1. Scope of Document

This document is one of three parts of the "Test Plan and Test Procedures" series of documents. A document is available for each of the test airports to be used in the BETA project:

- D16a-TPP Test Plan and Test Procedures document, test procedures for Prague (PRG).
- D16b-TPP Test Plan and Test Procedures document, test procedures for Hamburg (HAM).
- D16c-TPP Test Plan and Test Procedures document, test procedures for Braunschweig (BWE).

1.1 Objectives

This document, D16a-TPP, is the output of BETA WP5100 and describes the specific test procedures for Prague airport.
This document builds upon:

- WP 1200 Operational Concept, D03-OCD-1.0 [1]
- Draft version WP 2100 General Test Concept, D10-GTC-0.3 [2]
- Test Handbook, D33_THE [3]
- EUROCAE Working Group 41, MASPS on A-SMGCS, [4]

1.2 Document Structure

This document is structured into 7 chapters

- Chapter 1 is the scope of the document
- Chapter 2 in the introduction the BETA subsystems involved in the testing and the human actors for the tests are listed
- Chapter 3 is an excerpt of the complete Test Tools Document (D15) [ref ?] and summarises the test vehicles, the data recording devices, the analysis tools, the responsibilities
- Chapter 4 outlines the evaluation methodology
- Chapter 5 describes the technical functional tests as Surveillance, Alerting, Planning, Guidance and HMI Performance Test
- Chapter 6 describes the operational testing
- Chapter 7 outlines the assessment of the overall system performance
- Chapter 8 is the annex including test forms for protocols and observer notes

2. Introduction of the BETA System

Figure 2-1 describes the subsystems, used at Prague, with the recording and playback system connected to the local area network.

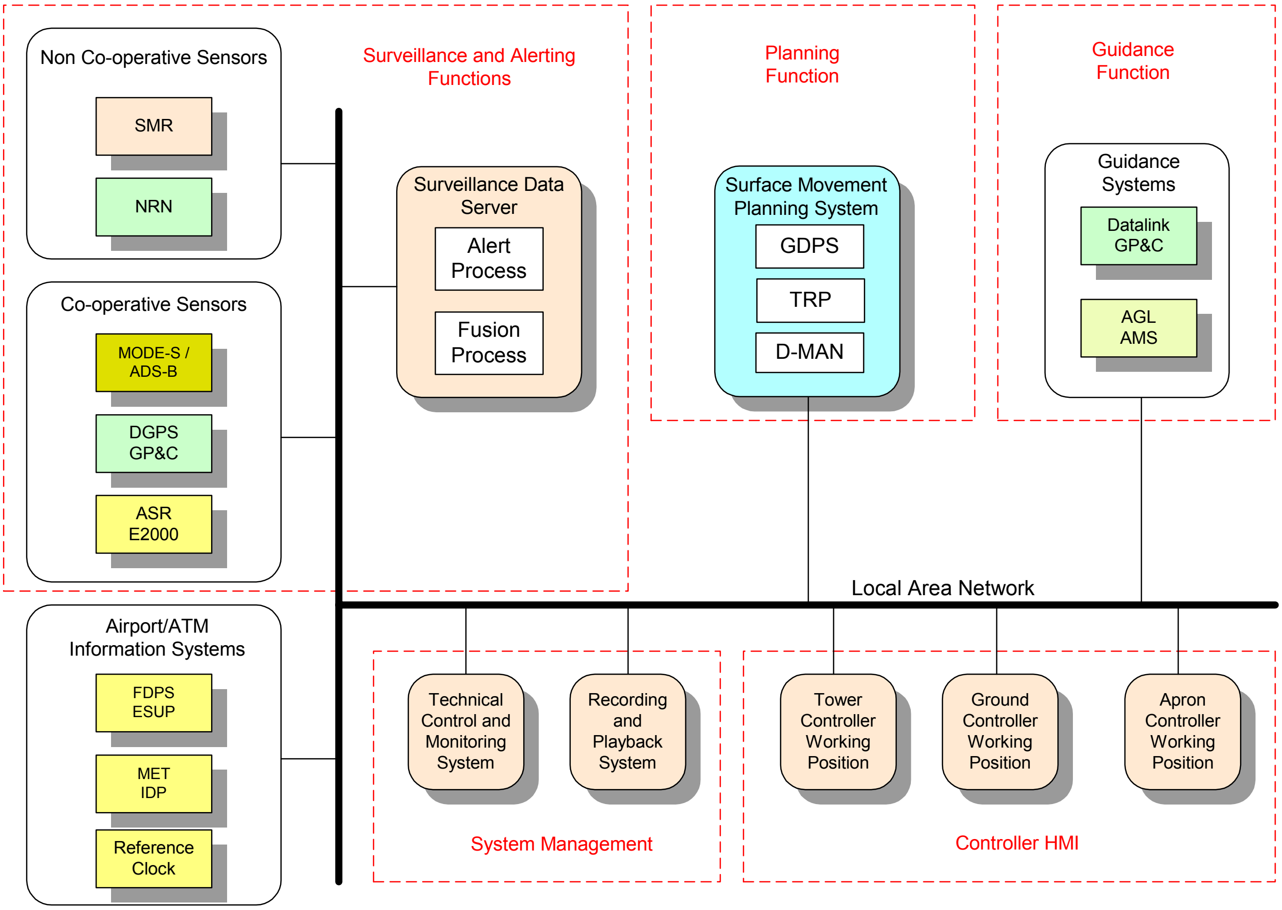


Figure 2-1: Overall System Block Diagram for Prague

2.1 Subsystems

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, Surface Movement Radar with digital extractor system (PAS)
- NRN, Near-range Radar Network (DLR)

Co-operative Sensor Subsystems

- ASCS, Mode-S Multilateration/ADS-B system (ERA)
- ASR E2000, Airport Surveillance Radar (ANS-CR)
- GP&C, ADS-B based on differential GPS (DLR)

Surveillance Data Fusion

- SDS, surveillance data server (PAS)

Alerting/Control
- RIMCAS, runway incursion monitoring and conflict alert subsystem (PAS)
- Taxi route conformance monitoring and alerting (PAS)

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

Guidance
- AGL, aerodrome ground lighting system (CSL)
- Guidance Server (PAS)
- DL, Data Link comprising GP&C (DLR)

HMI
- CWP1, active BETA working position (PAS)
- CWP2, non-activ BETA working position (PAS)
- CWP3, non-activ BETA working position (PAS)
- BETA display in the Gate Management office of the airport (PAS)
- Pilot onboard HDD (DLR)

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

2.2 Human Actors in BETA Test

The following human actors during the BETA tests are defined in [3]:

OTC	Operational Test Co-ordinator (ANS)
TTC	Technical Test Co-ordinator (DLR)
ATO	Airport Test Co-ordinator (CSL)
BO	BETA Operator [more than one] (PAS; DLR, NLR, TATM)
BOB	BETA Observer (DLR)
BC	BETA Controller (ANS)
Driver	BETA test car driver (ANS, CSL, DLR)
Pilot	BETA Test Aircraft Pilot (DLR)
ATCO	Air Traffic Controller in the Tower and / or the Apron (ANS)

3. Test Tools

The tools to used for the testing in BETA are described in detail in the "BETA Test Tools Document" D15. In order to assist the reader in understanding the current material an excerpt from the mentioned D15 is given here.

3.1 Test Vehicles

Following test equipment is available at Prague (Partners responsible for the availability of the subsystems are shown in brackets):

Test Van (DLR)
Equipped with:

- GP&C
- Mode S
- Onboard HDD
- D-GPS, SAPOS
- Inertial Navigation System, INS

The Test Van can be used as reference for the position measuring of the A-SMGCS subsystems. SAPOS represents a position accuracy of better then 10cm with an update rate of 1 sec. For intermediate time the position report can be calculated by interpolation using the INS velocity with an update rate of 10Hz.

Onboard recording:

The update rate for the onboard recording is 1sec for SAPOS position reports and 10Hz for INS velocity and heading reports.

Test Aircraft DO228 (DLR)
Equipped with:

- GP&C transponder
- Onboard HDD

Follow Me Cars (two cars from ANS)
Equipped with:

- GP&C transponder
- Mode-S transponder
- Onboard HDD (via a laptop)

Other Cars (five cars from CSL)
Equipped with

- GP&C transponder
- Mode-S transponder

3.2 Data Recording

As different partners supply the data loggers, various formats are used. Therefore, in a first step each responsible partner has to convert these special formats into an ASCII table format readable by standard software (e.g. EXCEL).

a) Surveillance-Logger
Recording SDS Data (Surveillance Data Server) for offline evaluation:

- SDS- Out Recording Target Reports at the SDS (PAS)

Recording of the sensor output data:

- ASCS — Recording Mode-S/ADSB Position Report (DLR)
- NRN — Recording NRN Position Report (DLR)
- GP&C — Recording GP&C Position Report (PAS, DLR)

All recorded data include a time stamp of the recording time to evaluate the time latency.

b) HMI-Logger
Recording all HMI data for offline replay and offline evaluation:

- Controller HMI including planning and alert data (PAS)
- Pilot HMI, pilot human machine interface (DLR)

c) GP&C Data Link Logger

- Logger at GP&C Data Link for the guidance tests and recording of all Position Reports of GP&C equipped a/c and cars. (DLR)
- GP&C CATS Logger for offline demonstration of movement of GP&C equipped a/c and cars. (DLR)

d) MET Data Logger

Hourly recording of published meteorological data. (DLR)

e) Voice Button Counter

Voice-Button Counter for recording the number and duration of the overall VHF Radio Transmission between the relevant Controller and the pilots (DLR). Following data must be available:

- Start point of Radio Transmission
- End point of Radio Transmission

f) Quick Access Recorder

The data of onboard Quick Access Recorder, which are stored on a tape by the airline, must be available after each test run. CSA are able to provide these tapes or a copy of it. Following data will be extracted and stored in an EXCEL table format:

- Fuel burn during the aerodrome movements
- Number of stops while taxiing

g) Form Sheets (cf. chapter 5)

- **Test Observer Sheet**
  Is used by the BETA Observer in operational test runs.
- **Debriefing Notes**
  Debriefings will be carried out to get feedback from the controllers/ pilots directly after the completion of a test session. The debriefing sheet will help the BETA Interviewers to focus on the relevant issues of interest.
- **Test Protocol (TPR)**
  During all functional test runs test protocols have to be kept by the Technical Test Co-ordinator.
- **Questionnaires (QUE)**
  - Situation Awareness Rating Technique (SART)
  - NASA Task Load Index (NASA TLX)
  - System Usability Scale
  - Acceptance questionnaire

3.3 Analysis Tools

3.3.1 Analysis Tools for Functional Tests

The BETA installation for Prague covers no special reference system. In order to allow the evaluation of the reported position accuracy delivered by the whole surveillance part, two methods will be applied:

- The static analysis is performed by comparing the system data (e.g. the recorded data printed or the presentation on the controller HMI) with pre-defined locations where the test vehicles are positioned. The pre-defined locations are marked on the map and derived from map data (WGS84 co-ordinates) in the required precision.
- The dynamic analysis is performed by using the GP&C system as a (non-perfect) reference system. The quality of this sensor has been evaluated in detail by DLR (e.g. in Pre-demonstration I at Braunschweig, DEFAMM D-PBE101.DOC, [10]). The main disadvantage of this system is the latency, which corresponds to poor accuracy in a real-time system. To overcome this disadvantage the analysis is done offline where the latency can be eliminated.

Tools for offline analysis of recorded data:

Analysis Tool for Time Stamp Position Reports
Analysis tools for time stamped position report recorded with Surveillance-Logger and with HMI-Logger.

Analysis Tool for HMI Input data
Analysis tools for Planning Parameters recorded with HMI-Logger.
Analysis tools for Alert Parameters with HMI-Logger data.

Tools for offline analysis of form sheets:

Analysis Tool for Observer Notes

Analysis Tool for Test Protocol

3.3.2 Analysis Tools for Operational Tests

Analysis Tool for Time Stamp Position Reports (AT-TSP)

This analysis tool is one of the most important for measuring effects that are related to movements at the aerodrome. The Surveillance Logger records the position of every aircraft at the aerodrome with a respective time stamp. Derived from these data, the following data must be available in an ASCII table format:

- Average taxi speed of all aircraft per time unit
- Number of all stops (number of velocity vector = 0) per time unit
- Start time and End time of each aircraft on RWY
- Number of all aircraft at the aerodrome per time unit
- Start time and End Time of each aircraft at the runway threshold

The recorded data by the Surveillance logger can also be used to replay the traffic in real and fast time simulation on a display.

3.4 Responsibilities for the Test Tools

Tool	BETA Partner	Remarks
Test Van	DLR	
Test Aircraft	DLR	
Follow Me Car	ANS	
Other Car	CSL	
SDS Logger	PAS	
NRN Logger	DLR	
ASCS Logger	/DLR	
GP&C Logger	PAS/DLR	
HMI Logger	PAS	
GP&C Data Link Logger	DLR	
MET Data Logger	DLR	
Voice Button Counter	DLR	
Quick Access Recorder	BA, CSA	
Test Observer Sheet	DLR	
De-briefing Sheet	DLR	
Test Protocol Sheet	DLR	
Questionnaire SART	DLR	
Questionnaire NASA TLX	DLR	
Questionnaire System Usability Scale	NLR	
Analysis Tool for Time Stamp Position Reports	DLR	
Analysis Tool for HMI Input data	NLR, DLR	Controller, Pilot

Table 3-1: Responsibilities for the Test Tools

4. Evaluation Methodology

In order to perform the second phase of the evaluation of the BETA system a methodological framework is developed based on the characteristics of the BETA system and of the evaluation phase (i.e. second evaluation phase). The proposed validation framework considers the following project characteristics, which determine the nature of the validation problem at hand:

1) The fact that in an integrated A-SMGCS multiple institutional actors with multiple and sometimes conflicting objectives are involved,
2) The fact that the BETA project will involve a variety of sites which may operate under different institutional, legal, and cultural settings which lead to different user needs and system design objectives, and
3) The fact that some of the measures of effectiveness used to evaluate the performance of the proposed system can be measured **objectively** with a fairly good accuracy, i.e. cost, while others can be evaluated only **subjectively**, i.e. working conditions.

Taking into account the above-described characteristic an evaluation methodological framework initially developed by Zografos & Giannouli (1999), Zografos & Giannouli (1998), was adopted to the needs of the project. As it is presented in Figure 4-1 this methodological framework is focused into two important issues:

i) The identification of the measures of system performance (i.e. indicators) that will be used in order to perform the evaluation, and
ii) The identification of the different types of assessment that should be perform in order to ensure that the system performance has been evaluated in all different aspects.

For implementing the proposed methodological framework the following steps should be or has been already performed:

1. Identification of the stakeholders
2. Identification of the system assessment objectives
3. Identification of the different types of assessment that should be performed
4. Identification of the most appropriate techniques in order to perform the various types of assessment
5. Identification of an exhaustive set of indicators for measuring the assessment criteria
6. Development of the experimental design required to perform the various measurements
7. Data collection
8. Data analysis

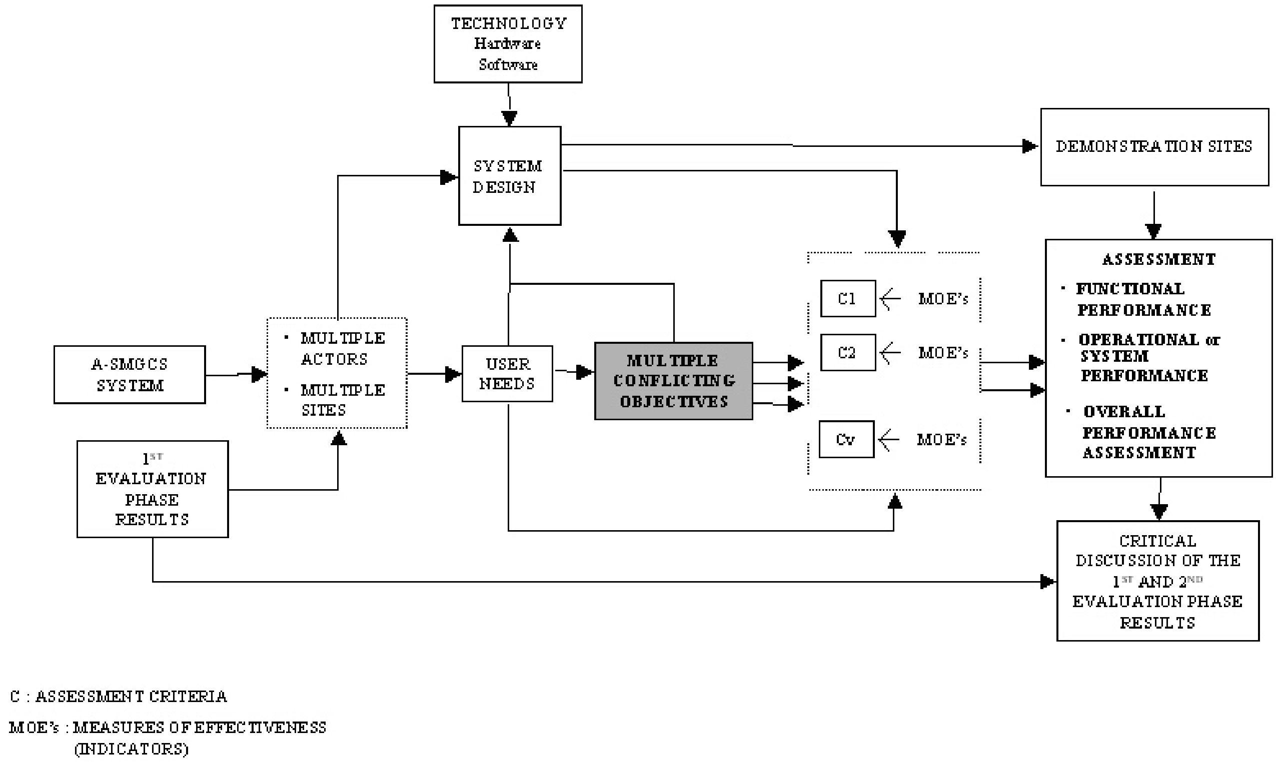


Figure 4-1: Evaluation Methodological Framework for the BETA System

In an A-SMGCS system it is very important to consider all involved parties in order to assess its performance therefore, the proposed evaluation framework takes into account all stakeholders involved in/or affected by the system. For the evaluation of the BETA system the following list of stakeholders has been identified:

1. Airlines
2. Airport Authorities Services
3. Air Traffic Control Providers
4. Passenger Associations

Taking into consideration the system assessment objectives as they have been identified in a previous section of this report and their impacts to the relevant stakeholders the following types of assessment will be performed in order to ensure that all aspects of the system will be captured and assessed:

- **System performance**, which is measured in terms of 'safety', 'efficiency of traffic movements', 'working conditions of the operators', and 'environmental impacts'. The proof of the functional performance serves as a prerequisite for the assessment of the operational performance. (cf. also chapter 5 and 6)
- **Costs**
- **Overall/Comparative assessment**

The objective of the performance assessment is to evaluate the BETA system based on its system performance characteristics. The emphasis of this type of evaluation is to determine if the proposed system can function properly from a technical point of view and if it can perform satisfactorily its intended functions. The system performance assessment is a prerequisite of any other type of assessment since systems that fail to fulfil the technical evaluation standards and criteria, cannot be further deployed and used [Zografos & Giannouli 1998, 1999].

The system performance assessment will be based on a number of functional and operational indicators. Some of these indicators will be measured objectively, e.g. the accuracy of surveillance, while some others will be measured subjectively, e.g. usability or acceptance indicators. The measured indicators will be either tested against a standard or a before and after analysis will take place.

Afterwards, expert judgements will be used based on ratio scales measuring the degree of fulfilment of the various features. These measurements will be further analysed using descriptive statistics in order to derive the overall performance of the BETA system. Furthermore, for some of the system features compliance checks may be required.

In order to validate whether the various indicators have reached an appropriate level, hypothesis testing will be performed. The testing of a statistical hypothesis involves the following six well-defined steps [Hicks, C.R, 1982].

1. Establishment of the hypothesis (H_0) and its alternative (H_1).
2. Selection of the significance level of the test (α) and the sample size (n). The determination of the sample size is based on the following criteria:
   (i) Size of the shift that we want to detect in a parameter.
   (ii) Degree of variability present in the population.
   (iii) Degree of risk we want to take in rejecting (H_0).
3. Determination of the test statistic required to test the hypothesis H_0.
4. Selection of the sampling distribution of the test statistic when H_0 is true.
5. Establishment of the critical region of the test statistic where H_0 will be rejected.
6. Selection of a sample of (n) observations required to compute the test statistic and decide on H_0

In this case of comparing against a standard we will test the following hypothesis:
H_0 : $\mu = \kappa$
H_1 : $\mu < \kappa$, or $\mu > \kappa$
where the null hypothesis (H_0) is that the mean value (μ) of the indicator is equal to the standard (κ), and the alternative hypothesis is that the mean value of the indicator is greater/smaller than the value of the standard (κ) against which the indicator is compared.

The test statistic required for testing (H_0) is given by the following formula:

$$t = \frac{\bar{y} - \mu_0}{s/\sqrt{n}} \qquad (1)$$

where $\bar{y}$: is the estimated value of the indicator under consideration
n : the sample size used to estimate the indicator
s^2 : the estimated variance of the indicator (Note: equation 1 is based on the assumption that the variance is known).
t : follows a t-distribution with n-1 degrees of freedom

In the case of comparison of before and after we will test the following hypothesis:
H_0 : $\mu_b = \mu_a$
H_1 : $\mu_b < \mu_a$ or $\mu_b > \mu_a$
where the null hypothesis (H_0) is that the mean value (μ_b) of the indicator before is equal to the mean value of the indicator after (μ_a), and the alternative hypothesis is that the mean value of the indicator before differs from the mean value after in a predefined direction.

The test statistic required for testing (H_0) is given by the following formula:

$$t = \frac{\overline{y_b} - \overline{y}_a}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \qquad \textit{(2)}$$

where $\overline{y}_a$, $\overline{y}_b$: is the estimated value of the indicator under consideration after and before the implementation of the BETA system respectively

n_1, n_2 : the sample size used to estimate the indicator before and after respectively

S_1^2, S_2^2: the estimated variance of the indicator before and after respectively.

As it is presented in the Figure 4-1 the development and implementation of this evaluation framework is on the light of the experience and the results of the first evaluation phase of the BETA system. The information obtained during the implementation of the evaluation framework during the first phase allows the reconsideration and enhancement/adjustment of the evaluation attributes, the methods used for performing the evaluation and the experimental design for the data collection and analysis processes. Furthermore, the results of the first phase not only provided information on the technical soundness and operation, but also enhance the understanding of the developers and users on its capabilities and operational performance, an issue that increase the reliability of the evaluation results of the second phase. Finally, it is considered appropriate that a critical discussion on the evaluation results of the two phases should be performed, in order to identify better possible improvements required on technical and operational aspects of the system.

5. Testing A-SMGCS Functional Performance Parameters

As already mentioned before, a system that fails to fulfil the functional performance requirements cannot be further deployed and used for operational tests. The functional performance requirements can be derived from the 'BETA Operational Concept' [1]. From there, the following A-SMGCS functional performance parameters will be measured and proved against the functional requirements:

Surveillance Integrity Parameters for SDS
• Reported Position Accuracy (RPA) • Reported Velocity Accuracy (RVA) • Target Report Update Rate (TRUR) • Target Report Latency (TRL)
Surveillance Reliability Parameters for SDS
• Probability of Detection (PD) • Probability of False Detection (PFD) • Probability of Identification of co-operative targets (PID) • Probability of False Identification of co-operative targets (PFID) • Continuity of target track (fast replay of the HMI) • Coverage Volume (CV)
Alert Parameters
• Probability of Detection of an Alert Situation (PDAS) • Probability of False Alert (PFA) • Alert Response Time (ART)
Planning Parameters
• **Optimal departure sequence:** o Take-Off Time Prediction Accuracy (TOTPA) (Accuracy of Estimated Time of Departure to Actual Time of Departure) o Ability to optimise departure sequence (taking into account traffic mix/wake vortex) • **Clearance control:** o Number of Alerts raised of non-conformance to clearance o Number of false alerts on plan non-conformance o Number of warnings asking that clearance is due o Number of false warnings o Number of alerts raised due to incoherent set of plans o Number of false alerts on incoherent plans • **Hand-over control:** o Ability of forced shoot/assume hand-overs o Ability of alerts on uncontrolled aircraft • **In general:** o o Taxi Plan Computation Response Time (TPCRT) o Ability to cover most common taxi routes
Guidance Performance Parameters:
• Clearance Delivery Response Time (CDRT) • Guidance Aid Response Time (GART) • Guidance Aid Confirmation Time (GACT)

5.1 Testing Surveillance Performance Parameters

Two types of test will be used for testing the Surveillance Performance Parameters:
1. Case Studies (CS) to measure the accuracy and timeliness of the surveillance data.
2. Regular Traffic Studies (RTS) to gather sufficient statistical data to establish the reliability of the surveillance system.

Surveillance at Prague will be provided by the combination of the following sensor systems:

- Surface Movement Radar (SMR) with digital extractor system
  - # Provides target position and size information only
  - # Provides coverage of most of the movement area, limited coverage of aprons and parking positions, some false targets on RWY 06/24
- Near-range Radar Network (NRN)
  - # Provides target position information only
  - # Does not detect stationary targets
  - # Provides coverage limited to a rectangle including the threshold of RWY 24, and taxiways A and B
- Mode-S Multilateration /ADS-B system (VERA-ASCS)
  - # Provides target position and identification (Mode-S code)
  - # Provides coverage of most of the manoeuvring area
- GP&C ADS-B system (NEAN)
  - # Provides target position and identification (transponder ID) for GP&C-equipped test vehicles and aircraft (some Lufthansa and Scandinavian only)
- Airport Surveillance Radar (ASR) system
  - # Provides target position and identification (SSR Mode-A code) for co-operating aircraft
  - # Provides multi-radar coverage of terminal area airspace, distributed via RMCDE
  - # No coverage of the aerodrome surface

Target reports from the sensor systems will be combined by a surveillance data fusion process. The following limitations will apply to the results of the integrated surveillance function:

- Targets should be acquired by the tracking system only when adequate detection is established, i.e.
  - # Arriving aircraft, minimum 10 NM from runway threshold
  - # Departing aircraft, when leaving Apron and entering taxiway
- The following targets should be identified automatically (with callsign or Mode-A code)
  - # Arriving aircraft squawking Mode-A code
  - # Arriving and departing aircraft squittering Mode-S code
  - # Co-operating GP&C-equipped aircraft and test vehicles

  All other targets will need to be identified manually (manual labelling function at CHMI) once acquired by the SDS target tracking system.

5.1.1 Testing Surveillance Accuracy and Timeliness (F1) – Case Studies – Objective Indicators -

The goal of this test is to evaluate the performance of the Surveillance System as described in the General Test Concept [2] chapter "Technical Function Test".
All the surveillance sensors (SMR, ASR, NRN, Mode-S, and GP&C) were tested individually during test phase I.
For phase II, testing will focus on the target reports output from the SDS and the information presented to controllers and pilots on their respective HMIs.

- The NRN system with new antenna positions
  Because of changing the antenna position and definition of a new coverage area the NRN has to be phase II again.

For testing the Surveillance parameters, the GP&C system will be used as reference system for static position accuracy.

From [2] and [4], the Surveillance accuracy and timeliness parameters are:

- Reported Position Accuracy (RPA)
- Reported Velocity Accuracy (RVA)
- Target Report Update Rate (TRUR)
- Target Report Latency (TRL)

Test Procedures for RPA, RVA and TRUR:

Two test procedures are prepared for testing the RPA, RVA and TRUR [4]:

Test of RPA, RVA and TRUR during normal taxiing, including stops for static test of position accuracy:

The reference position will be derived from GP&C installed in the Test Van.

Accuracy of the reference system (GP&C):

Position accuracy:	3.0 m
Velocity accuracy:	2.0 m/s
Update rate:	1 second.
Time latency:	not significant for offline evaluation of time stamped reports.

For testing the Reported Position Accuracy at the output of the Surveillance Data Server, the GP&C will be disconnected from the SDS.

GP&C and SDS target report data will be recorded and analysed offline.

Note: the reference point of the ‘reference’ antenna has to be considered in the analysis.

Dynamic test of RPA and RVA:

For this test, the test vehicle is driven at constant speed along a pre-defined test track that includes straight portions and 90-degree turns.

The test is carried out five times.

SDS target report data will be recorded and analysed offline.

Test Procedure for Target Report Latency (TRL) at the Controller HMI

The Target Report Latency (TRL) will be measured by viewing the CWP traffic situation display while at the same time observing a test vehicle driving at high speed on the runway. The time difference between the test vehicle passing a pre-defined position on the runway to the time the target passes the corresponding position on the CWP display will be measured by a stopwatch and indicates the TRL of the overall system. This test will be carried out five times.

Test Scenario:

F1A: Testing the Surveillance Integrity Parameter of the NRN system.
The Test Van (GP&C equipped) proceeds inside the CV on the NRN system (TWY-Alpha, TWY-

Bravo and RWY-24)
GP&C is disconnected from SDS.

F1B: Testing the RPA, RVA and TRUR during normal taxiing.
The Test Van (GP&C equipped) proceeds along the centrelines of all runways and taxiways. The Test Van stops at known positions for about 30 s while the operator notes the time and position of the Test Van on Test Report Sheet.
GP&C is disconnected from SDS.

F1C: Dynamic test of the RPA and RVA parameters (Elk- Test).
The Test Van taxis at a constant speed along the centrelines of TWY- Hotel, TWY-Juliet, TWY-Golf and TWY-Charlie.
Sufficient distance must be allowed prior to the vehicle crossing the measurement start point to ensure that a constant speed is maintained.

F1D: Measuring the Target Report Latency (TRL).
The test vehicle is driven at a constant high speed along that portion of the runway that is clearly visible in front of the BETA Observer. The BETA Observer monitors the position of the vehicle on the runway and the corresponding target position shown on the CWP display. Using a stopwatch, the Observer measures the time difference between the test vehicle passing easily recognisable markers on the runway and the target passing the same markers on the CWP display. The measured data is recorded in a protocol sheet.

Data Recording:

- GP&C-Data Logger — GP&C-Data Recording via LAN (DLR)
- GP&C-CATS — Recording GP&C data for offline replay (DLR)
- NRN- Logger — Recording at NRN Output (DLR)
- ASCS- Logger — Recording at ASCS Output (DLR)
- SDS- Logger — Recording at SDS Output (PAS)
- HMI-Logger — Recording all data at HMI (PAS)
- Stop watch — Measuring the time latency

Test-protocol of BETA Observer:
Observing the real airport traffic and the HMI output:
Number and operation time of GP&C equipped vehicles in the vicinity.
Number of GP&C equipped vehicles shown on the HMI.
Number and operation time of unequipped vehicles in the vicinity.
Number of all vehicles shown on the HMI.
Protocol of CWP – TRL.

		F1A	F1B	F1C	F1D
	Test Equipment				
1	BETA Test Vehicle (DLR) equipped	X	X	X	X
2	BETA Test a/c (DLR) Mode-S equipped				
3	Second Test Vehicle GP&C equipped				
	Human Actors				
1	Operational Test Co-ordinator	X	X	X	X
2	Technical Test Co-ordinator	X	X	X	X
3	Airport Test Co-ordinator	X	X	X	X
4	BETA Controller				
5	BETA Test Vehicle Driver I (airport licence)	X	X	X	X
6	BETA Test Car Driver II (airport licence)				
7	BETA Test Aircraft Pilot				
8	BETA Operator (PAS)	X	X	X	X
9	BETA Operator for SMR – System				
10	BETA Operator (DLR) for NRN – System	X	X	X	X
11	BETA Operator (ERA) for ASCS – System	X	X	X	X
12	BETA Operator (PAS) for ASR – System	X	X	X	X
13	BETA Operator (DLR) for GP&C – System	X	X	X	X
14	BETA Observer (DLR)	X	X	X	X
15	BETA Operator for Pilot HMI				

Table 5-1: BETA Test Equipment and Human Actors involved in F1 Tests

Recording Tools:

Recording Tools are

- Surveillance Logger
- Observer Notes, ON-F1D and ON-F1E
- Stopwatch for measuring TRL

Analysis of Recorded Data

- Calculating the Reported Position Accuracy (RPA)
  The 'best guess' position is recorded from the reference system using the differential GPS, GP&C,
  The reported position of each sensor will be compared with the true position.
  a) Reported Position Accuracy with static tests.
     The true position is given by the position report of the GP&C System. If the possibility arises for readout of the position online, the difference between the position report and the true position can be calculated directly while the test target is stopped.
  b) Reported Position Accuracy with dynamic tests.
     The true position is given by the position report of the GP&C System recorded with the GP&C data-logger. The difference between the position report and the true position can be calculated offline using the timestamp.

  Calculate the RPA as follows:
  For each position report calculate the error in the X position, Δx, and in the Y position, Δy.

$$\Delta x = (\text{true X position} - \text{reported X position}) \quad \text{in metres}$$
$$\Delta y = (\text{true Y position} - \text{reported Y position}) \quad \text{in metres}$$

$$\text{mean deviation X,} \quad m_x = 1/n \sum \Delta x_i$$
$$\text{mean deviation Y,} \quad m_y = 1/n \sum \Delta y_i$$
$$\text{quadratic X,} \quad q_x = 1/n \sum (\Delta x_i)^2$$
$$\text{quadratic Y,} \quad q_y = 1/n \sum (\Delta y_i)^2$$

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

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

$$Rx = C \bullet RMS_X + m_x$$
$$Ry = C \bullet RMS_y + m_y$$

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

Where the coefficient C is given by the following table:

Confidence Level %	C	Confidence Level %	C
90	1.645	95	1.960
91	1.695	96	2.054
92	1.751	97	2.170
93	1.812	98	2.326
94	1.881	99	2.576

Table 5-2: Confidence Level Coefficients

- Calculating the Reported Velocity Accuracy (RVA)
  The true velocity is recorded at the reference system using the GP&C System. The reported velocity (speed and heading or speed x and speed y) will be compared with the true velocity.
  This can be done only with dynamic tests.

  Calculate the RVA as follows [4]:
  For each position report calculate the error in velocity, Δv.

$$\Delta v_x = (\text{ true velocity } - \text{ reported velocity})_x \quad \text{in m/s}$$
$$\Delta v_y = (\text{ true velocity } - \text{ reported velocity})_y \quad \text{in m/s}$$

mean deviation X, $m_x = 1/n \sum \Delta Vx_i$
mean deviation Y, $m_y = 1/n \sum \Delta Vy_i$
quadratic X, $q_x = 1/n \sum (\Delta Vx_i)^2$
quadratic Y, $q_y = 1/n \sum (\Delta Vy_i)^2$

$$RMS_{Vx} = \sqrt{(q_x - m_x^2)}$$

$$RMS_{Vy} = \sqrt{(q_y - m_y^2)}$$

$$Rv_x = C \bullet RMS_{Vx} + m_x$$
$$Rv_y = C \bullet RMS_{Vy} + m_y$$

$$RVA = \sqrt{(Rv_x^2 + Rv_y^2)}$$

Where the coefficient C is given by the Table 5-2 listed above.

- Calculating the Target Report Update Rate (TRUR)
  Measuring the number of reports from individual test targets by evaluation of the SDS-Logging data.

  TRUR = (No. of target reports per target) / (No. of seconds) in No. per sec

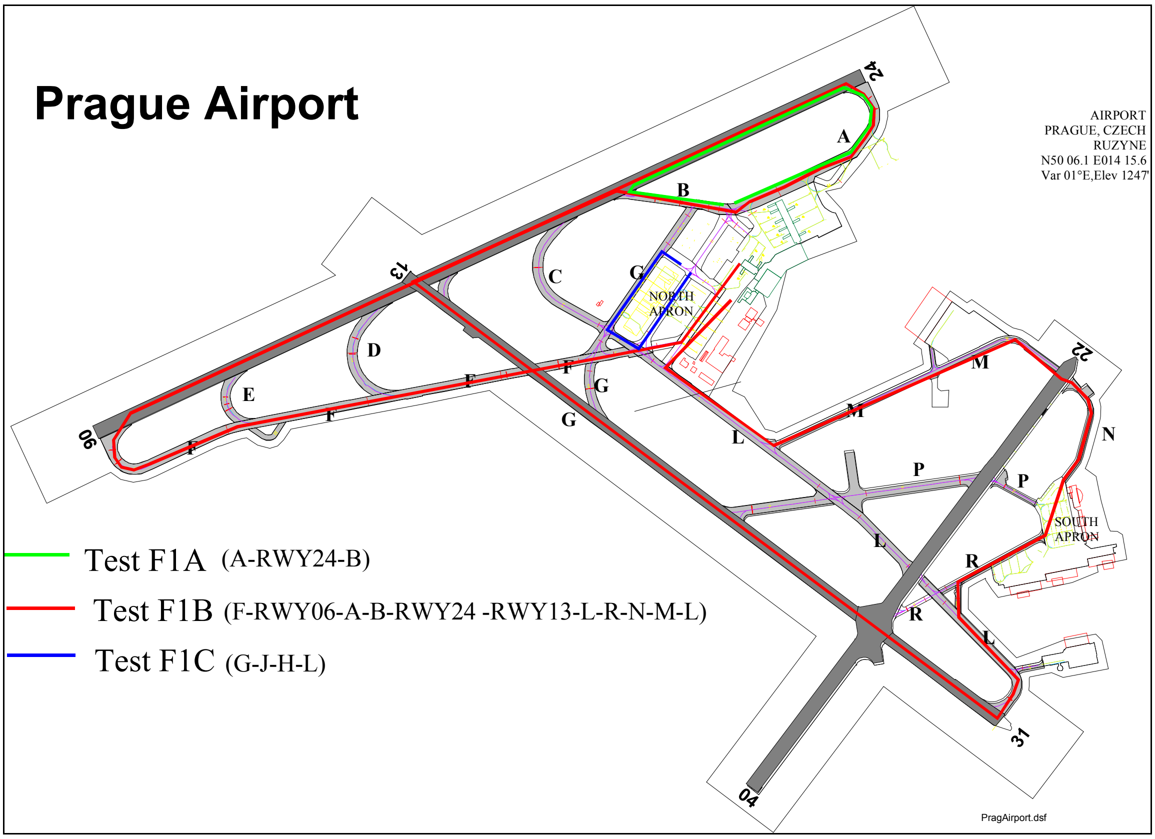


Figure 5-1: Scenario for Functional Performance Tests F1

5.1.2 Testing Surveillance System Reliability (F2) Regular Traffic Studies – Objective Indicators

The requirement of the Surveillance System is to detect all objects of operational interest and to identify co-operating traffic (aircraft and controlled vehicles), by callsign, registration mark or some other unique identifier. Non co-operative traffic and obstacles should be detected and classified by size. The goal of this series of tests is to use 'Regular Traffic Studies' (RTS) in order to collect sufficient data to verify the requirement and quantify the reliability of the surveillance system .

Surveillance Reliability Parameters [2] and [4]:

- Probability of Detection (PD)
- Probability of False Detection(PFD)
- Probability of Identification of co-operative targets (PID)
- Probability of False Identification of co-operative targets (PFID)
-
- Probability of Continuous of Target Track (PCT)
- Coverage Volume (CV)

Test Procedure:

Testing the Surveillance Reliability Parameters will be done by observing the airport traffic by multiple observers throughout the test period and continuous recording of the surveillance and HMI data. The BETA observers write a protocol of relevant differences between the airport traffic and the airport situation shown on the BETA CWP displays.

Test Scenario:

F2: Test during normal airport traffic situation.
In order to gather sufficient data for analysis, the BETA Observers will write a protocol of the situation and differences between the CWP display and the real airport situation throughout the test period. The Observers should specifically note the times and locations of all instances of false detection or false identification, and areas where target tracks are lost. Observers will also need to determine the number of identifiable targets in the movement area, ensuring they are properly equipped and active. Surveillance and HMI data shall be continuously recorded throughout the test period.

Data Recording:

- SDS- Logger — Recording at SDS Output (PAS)
- HMI-Logger — Recording all data at HMI (PAS)

		F2
	Test Equipment	
	Human Actors	
1	Operational Test Co-ordinator	X
2	Technical Test Co-ordinator	X
3	Airport Test Co-ordinator	
4	BETA Controller	
5	BETA Test Vehicle Driver I (airport licence)	
6	BETA Test Car Driver II (airport licence)	
7	BETA Test Aircraft Pilot	
8	BETA Operator and Observer (PAS)	X
9	BETA Operator for ASR – System	
10	BETA Operator (DLR) for NRN – System	
11	BETA Operator (ERA) for ASCS – System	
12	BETA Operator (ANS-CR) for ASR – System	
13	BETA Operator (DLR) for GP&C – System	
14	BETA Operator (DLR)	
15	BETA Observer (Airport and HMI)	X
16	BETA Operator for Pilot HMI	

Table 5-3: BETA Test Equipment and Human Actors involved in F2 Tests

Test protocol of BETA Observer:
The following items should be noted in the test protocol. For validation and analysis of particular events (such as a false target), a CWP replay of the HMI input data can be used.
Protocol for all target types:

Time of observation
Type of event (non-detection, false target, false identification)
In the event of non-detection: Type/Size/ID/Location of object not detected
In the event of false target: Location/Duration of Track
In the event of false identification: Location/Duration/Correct ID/False ID

Recording Tools:

Recording Tools are:

- Surveillance and HMI logger
- Observer Notes, ON–F2
- Debriefing reports (DEB)
- Questionnaire (QUE).

Analysis of Recorded Data

- Calculating the Probability of Detection (PD)
  Count the number of actual known targets (including fixed targets) by evaluation of the Observer Notes and use this information to calculate the expected number of target reports over the observation period.
  Count the number of reports from all known targets by evaluation the recorded surveillance and HMI data over the observation period, total number of correct target reports.
  Calculate the Probability of Detection by the following formula:

  PD = (No. of correct target reports/Expected No. of reports)*100%

- Calculating the Probability of False Detection (PFD)
  Count the number of reports from all targets during the observation period by evaluation of the recorded surveillance data, total number of target reports.

Count the number of false targets during the observation period by evaluation of the Observer Notes.
Calculate the Probability of Detection by the following formula:

PFD = (No. of false target reports /Total No. of target reports) * 100%

- Calculating the Probability of Identification for Co-operating Targets (PID)
  Determine which targets are suitably equipped and co-operating (i.e. following the recommended procedure for use of Mode-S on the ground) by evaluation of the Observer Notes and use this information to calculate the expected number of reports for identifiable targets over the observation period, expected number of reports with ID.
  Count the number of reports from these targets by evaluation of the recorded surveillance data during the observation period, number of target reports with correct ID.
  Calculate the Probability of Identification by the following formula:

  PID = (No. of target reports with correct ID/Expected No. of reports with ID)*100%

- Calculating Probability of False Identification for Co-operating Targets (PFID)
  Count the number of reports from all targets over the observation period by evaluation of the recorded surveillance data, total number of target reports.
  Count the number of targets with erroneous identity over the observation period by evaluation of the Observer Notes and (fast) playback of recorded data.
  Calculate the Probability of False Identification by the following formula:

  PFID = (No. of target reports with erroneous ID/Total No. of reports)*100%

- Calculating Probability of Continuous Track (PCT)
  Count the number of known targets arriving and departing during the observation period by evaluation of the Observer Notes and (fast) playback of recorded data.
  For the known targets, count the number of tracks that are maintained continuously from approach to apron and from apron to take-off.
  Calculate separately for arrivals and departures the Probability of Continuous Track by the following formula:

  PCT = (No. of continuous tracks/No. of known targets)*100%

- Ascertaining the Coverage Volume (CV)
  The coverage volume can be ascertained by plotting recorded surveillance data onto an aerodrome map, backed up by evaluation of the Observer Notes and (fast) replay of Controller HMI.

5.2 Testing Alerting Performance Parameters (F3)

Alerts will be presented on the controller HMI whenever a predefined alert situation is detected by the BETA system.

The following alert situations will be addressed:

- Operational alerts categorised as follows:
  - Conflict alert for situations where an aircraft movement conflicts with predefined separation criteria
    - Arrival predicted to conflict with target on or about to enter runway ahead
    - Departure predicted to conflict with target on or about to enter runway ahead

- Restricted area (incursion) alert in case of an intrusion by any target into a portion of the airport area defined as restricted.
- Stop bar crossing alert in the event that the system detects a target crossing a lit stop bar.
- Deviation alerts in the event that a target enters a taxiway or runway not on its assigned route.

Sufficient data will be collected to evaluate the following alert parameters:

- Probability of Detection of an Alert Situation (PDAS)
- Probability of False Alert (PFA)
- Alert Response Time (ART)

Tests will use Case Studies combining regular traffic and test vehicles in contrived, safe scenarios.

Test Procedures:

F3A: Conflict alert for situations where an aircraft movement conflicts with predefined separation criteria:

- Testing is carried out in normal visibility conditions, but with the alert criteria set for low visibility.
- The test vehicle crosses the low visibility hold in front of an arriving aircraft and stops at the normal visibility hold.
- The test vehicle crosses the low visibility hold in front of a departing aircraft and stops at the normal visibility hold.

F3B: Restricted area alert in case of an intrusion into a portion of the airport area defined as restricted:
A restricted area has been defined for the BETA system at Prague. The Restricted Area monitoring is enabled at the CWP. The test van enters the restricted area. The BETA operator at the controller working place, CWP, is watching if the incursion alerts are displayed.
Test van and BETA operators are involved.

F3C: Stop bar crossing alert in the event that the system detects a target crossing a lit stop bar:
Switch on a stop bar at a given RWY and prove that the red light is receiving bay the BETA system. The test van is simulating a departing a/c and is passing the stop bar. . The BETA operator at the controller working place, CWP, is watching if the incursion alerts are displayed.
Test van and BETA operators are involved.

F3D: Deviation alert in the event that the system detects a target entering a taxiway or runway that is not on its assigned route:

Data Recording:

- SDS- Logger — Recording at SDS Output (PAS)
- HMI-Logger — Recording all data at HMI (PAS)

		F3A	F3B	F3C	F3D	F3F	
	Test Equipment						
1	BETA Test Vehicle (DLR) equipped	X	X	X	X		
2	BETA Test a/c (DLR) Mode-S equipped						
3	Second Test Vehicle GP&C equipped						
	Human Actors						
1	Operational Test Co-ordinator	X	X	X	X		
2	Technical Test Co-ordinator	X	X	X	X		
3	Airport Test Co-ordinator	X	X	X	X		
4	BETA Controller						
5	BETA Test Vehicle Driver I (airport licence)	X	X	X	X		
6	BETA Test Car Driver II (airport licence)						
7	BETA Test Aircraft Pilot						
8	BETA Operator and Observer (PAS)	X	X	X	X		
9	BETA Operator for SMR – System						
10	BETA Operator (DLR) for NRN – System	X	X	X	X		
11	BETA Operator (ERA) for ASCS – System	X	X	X	X		
12	BETA Operator (ANS-CR) for ASR – System	X	X	X	X		
13	BETA Operator (DLR) for GP&C – System	X	X	X	X		
14	BETA Operator (DLR)	X	X	X	X		
15	BETA Observer (Airport and HMI)	X	X	X	X		
16	BETA Operator for Pilot HMI						

Table 5-4: BETA Test Equipment and Human Actors involved in F3 Tests

Recording Tools:
Recording Tools are:

- Surveillance and HMI logger
- Observer Notes, ON–F3A, ON-F3B
- Debriefing reports (DEB)
- Questionnaire (QUE).

Test protocol of BETA Observer (F3A, F3B):
The following items should be noted at the Test protocol. For validation, the CWP replay can be used.
Observing CWP:
Alert On Time
Alert Off Time
Alert type
Identity of targets involved in alert situation
Location of targets involved in alert situation

Analysis of Recorded Data

- **Calculating the Probability of Detection of an Alert Situation (PDAS)**
  Calculate the Probability of Detection of an Alert by following formula:

  PDAS = (No. of correct alert reports)/(Total no. of actual alert situations) * 100%

- **Calculating the Probability of False Alert (PFA)**
  Calculate the Probability of False Alert by following formula:

  PFA = (No. of false alerts)/(Total no. of aircraft movements) * 100%

- **Calculating the Alert Response Time (ART)**

For each alert situation, note the time (t1) at which the specified alert conditions occur by evaluation of the Observer Notes. Note the time (t2) at which the alert is given by evaluation the HMI recording. Calculate the Alert Response Time by following formula:

$$\mathbf{ART = 1 / n \sum^{n}_{i=1} (t2 - t1)}$$

where n is the total number of alert situations detected.

5.3 Testing Planning Performance Parameters (F4)

The following functions will be tested for:

Optimal departure sequence:

- Take Off Time Prediction Accuracy
  (Accuracy of estimated time of departure to actual time of departure)
  . TOTPA*(Analysis by NLR based on PAS recordings)*
- Departure Sequence Response Time DSRT *(Test Procedure from NLR)*
- Ability to optimise departure sequence (taking into account traffic mix/wake vortex)
  (Test procedures from NLR)

Testing the optimal departure sequence. Detailed test procedures will be prepared by NLR. The analyses will be done by NLR based on PAS data recordings.

Clearance control:

- Number of Alerts raised of non-conformance to clearance Check
- Number of false alerts on plan non-conformance Check
- Number of warnings asking that clearance is due Check
- Number of false warnings Check
- Number of alerts raised due to incoherent set of plans Check
- Number of false alerts on incoherent plans Check

These tests need detailed test procedures from TATM. The analyses will be done by PAS with PAS data recordings.

Hand over control:

- Ability of forced shoot/assume hand-overs Check by PAS
- Ability of alerts on uncontrolled aircraft Check by PAS

In general:

- Taxi Plan Computation Rate TPCR Time check by PAS
- Taxi Plan Computation Response Time TPCRT Time check by PAS
- Taxi Plan Prediction Accuracy TTPA No test
- Ability to cover most common taxi routs Check by PAS

Test procedures and test scenarios:
F4 Test procedures outlined by NLR, TATM and PAS.

Data Recording:

- GP&C-Data Logger GP&C-Data Recording via LAN (DLR)
- GP&C-CATS Recording GP&C data for offline replay (DLR)
- SDS- In/Out-Logger Recording at SDS In-/Output (PAS)
- HMI-Logger Recording all data at HMI (PAS)

Recording Tools:

Recording Tools are

- Surveillance Logger
- Observer Notes, ON-F4-PAS

		F4					
	Test Equipment						
1	BETA Test Vehicle (DLR) equipped						
2	BETA Test a/c (DLR) Mode-S equipped						
3	Second Test Vehicle GP&C equipped						
	Human Actors						
1	Operational Test Co-ordinator	X					
2	Technical Test Co-ordinator	X					
3	Airport Test Co-ordinator	X					
4	BETA Controller						
5	BETA Test Vehicle Driver I (airport licence)						
6	BETA Test Car Driver II (airport licence)						
7	BETA Test Aircraft Pilot						
8	BETA Operator (PAS)	X					
9	BETA Operator for SMR – System						
10	BETA Operator (DLR) for NRN – System	X					
11	BETA Operator (ERA) for ASCS – System	X					
12	BETA Operator (ANS-CR) for ASR – System	X					
13	BETA Operator (DLR) for GP&C – System	X					
14	BETA Operator (DLR)	X					
15	BETA Observer (Airport and HMI)	X					
16	BETA Operator for Pilot HMI						

Table 5-5: BETA Test Equipment and Human Actors involved in F4 Tests

5.4 Testing Guidance Performance Parameters (F5)

The functionality of onboard guidance has been tested in phase I with specific CWP operator console (DALICON).
In phase I was tested:

- Guidance Aid Response Time GART = 0.6 sec
- Guidance Aid Confirmation Time GACT = <3 sec

In test phase II the controller input at the CWP has to be tested.
Following test has to be prepared:

- Request from onboard HMI is displayed on the CWP Checked by PAS/DLR
- Clearance from CWP is displayed at the onboard HMI Checked by PAS/DLR
- Taxi Route given by CWP is displayed at the onboard HMI Checked by PAS/DLR

- Clearance Delivery Response Time CDRT measured with stopwatch
- Guidance Aid Response Time GART measured with stopwatch
- Guidance Aid Confirmation Time GACT measured with stopwatch

Test Procedure and Test Scenario:

F5 Testing the on board guidance at the test van:
The test van equipped with Pilots HMI and GP&C Data-link will be located at a parking position on the ramp.
The BETA Driver in the Test Van or Test a/c will operate the pilot HMI and report the HMI actions via radio to the ground station.
One BETA Operator on the CWP (PAS operator) gives the inputs at the CWP.
The second BETA Operator is measuring the time from CWP input to the receiving at the onboard HMI.

Data Recording:

- GP&C-Data Logger GP&C-Data Recording via LAN (DLR)
- GP&C-CATS Recording GP&C data for offline replay (DLR)
- SDS- In/Out-Logger Recording at SDS In-/Output (PAS)
- HMI-Logger Recording all data at HMI (PAS)

		F5					
	Test Equipment						
1	BETA Test Vehicle (DLR) equipped	X					
2	BETA Test a/c (DLR) Mode-S equipped						
3	Second Test Vehicle GP&C equipped						
	Human Actors						
1	Operational Test Co-ordinator	X					
2	Technical Test Co-ordinator	X					
3	Airport Test Co-ordinator	X					
4	BETA Controller						
5	BETA Test Vehicle Driver I (airport licence)						
6	BETA Test Car Driver II (airport licence)						
7	BETA Test Aircraft Pilot						
8	BETA Operator (PAS)	X					
9	BETA Operator (PAS) for SMR – System						
10	BETA Operator (DLR) for NRN – System						
11	BETA Operator (ERA) for ASCS – System						
12	BETA Operator (PAS)for ASR – System						
13	BETA Operator (DLR) for GP&C – System	X					
14	BETA Operator (DLR)	X					
15	BETA Observer (Airport and HMI)	X					
16	BETA Operator for Pilot HMI	X					

Table 5-6: BETA Test Equipment and Human Actors involved in F5 Tests

Test-protocol of BETA Observer:
The following Items should be noted in the test protocol. For validation, the replay of the CWP input data can be used.
Protocol of the BETA Operator at the HMI:
Operating and Observing HMI:
Start Time of Taxi Plan generation
Response Time of Taxi Plan generation
Taxi Plan Routing

Recording Tools:
Recording Tools are Observer Notes (F5-PAS), Debriefing and Questionnaire (ON, DEB, QUE) and Software Analysis of recorded data of GP&C Logger and Pilot HMI Data Logger.

5.5 Test Equipment and Human Actors involved at Prague Functional Tests

			F1					F2		F3						F4		F5	
			Surveillance Accuracy					Reliability		Alert Functions						Planning		Guidance	
			F1A	F1B	F1C	F1D		F2		F3A	F3B	F3C	F3D	F3E		F4		F5	
	Test Equipment																		
1	Test Van GP&C, Mode-S, P-HMI equipped		X	X	X	X				X	X	X	X	X		?		X	
2	Test a/c GP&C, Mode-S, P-HMI equipped																		
3	Test Car GP&C equipped																		
	Human Actors																		
1	Operational Test Co-ordinator	OTC	X	X	X	X		X		X	X	X	X	X		X		X	
2	Technical Test Co-ordinator	TTC	X	X	X	X		X		X	X	X	X	X		X		X	
3	Airport Test Co-ordinator	ATO	X	X	X	X				X	X	X	X	X		X		X	
4	BETA Controller	BC																	
5	BETA Test Van I Driver	TCD	X	X	X	X				X	X	X	X	X					
6	BETA Test Van II Driver	TCD-II																	
7	BETA Test a/c Pilot																		
8	BETA Operator (PASS) for HMI	BO-HMI	X	X	X	X		X		X	X	X	X	X		X		X	
9	BETA Operator (PAS) for SMR - system	BO-SMR	X	X	X	X		X		X	X	X	X	X		X			
10	BETA Operator (DLR) for NRN	BO-NRN	X	X	X	X		X		X	X	X	X	X		X			
11	BETA Operator (ERA) for ASCS	BO-ASCS	X	X	X	X		X		X	X	X	X	X		X			
12	BETA Operator (ANS-CR) for ASR	BO-ASR	X	X	X	X		X		X	X	X	X	X		X			
13	BETA Operator (DLR) for GP&C	BO-GP&C	X	X	X	X		X		X	X	X	X	X		X		X	
14	BETA Operator (DLR)	BO	X	X	X	X										X			
15	BETA Observer (Airport and HMI)	BO-HMI				X		X		X	X	X	X	X		X		X	
16	BETA Operator for pilot HMI	BI-PHMI																	
	BETA Subsystems																		
1	SMR, Surface movement radar with extractor	SMR	X	X	X	X		X		X	X	X	X	X		X			
2	NRN, Near-range Radar Network	NRN	X	X	X	X		X		X	X	X	X	X		X			
3	ASCS, Mode-S multilateration/ADS-B	ASCS	X	X	X	X		X		X	X	X	X	X		X			
4	ASR E200, airport surveillance radar	ASR	X	X	X	X		X		X	X	X	X	X		X			
5	GP&C, ADS-B differential GPS system	GP&C	X	X	X	X		X		X	X	X	X	X		X		X	
6	Surveillance Data Server	SDS	X	X	X	X		X		X	X	X	X	X		X			
7	Planning Subsystem	PL														X			
8	Controller working position (3 systems)	CWP	X	X	X	X		X		X	X	X	X	X		X		X	
9	Ground based guidance aids																		
	Data Recording																		
1	SDS – In / Out Data Logger (PAS)	SDS	X	X	X	X		X		X	X	X	X	X		X		X	
2	ASR – Data Logger (PAS)	ASR	X	X	X	X		X		X	X	X	X	X		X			
3	ASCS –Data Logger (DLR)	ASCS	X	X	X	X		X		X	X	X	X	X		X			
4	SMR – Data Logger (PAS)	SMR	X	X	X	X		X		X	X	X	X	X		X			
5	NRN – Data Logger (DLR)	NRN	X	X	X	X		X		X	X	X	X	X		X			

			F1					F2		F3						F4		F5	
			Surveillance Accuracy					Reliability		Alert Functions						Planning		Guidance	
			F1A	**F1B**	**F1C**	**F1D**		**F2**		**F3A**	**F3B**	**F3C**	**F3D**	**F3E**		**F4**		**F5**	
6	GP&C – Data Logger (DLR)	GP&C	X	X	X	X		X		X	X	X	X	X		X		X	
7	HMI – Data Logger (PAS)	HMI	X	X	X	X		X		X	X	X	X	X		X		X	
8	Planning Data (PAS)	CWP														X		X	
9	GP&C Data Link Logger (DLR)	GP&C														X		X	
10	GP&C CATS (DLR)	GP&C	X	X	X	X		X		X	X	X	X	X		X		X	
11	Stop watch					X													
	Form Sheets																		
1	Test Protocol of TTC	TPR-TTC	X	X	X	X		X		X	X	X	X	X		X		X	
3	Observer Notes	ON				**F1D**		**F2**		**F3A**	**F3B**	**F3C**	**F3D**	**F3E**		**F4**		**F5**	

Table 5-7: Test Tools for Functional Tests

6. Testing A-SMGCS Operational Benefit Parameters

This chapter should be regarded as a continuation of the general thoughts outlined in document D10 'General Test Concept', chapter 4 **[2]**. The general hypotheses listed in D10 will now be transformed into an experimental design. The chapter will describe what tests will be carried out, what data are needed, how these data are obtained and what recording tools are needed. Chapter 6 outlines how the evaluation will be conducted on the data in order to prove the hypotheses.

6.1 Experimental Design

6.1.1 Test Sites and Dates

6.1.1.1 Test Sites

One BETA working position for use by an active controller will be situated in the Control Tower. Two further BETA positions for the use of non-active controllers will be situated in the Visual Control Room (VCR) one floor under the Tower. Additionally, there is also a BETA surveillance display located in the gate management centre.

- Tower
- Visual Control Room (VCR)
- Gate Management office in the airport building

6.1.1.2 Dates

Operational tests will be performed over 10 days from **27th to 31st of May** and **3rd to 7th of June**. The following backup week (**10th to 14th of June**) will be used to obtain subjective baseline data.

6.1.2 Hypotheses

The main objective of BETA is to demonstrate that an A-SMGCS can contribute quantitative and qualitative benefits to the current surface traffic management at the aerodrome. As outlined in D10 **[2]**, more significant effects are expected under low visibility conditions and in congested traffic situations. However, testing with a high density of traffic and under low visibility conditions at an operational airport is a safety risk and is therefore not permitted. Since "visibility" and "traffic amount" cannot be varied and so cannot be handled as additional independent variables, it has to be attempted to show effects of the BETA A-SMGCS system even under good visibility conditions and with an average amount of traffic. The remaining independent variable of interest therefore is the system being used by the controller. Here there are two test conditions, the current system (baseline) and the BETA system.
The following hypothesis (**$H_{1,1}$**) is therefore formulated:

$H_{1,1}$: **The use of BETA (A-SMGCS) will contribute quantitative and qualitative benefits to the current surface traffic management at the aerodrome.**

The overall objective of testing is to assess the benefit in terms of the BETA system performance as one part of the ratio of BENEFIT and COST[1] to quantify the overall efficiency of the system. For this form of assessment the BETA system performance is measured in terms of:

[1] The required costs are not part of operational testing and will be estimated by the respective experts, which are involved in the BETA trials.

1. Safety
2. Efficiency (of traffic movements)
3. Working Conditions
4. Environmental Impacts

Following sub-hypotheses can be derived:

$H_{1,1a}$: **The use of BETA (A-SMGCS) will maintain the current level of safety.**
$H_{1,2b}$: **The use of BETA (A-SMGCS) will increase the efficiency of traffic movements.**
$H_{1,3c}$: **The use of BETA (A-SMGCS) will improve the current working conditions.**
$H_{1,4d}$: **The use of BETA (A-SMGCS) will reduce the environmental impact of a single aircraft.**

A further limitation of the testing is the number of controllers equipped with the BETA system. For each test active control using BETA equipment can be performed only at one control position in the Tower and one in the Apron Control. There are however, three important control positions in the Tower (Platzlotse 1 [TWR1], Platzlotse 2 [TWR 2], and the Platzbodenlotse [GND]) (cf. 6.6), and two important control positions in the Apron control (Apron 1 and Apron 2). But only the GND position in the Tower and the Apron 1 position in the Apron Control will be performed by an active BETA position.

The "Control Position" (GND control and Apron1 Control Position) shall be a second independent variable. Since it is assumed that both position of the BETA controller will experience positive effects of the BETA system, no differences regarding the BETA benefit are expected. The following null hypothesis can be generated:

$H_{0,2}$: **There will be no significant interactions between the effects of the use of the BETA system and the control position (GND vs. Apron 1 control).**

6.1.3 Experimental Variables

6.1.3.1 BETA vs. BASELINE

Data will be collected from BETA controllers both for the Baseline condition, with the controller working at his normal working position using existing equipment and procedures, and for the BETA A-SMGCS condition, with the controller working at the BETA Controller Working Position (CWP). The following functions will be available to the controller and Pilot:

BETA system functions:

- Surveillance
  (Detection and identification of all a/c, equipped cars and tugs, detection of all other targets on the overall aerodrome)
- EFS for arrival and departure and tugs
- Routing (standard routes)
- Alerting (Area infringement settable by the controllers)
- Planning alerts
- Clearance Monitoring
- Departure Manager (D-MAN)
- Uplink and downlink of clearances via data link
- R/T communication
- Onboard HDD for Ground Guidance

BASELINE system function:

- Surveillance (Detection of targets on the most of the aerodrome area)
- EFS for arrival

- Paper strips for departure
- R/T communication

6.1.3.2 Control Positions

As mentioned above, for each test active control using BETA equipment can be performed only at one control position in the Tower. This reduces the possibility of achieving a positive BETA effect again, since it is not possible to use the BETA system to support the entire operational phases of an a/c from gate to airborne (and vice versa) in one test. Also synergy effects between the positions will be missing. Separate tests which each of the three controller roles operating with the BETA system will be conducted however, so that measurements will be obtained for the use of the BETA system in the differing roles.

The BETA controller can take the role of CEC, GEC or TEC at the BETA CWP in the Tower. The two non-active-control positions in the VCR can be used for handover of EFS to or from the active BETA position. In the Gate Management the employees could take advantage of the BETA display but will not influence the traffic actively.

- TEC, GEC, or CEC can be taken by the BETA position
- Two non-active position in VCR (handover of EFS to or from the active BETA position
- Display in the Gate management

6.1.3.3 Combinations of Experimental Variables

Two experimental variables will be combined in the BETA field tests:

- A: BETA (BETA, Baseline)
- B: Role of BETA controller (CEC, GEC, TEC),

The following combination of experimental conditions results:

		B: Role of BETA Controller		
		B_1: CEC	***B_2: GEC***	***B_3: TEC***
A: BETA	***A_1: BETA***	6 Controller	6 Controller	6 Controller
	A_2: Baseline	6 Controller	6 Controller	6 Controller

Table 6-1: Combination of experimental variables

Six Prague ATC controllers are available for the field tests. Every controller will run through every cell of the table so that he will work three times with BETA and three times without the BETA system at three different control positions. Altogether 36 test runs will be performed.

6.1.3.4 Allocation of the Controllers to experimental conditions

The six controllers have to be allocated to the different test runs depending on their duty roster (cf. Table 6-2). Each day three controllers are permanently available so that two to three test runs with three different controllers per day are aimed. To facilitate the allocation each controller will be allocated an index number:

Index	**Initials of Controller**
1	PA
2	ČN

3 IS
4 ZL
5 JH
6 ZH
7 MT (additional backup controller for taking over the non-active control position)

Controller index	Mo 27.5	Tu 28.5	We 29.5	Th 30.5	Fr 31.5	Mo 3.6	Tu 4.6	We 5.6	Th 6.6	Fr 7.6
1	BETA	BETA	½ BETA pm	*Supervisor*	BETA	*W*	-	*W*	BETA	BETA
2	BETA	BETA	BETA	BETA						BETA
3	BETA	T3		BETA	BETA	BETA	BETA	BETA	T7	
4		BETA	BETA	BETA	T6		BETA	½ BETA am		BETA
5	T3	-	BETA	-	-	BETA		BETA	BETA	
6	-	-	-	-	BETA	BETA	-		BETA	*W*
7			BETA				BETA	BETA		
Remarks:	BETA = BETA controller T = Shift on the TWR with changing roles T3 = 0800 – 1700 T6 = 1100 – 2100 T7 = 1400 - 2100 W = Supervisor TWR (0700 – 1900)									

Table 6-2: Duty Roster of Prague Controller

Derived from the duty roster and the combination of the experimental variables a test plan was generated (

Test Run	Date	Controller index	BETA / Baseline	BETA control position	Connected Case studies	Observer for TWR and CS	Done?
1	Mo 27.05.	1	BETA	CEC	-	Jakobi	
2	Mo 27.05.	3	BETA	CEC	-	Jakobi	
3	Mo 27.05.	2	BETA	CEC	-	Jakobi	
	Mo 27.05.	5	Baseline		-		
4	Tu 28.05.	1	BETA	TEC	Alerts (a+b)	Jakobi	
5	Tu 28.05.	4	BETA	TEC	Alerts (a+b)	Jakobi	
6	Tu 28.05.	2	BETA	TEC	Alerts (a+b)	Jakobi	
	Tu 28.05.	3	Baseline		-		
7	We 29.05.	5	BETA	CEC		Jakobi	
8	We 29.05.	4	BETA	CEC		Jakobi	
9	We 29.05.	5	BETA	TEC	Alerts (a+b)	Jakobi	
	We 29.05.	2	BETA				
10	Th 30.05.	3	BETA	TEC	Alerts (a+b)	Jakobi	
	Th 30.05.	2	BETA				
	Th 30.05.	4	BETA				

11	Fr 31.05.	6	BETA	TEC	Alerts (a+b)	Jakobi	
12	Fr 31.05.	6	BETA	CEC	-	Jakobi	
	Fr 31.05.	1	BETA				
	Fr 31.05.	3	BETA				
	Fr 31.05.	4	Baseline				
13	Mo 03.06.	5	BETA	GEC	DLR aircraft	Jakobi / Klein	
14	Mo 03.06.	6	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Mo 03.06.	7	BETA				
15	Tu 04.06	3	BETA	GEC	DLR aircraft	Jakobi / Klein	
16	Tu 04.06	4	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Tu 04.06	7					
17	We 05.06.	2	BETA	GEC	DLR aircraft	Jakobi / Klein	
	We 05.06.	3					
	We 05.06.	5					
	We 05.06.	7					
18	Th 06.06.	1	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Th 06.06.	2					
	Th 06.06.	5					
	Fr 07.07.	1					
	Fr 07.07.	2					
	Fr 07.07.	4					
19	Tu 11.06.	4	Baseline	CEC			
20	Tu 11.06	4	Baseline	GEC			
21	Tu 11.06	4	Baseline	TEC			
22	Mo 17.06.	3	Baseline	CEC			
23	Mo 17.06.	3	Baseline	GEC			
24	Mo 17.06.	3	Baseline	TEC			
25	Tu 18.06.	5	Baseline	CEC			
26	Tu 18.06.	5	Baseline	GEC			
27	Tu 18.06.	5	Baseline	TEC			
28	We 19.06.	1	Baseline	CEC			
29	We 19.06.	1	Baseline	GEC			
30	We 19.06.	1	Baseline	TEC			
31	24.06.	2	Baseline	CEC			
32	24.06.	2	Baseline	GEC			
33	24.06.	2	Baseline	TEC			
34	24.06.	6	Baseline	CEC			
35	24.06.	6	Baseline	GEC			

36	24.06.	6	Baseline	TEC			

Remarks:

A cell without a test run number marks a backup test run, which can be conducted if the respective previous planned test run could not take place. The cell will be filled with the test run number of the previous planned test run. The controller index column marks the availability of the controller.

The connected case studies (CS) refer to the terms in Table 6-6.

Table 6-3). The availability of a controller, as a basic requirement, was linked with a specific control position. It was also aimed to have a constant BETA CWP over more than one test run in order to ease the permanent adaptation of the BETA equipment. Each test run gets a specific test run number. 36 test runs are 36 numbers. The numbers results from the chronological order of the test runs' planned execution.

Sometimes more than three test runs are planned per day, which does not mean that all these test runs has to be carried out at this day but more that these test runs can be carried out this day in accordance to the availability of the controllers. If a test run was not conducted there are additional lines in the table, where the missed test run can be repeated. These lines are marked with a star and do also indicate the availability of the needed controller (controller index). This test plan procedure was choosen to get the best flexibility in order to cope with the permanent changing conditions with field testing. When a test run was performed the test co-ordinator can make a mark in the last column.

Test Run	Date	Controller index	BETA / Baseline	BETA control position	Connected Case studies	Observer for TWR and CS	Done?
1	Mo 27.05.	1	BETA	CEC	-	Jakobi	
2	Mo 27.05.	3	BETA	CEC	-	Jakobi	
3	Mo 27.05.	2	BETA	CEC	-	Jakobi	
	Mo 27.05.	5	Baseline		-		
4	Tu 28.05.	1	BETA	TEC	Alerts (a+b)	Jakobi	
5	Tu 28.05.	4	BETA	TEC	Alerts (a+b)	Jakobi	
6	Tu 28.05.	2	BETA	TEC	Alerts (a+b)	Jakobi	
	Tu 28.05.	3	Baseline		-		
7	We 29.05.	5	BETA	CEC		Jakobi	
8	We 29.05.	4	BETA	CEC		Jakobi	
9	We 29.05.	5	BETA	TEC	Alerts (a+b)	Jakobi	
	We 29.05.	2	BETA				
10	Th 30.05.	3	BETA	TEC	Alerts (a+b)	Jakobi	
	Th 30.05.	2	BETA				
	Th 30.05.	4	BETA				
11	Fr 31.05.	6	BETA	TEC	Alerts (a+b)	Jakobi	
12	Fr 31.05.	6	BETA	CEC	-	Jakobi	
	Fr 31.05.	1	BETA				
	Fr 31.05.	3	BETA				
	Fr 31.05.	4	Baseline				

13	Mo 03.06.	5	BETA	GEC	DLR aircraft	Jakobi / Klein	
14	Mo 03.06.	6	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Mo 03.06.	7	BETA				
15	Tu 04.06	3	BETA	GEC	DLR aircraft	Jakobi / Klein	
16	Tu 04.06	4	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Tu 04.06	7					
17	We 05.06.	2	BETA	GEC	DLR aircraft	Jakobi / Klein	
	We 05.06.	3					
	We 05.06.	5					
	We 05.06.	7					
18	Th 06.06.	1	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Th 06.06.	2					
	Th 06.06.	5					
	Fr 07.07.	1					
	Fr 07.07.	2					
	Fr 07.07.	4					
19	Tu 11.06.	4	Baseline	CEC			
20	Tu 11.06	4	Baseline	GEC			
21	Tu 11.06	4	Baseline	TEC			
22	Mo 17.06.	3	Baseline	CEC			
23	Mo 17.06.	3	Baseline	GEC			
24	Mo 17.06.	3	Baseline	TEC			
25	Tu 18.06.	5	Baseline	CEC			
26	Tu 18.06.	5	Baseline	GEC			
27	Tu 18.06.	5	Baseline	TEC			
28	We 19.06.	1	Baseline	CEC			
29	We 19.06.	1	Baseline	GEC			
30	We 19.06.	1	Baseline	TEC			
31	24.06.	2	Baseline	CEC			
32	24.06.	2	Baseline	GEC			
33	24.06.	2	Baseline	TEC			
34	24.06.	6	Baseline	CEC			
35	24.06.	6	Baseline	GEC			
36	24.06.	6	Baseline	TEC			

Remarks:

A cell without a test run number marks a backup test run, which can be conducted if the respective previous planned test run could not take place. The cell will be filled with the test run number of the previous planned test run. The controller index column marks the availability of the controller.

The connected case studies (CS) refer to the terms in Table 6-6.

Table 6-3: Test Plan

The following table can be used by the test co-ordinator to keep track when marking the already performed test runs.

Controller index	BETA			Baseline		
	CEC	GEC	TEC	CEC	GEC	TEC
1						
2						
3						
4						
5						
6						

Table 6-4: Controllers associated with the Test Conditions

6.2 Measurements

The following diagram shows the summary of the indicators that will be measured in order to decide about the four alternative hypotheses (cf. section 6.1.2). The indicators shown in thin text will not be measured in the baseline tests because the BETA system will not be used.

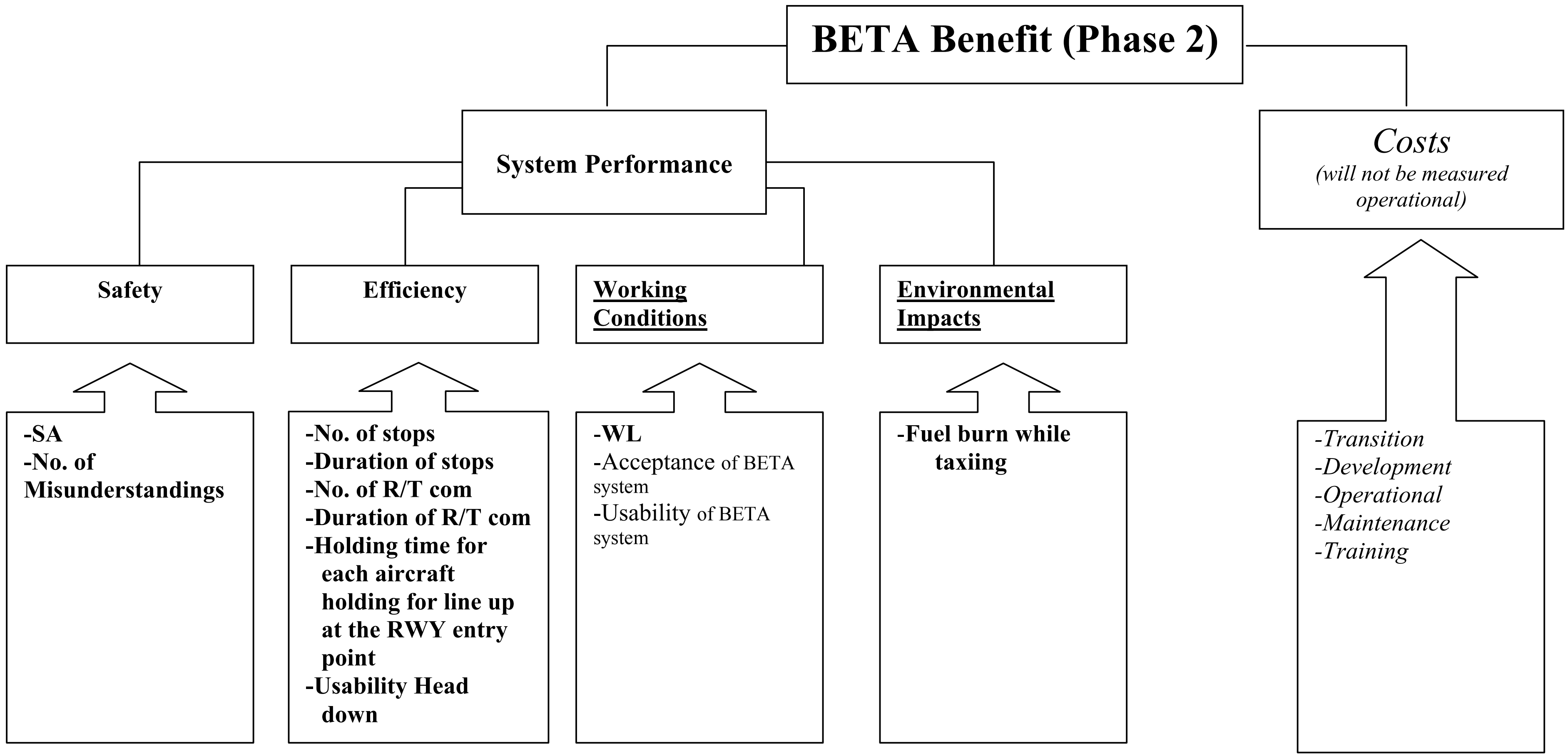


Figure 6-1: Hierarchical decomposition of the Assessment of the BETA System

6.2.1 System Performance Criteria

6.2.1.1 Safety

Safety on an airport can be described by the number of incidents or even accidents in a certain (relatively long) time period. Unfortunately such long term studies can not be performed within the BETA project. Therefore other safety indicators have to be used to predict the safety of ground movements with and without the BETA A-SMGCS system. In line with other studies, subjective measurements of **'Situation Awareness'** and 'Workload' of the participants will be used to estimate the safety of the system. The construct of Situation Awareness (SA) will be understood in terms of ENDSLEY's definition: *"the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future"* (p. 36) [5]. SA will be measured with the standardised and acknowledged SART (Situation Awareness Rating Technique) questionnaire [7]. For the field-testing the 14 dimension version will be used. The SART covers also the workload dimension of SA, thus that separate workload measurements will not be used for prediction of safety.

A second safety indicator will be the **'Number of Misunderstandings'** of the radio communication between controllers and pilots. Misunderstanding frequently cause potential safety critical situations, a reduction would therefore have a positive effect on safety. The misunderstandings will be measured through a standardised observer sheet (cf. Annex H).

The hypothesis $\mathbf{H_{1,1a}}$ states: "The use of BETA (A-SMGCS) will maintain the current level of safety.". 'Maintain' instead of 'increase' takes into account that the safety on airport is already of a high standard but that with an increasing level of traffic safety must be guaranteed through new technical support like an A-SMGCS. BETA shall cope with this requirement. However the proof of maintenance of safety with increasing traffic amount cannot be achieved with the field-testing since testing with high levels of traffic is safety-critical and not permitted. That is, scores of SART and 'Number of misunderstandings' with BETA are expected to be similar to those in the existing (baseline) condition, it is possible that they could be slightly higher, because the controller has already a high amount of SA under good sight conditions and low traffic.

Another indirect safety indicator is a well-working alerting function. Coupled with high controller ratings regarding the usability and acceptance of the alerts, safety is more guaranteed with increasing traffic and bad visibility conditions.

6.2.1.2 Efficiency

Efficiency can be seen as the ratio of costs and benefit. When the same amount of traffic can be handled with less effort or a higher amount of traffic with the same effort, then a system can be viewed as being more efficient. BETA has the goal to increase the efficiency in order to cope with the increasing rate of traffic even under poor weather conditions whilst maintaining the amount of effort.

Unfortunately since testing in high traffic and poor visibility conditions is not permissible during field-testing BETA attempts to reduce the cost (or effort) in parallel with a relative low amount of traffic and good visibility conditions. The **"No. of stops", "Duration of stops", "No. of R/T com", "Duration of R/T com", "Holding time for each aircraft holding for line up at the RWY entry point"**, and the **"Usability working head down"** are the chosen efficiency indicators and shall be influenced by BETA. The majority of these parameters will be recorded by the system itself. The exception is 'usability working head down'.
In order to measure this parameter the controllers will be requested to work 'head down' or without looking out of the window to simulate poor visibility conditions. When he is able to do this in parallel with a safe and effective controlling of the present traffic, then it is a good indication of the BETA system causing an increase in efficiency. This parameter will be measured by observation during the tests and by the recording of the opinion of the BETA controllers.

6.2.1.3 Working Conditions

A new system can only work efficiently if the working conditions of the users are acceptable, that is, that the **workload** as well the **usability** and **acceptance** of the new system and new procedures are viewed as appropriate by the users.

The user's workload will be assessed by the NASA-TLX questionnaires (cf. Annex D). NASA TLX is a subjective workload measure developed by NASA. It is based on the premise that subjective or "perceived" workload is a combination of 6 factors. It has been used in real-time ATC simulations for over 5 years. The workload associated with completing a task will depend on the controller's perception of the task and the controller itself.

The general system usability and the user's acceptance will be measured by a usability scale (SUS) **[4]** and a self-developed acceptance questionnaire, which refers to special functions and procedures (cf. Annex F).

6.2.1.4 Environmental Impact

The implementation of ASMGCS also aims to reduce the environmental impact of each aircraft in terms of noise and pollution. This can be realised by lower waiting times of aircraft with running engines and fewer stops during taxiing. The environmental impact will be measured by recording the **"Fuel burn while taxiing"** of each aircraft. This data will be obtained from the 'Quick Assess Recorder', which is mounted in each aircraft. These data will be provided by CSA Airline for all CSA aircraft.

6.2.2 Indicators

The table below (Table 6-5) shows the selected indicators including the definition of the indicator, the measuring instrument, the expected influence of the BETA system, and some comments or requirements.

Indicator	Definition of indicator	Measuring instruments	Probable Influences of BETA A-SMGCS	COMMENTS
SAFETY				
Situation Awareness	SART index	14D-SART questionnaire	Improved SA due to: -Surveillance HMI -EFS -Alerting -Planning -Routing	-Just post run assessment possible
Number of misunder-standings	Number of misunder-standings per time and handled a/c	Observer Sheet (NLR)	Lower number of misunderstandings due to: -Labelled a/c on the surveillance HMI (controller could give more precise advisories) - Taxi Route displayed in letters -EFS -*On-board HMI with Data link (just one a/c and one FM)*	-Definition of 'misunderstanding' is required -Misunderstandings are measured via a valid observer sheet
EFFICIENCY				
Number of R/T Communications	Number per time and handled a/c	V-BC (Voice-Button Counter)	Lower number of R/T communication due to: -Displayed Taxi Route -EFS -Labelled a/c on the surveillance HMI (controller could give more precise advisories) -Alerts -*On-board HMI with Data link (just one a/c and one FM)*	
Duration of R/T Communications	Average duration per time and handled a/c	V-BC	Shorter duration of RT communications due to: -EFS -Displayed Taxi Route -Labelled a/c on the surveillance HMI -Alerts -*On-board HMI with Data link (just one a/c and one FM)*	
Number of stops of a/c during taxiing	Average number of stops of a/c	Surveillance Logger	Fewer stops by a/c due to: -Displayed Taxi Route -Labelled a/c at the surveillance HMI (controller could give more precise advisories) -Planning (optimal EOBT)	-(PAS) -Similar traffic density between BETA and Baseline is very important

Indicator	Definition of indicator	Measuring instruments	Probable Influences of BETA A-SMGCS	COMMENTS
Duration of stops during taxiing	Average duration of each a/c	Surveillance logger	Shorter duration of stops due to: -Shorter stops by a/c due to: Displayed Taxi Route -Labelled a/c at the surveillance HMI (controller could give more precise advisories) -Planning (D-MAN gives optimal EOBT)	
Holding time for each aircraft holding for line up at the RWY entry point	Average duration of each a/c	Surveillance Logger	Shorter holding time due to: -Planning (D-MAN with optimal EOBT) -Labelled a/c on the surveillance HMI (controller could give more precise advisories) -EFS with time line	-High traffic load is needed -Planning (D-MAN), routing must be working properly -Controller must accept the D-MAN advisories very often, otherwise no measurement possible
Usability Head Down	Usability yes or no If no: Average number of gazes to outside view	-Test Observation sheet (cf. 8.2.1)	Usability head down possible due to: -Detection and labelling of all a/c -EFS with flight status	-Controller are requested to work head down as much as possible -Observer counts the number of gazes outside -Times of gazes will be randomised by themselves (Contents of information within the duration of gazes is very low) -The reasons why the controller felt the need to look outside needs to be covered in the debriefing -Observer also counts the faults of Surveillance HMI (cf. **8.2.1**)
WORKING CONDITIONS				
Level of workload	-NASA TLX index	NASA-TLX	Maintenance of acceptable level of workload: -Surveillance HMI -EFS -Alerting -Planning -Routing	-Just post run assessment possible
Usability	Usability index	SUS (System Usability Scale)	High usability	-Post run
Acceptance	Acceptance index	?	High acceptance	-Questionnaire IS NEEDED (NLR) -Post run
ENVIRONMENTAL IMPACTS				
Lower fuel burn while taxiing	Average fuel burn of all CSA a/c while taxiing depending of a/c type	-QAR	Lower fuel burn due to: -Planning (optimal EOBT) -Displayed Taxi Route -Labelled a/c at the surveillance HMI (controller could give more precise advisories)	

Table 6-5: Indicators and Measuring Instruments

6.3 Test Procedure

In this section it is explained how a typical test run will be carried out. This includes when and how measurements will be taken, what site conditions have to predominate, and what tasks will be by each person.

For a controlled experimental design it is important that only the experimental variables (BETA; Controller role) will be contrasted whilst all other factors should be stable or at least do not effect systematically. For this reason, a comparable traffic situation, which differs only in 'BETA/Baseline' and/or 'TEC, GEC, or CEC', has to be found. The traffic situation shall be stable regarding:

- Runway in use
- Traffic mix (VFR vs. IFR)
- Traffic density

To control these periphery conditions traffic data will be logged continuously during the normal work of the controllers for a week before the operational test phase commences. The recording tools used will be the 'Surveillance logger', 'flight plan data', 'QAR', and the 'Voice-Button Counter'. Since this baseline data pool consists of data of a time window of a complete week, almost every traffic situation regarding runway in use, time of day, etc. will be available (cf. 6.3.7 Baseline Data).

6.3.1 Measuring Instruments

Measuring instruments for objective traffic data:

- QAR (CSA)[2]
    - Data from the **Quick Access Recorder** of the two airlines CSA are stored continuously. The needed data of the involved aircraft of the airlines can be provided easily. CSA is able to deliver them by request.

- Surveillance logger (PAS)
    - Traffic data (number and duration of stops, etc.) can be recorded either in advance or after the operational test phase, but at least one whole week in total

- Flight Plan data (ANS)
    - Are permanently available. Can be delivered by ANS by request.

- Voice-Button Counter (DLR)
    - Record of the number and duration of communications on the respective controller radio frequency

Measuring instruments for subjective data: (DLR)

- Questionnaires
    - SART 14-D (for measurement of the operator's situation awareness post run)
    - NASA-TLX (for workload measurement post run)
    - SUS (Measurement of BETA's usability)
    - Acceptance questionnaire
    - Assessment of BETA A-SMGCS benefits questionnaire

6.3.2 Briefing

Each morning before testing a briefing session will be carried out with all participants in order to agree on the current day in terms of:

[2] Company in brackets marks the responsibility

- Which controllers, drivers, pilots, or test co-ordinators are needed
- Who is responsible for what…
- Current time schedule of testing
- What is planned to do (scenarios, mid-run questionnaires explanations etc.)

6.3.3 Procedure of a BETA Test Run

When the Tower supervisor and the Operational Test Co-ordinator raise the green flag a BETA test run can be started. The best test periods with regard to the traffic amount, which shall be not so low, are in the morning from 10 am to 1 pm and in the afternoon from 3.30 pm to 5.30 pm. The two non-active BETA controllers take over the two non-active CWP in the VCR and the active BETA controller takes over the BETA CWP in the Tower. The respective role of control depends on the test plan, whereas the non-active controllers take over the two remaining roles and support the BETA position with the handover of the EFS.

The controller of the normal control position, which is now taken over by BETA, becomes the backup controller, who can immediately take back control in case of safety risks. After agreement between the BETA controller and the backup controller the control is transferred to the BETA controller and the test run starts.

Shortly before the beginning of a test run the BETA operator (BO) starts the recording of the Voice-Button Counter for the respective controller frequency (TEC = 118.1 MHz [channel 54], GEC = 121.9 [channel 98] MHz, CEC =119.7 MHz [channel 99]) He/she assures further that all required data loggers are working.

The BETA observer will sit close to the BETA controller and note all comments made by the BETA controller and their own observations. Additionally s/he notes following items on the 'test observer sheet' (cf. 8.2.1):

- Sheet number
- Date
- Test run number
- Start time (UTC)
- End time (UTC)
- Runway in use
- Weather conditions
- Condition: BETA or Baseline
- Condition: Controller role
- Controller index
- Missing targets or identifications
- EFS failure
- Compliance to D-MAN advisories
- Number of gazes outside
- Misunderstandings (separate observer sheet)

For a BETA test run the BETA controller will have control of the regular traffic. A test run will last at least one hour or so long until the OTC, supervisor, backup controller or even the BETA controller stop the trial. When a test run is shorter than one hour it is invalid and will be repeated.

In order to get comparison data a baseline test run will be conducted using the same procedure as a BETA test run. In this situation the BETA observer will sit close to the normal control position of interest instead of the BETA position and will note the same observations and information as during a BETA test run, with the exception of items relating to the BETA system. Only the controllers, which are also involved in the BETA tests, will participate in these tests.

6.3.4 Debriefing

After each test run a debriefing session will be held in a separate room. Three questionnaires will be given to the BETA controller by the BETA observers. These are SART, NASA-TLX and the SUS. The SUS questionnaire regarding 'usability' is only related to BETA A-SMGCS and will be given to the controller only after a BETA test run. The controller will also be interviewed regarding any observations made by the observer during the test run including any problems experienced and/or misunderstandings that occurred, and additionally with regard to the following BETA sub-tasks, whereas the controllers are requested to write down their impressions and experiences (cf. 'Debriefing Questionnaire' section 8.2.3):

- Use of Surveillance HMI
- Use of EFS
- Handover of EFS
- Use of clearance monitoring alerts
- Use of the Routing function
- Use of D-MAN function
- Use of data link clearances
- Use of Route deviation alert
- Use of runway incursion alert
- Use of Planning alerts

If a task did not happen during a test run, the BETA test subject should disregard questions to this task. On completion of all test runs, two further questionnaires will be given to the controllers. Firstly they will be requested to estimate subjectively benefits of BETA (Annex E: Assessment of BETA A-SMGCS benefits) and secondly they will be asked questions regarding the acceptance of individual BETA system functions (Annex F: Acceptance Questionnaire to single BETA functions).

6.3.5 D-Man Procedure

The D-MAN will only work as intended if it is informed about the event 'departure clearance given', which is given over the clearance button in the EFS by the CEC. After this event the optimal EOBT and ETD of the respective a/c is displayed to the controller.
Depending on the 'Role of BETA Controller' different operations have to be carried out to guarantee that all controllers can take advantage of the D-MAN results and the traffic can be controlled with the support of D-MAN recommendations. That is, D-MAN information has to be kept in the control loop of the three controllers (CEC, GEC, TEC) independent of the role of BETA. D-MAN information is only forwarded automatically within the BETA system, in some situations D-MAN information will need to be passed manually. The following procedures will be applied depending on the role of the BETA controller:

BETA CEC:
If CEC is performed by use of the BETA system then the active BETA controller himself presses the 'Departure Clearance' button. The BETA system will start to calculate and the information about EOBT will be forwarded to the normal GEC by the backup controller. Also the calculated departure sequence after starting taxiing will be forwarded to the normal GEC and TEC. However, GEC and TEC are never forced to act in accordance to the D-MAN sequence proposals. When they have certain reasons to deviate from the proposals they are allowed to do it.

BETA GEC:
If GEC is performed by use of the BETA system then the non-active CEC BETA controller in the VCR, who is permanently monitoring the CEC R/T communication, presses the 'Departure Clearance' button. After handover of the EFS to the active GEC BETA controller, he will be informed about EOBT, ETD and the departure sequence. The respective departure sequence is passed once more to the TEC by the backup controller.

BETA TEC
Whether the D-MAN can be used properly, when the TEC is performed by BETA, has to be checked on-site.The active BETA TEC will not receive the EFS before handover of the non-active GEC BETA controller, this means, that the information about the best EOBT is not available in the Tower and can not be given to the normal GEC. Eventually, the information could be forwarded via phone but this could prove too labour intensive to be practicable.

6.3.6 'Usability head down'

As mentioned-before 'Usability head down' is an efficiency indicator, which aims to show that with support of BETA even under low visibility conditions controlling of the airport traffic is possible without significant limitations. Therefore, when a test run starts, the BETA controllers are requested to work head down exclusively. To cover all safety risks the back up controller will look out of the windows and monitor the controlling of the BETA controller. S/he will warns the BETA controller in case of conflicts or will takes back control when safety is impaired. However, in case the BETA controller doubts the information shown or he needs information that is not displayed, he may look out of the window himself. The BETA observer will note any unit of gazes outside made by the BETA controller, when they occur, and ask for their reasons in the debriefing session. Units are related to specific traffic situation: If the controller wants to survey the approaching of two aircraft to an intersection and the surveillance display is not able to provide him with the right information then he will feel forced to look out of the window, what will be recorded as on unit. It is then out of interest whether he looks permanently out of the window for 10 seconds or 5 time for 2 seconds if he only wants to get information about this specific traffic situation.

6.3.7 Baseline Data

Both objective (traffic) data and subjective baseline data will be recorded. For the assessment of the subjective data, gained from the opinions of the BETA controllers, the BETA controller are interviewed after their normal shift in the same way as it is done during the BETA test sessions, but without interviews to BETA's usability and acceptance. It must be ensured that the test site conditions are similar to that during which BETA tests were conducted, e.g. the amount of traffic, the control position, and the runway in use.

The test times for the assessment of the subjective data depend much on the availability of the BETA controller and are planned in

Test Run	Date	Controller index	BETA / Baseline	BETA control position	Connected Case studies	Observer for TWR and CS	Done?
1	Mo 27.05.	1	BETA	CEC	-	Jakobi	
2	Mo 27.05.	3	BETA	CEC	-	Jakobi	
3	Mo 27.05.	2	BETA	CEC	-	Jakobi	
	Mo 27.05.	5	Baseline		-		
4	Tu 28.05.	1	BETA	TEC	Alerts (a+b)	Jakobi	
5	Tu 28.05.	4	BETA	TEC	Alerts (a+b)	Jakobi	
6	Tu 28.05.	2	BETA	TEC	Alerts (a+b)	Jakobi	
	Tu 28.05.	3	Baseline		-		
7	We 29.05.	5	BETA	CEC		Jakobi	
8	We 29.05.	4	BETA	CEC		Jakobi	
9	We 29.05.	5	BETA	TEC	Alerts (a+b)	Jakobi	
	We 29.05.	2	BETA				

10	Th 30.05.	3	BETA	TEC	Alerts (a+b)	Jakobi	
	Th 30.05.	2	BETA				
	Th 30.05.	4	BETA				
11	Fr 31.05.	6	BETA	TEC	Alerts (a+b)	Jakobi	
12	Fr 31.05.	6	BETA	CEC	-	Jakobi	
	Fr 31.05.	1	BETA				
	Fr 31.05.	3	BETA				
	Fr 31.05.	4	Baseline				
13	Mo 03.06.	5	BETA	GEC	DLR aircraft	Jakobi / Klein	
14	Mo 03.06.	6	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Mo 03.06.	7	BETA				
15	Tu 04.06	3	BETA	GEC	DLR aircraft	Jakobi / Klein	
16	Tu 04.06	4	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Tu 04.06	7					
17	We 05.06.	2	BETA	GEC	DLR aircraft	Jakobi / Klein	
	We 05.06.	3					
	We 05.06.	5					
	We 05.06.	7					
18	Th 06.06.	1	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Th 06.06.	2					
	Th 06.06.	5					
	Fr 07.07.	1					
	Fr 07.07.	2					
	Fr 07.07.	4					
19	Tu 11.06.	4	Baseline	CEC			
20	Tu 11.06	4	Baseline	GEC			
21	Tu 11.06	4	Baseline	TEC			
22	Mo 17.06.	3	Baseline	CEC			
23	Mo 17.06.	3	Baseline	GEC			
24	Mo 17.06.	3	Baseline	TEC			
25	Tu 18.06.	5	Baseline	CEC			
26	Tu 18.06.	5	Baseline	GEC			
27	Tu 18.06.	5	Baseline	TEC			
28	We 19.06.	1	Baseline	CEC			
29	We 19.06.	1	Baseline	GEC			
30	We 19.06.	1	Baseline	TEC			
31	24.06.	2	Baseline	CEC			

32	24.06.	2	Baseline	GEC			
33	24.06.	2	Baseline	TEC			
34	24.06.	6	Baseline	CEC			
35	24.06.	6	Baseline	GEC			
36	24.06.	6	Baseline	TEC			

Remarks:

A cell without a test run number marks a backup test run, which can be conducted if the respective previous planned test run could not take place. The cell will be filled with the test run number of the previous planned test run. The controller index column marks the availability of the controller.

The connected case studies (CS) refer to the terms in Table 6-6.

Table 6-3. It will be conducted immediately after the two weeks of operational testing. Recording of the objective traffic data will be carried out before the operational test phase with a permanent record of traffic data over several days.

6.3.8 Usability of BETA in Gate Management

An additional BETA display is installed in the Gate Management Centre. The Gate Co-ordinators can survey all traffic at and in the vicinity of the airport and thus are better able to manage the gate distribution. Each Gate Co-ordinator, who has used the BETA display during his/her work, shall be interviewed afterwards. The user shall fill in the SUS questionnaire and will be encouraged to give free comments regarding the BETA surveillance display.

6.3.9 Interview concerning the Overall Assessment of BETA

Chapter 7 outlines how the overall assessment of the BETA system shall be assessed. Amongst other things, the opinions of various decision makers regarding the BETA system will be used to weight the experimental results gained in order to be able to place the BETA system performance within the baseline system performance.

For the assessment of the A-SMGCS experts' opinions the operational test phase will also be used. In test breaks at the end of the second week the BETA controllers will be confronted with the 'Overall Assessment questionnaire' (cf. ANNEX G) and requested to compare different BETA system performance indicators and criteria.

6.3.10 Case Studies

The test runs, where the regular airport traffic is controlled by the use of the BETA system, would be sufficient if there were not a requirement to investigate the effects of BETA during safety-critical traffic situations such as runway incursions or route deviation conflicts. These incidents are unlikely to occur in sufficient quantities (if at all, one hopes) during the limited time of the BETA tests. Additionally, it is required to investigate situations while the controller handles BETA equipped aircraft and follow-me cars via data link instead of R/T communication. To cover such situations it will be necessary to produce artificial traffic scenarios, which will be integrated into the regular traffic. These test procedure will be called '**Case Studies**'.

In order to confront active BETA controllers with safety-critical situations and data link controlling, and further to save valuable operational test time, these artificial traffic scenarios are linked with regular test runs. It is aimed that each BETA controller is confronted with a safety-critical situation or the data link function at least once. At which test runs a BETA controller will be confronted with a specific case study can be seen in the test plan (

Test Run	Date	Controller index	BETA / Baseline	BETA control position	Connected Case studies	Observer for TWR and CS	Done?
1	Mo 27.05.	1	BETA	CEC	-	Jakobi	
2	Mo 27.05.	3	BETA	CEC	-	Jakobi	
3	Mo 27.05.	2	BETA	CEC	-	Jakobi	
	Mo 27.05.	5	Baseline		-		

4	Tu 28.05.	1	BETA	TEC	Alerts (a+b)	Jakobi	
5	Tu 28.05.	4	BETA	TEC	Alerts (a+b)	Jakobi	
6	Tu 28.05.	2	BETA	TEC	Alerts (a+b)	Jakobi	
	Tu 28.05.	3	Baseline		-		
7	We 29.05.	5	BETA	CEC		Jakobi	
8	We 29.05.	4	BETA	CEC		Jakobi	
9	We 29.05.	5	BETA	TEC	Alerts (a+b)	Jakobi	
	We 29.05.	2	BETA				
10	Th 30.05.	3	BETA	TEC	Alerts (a+b)	Jakobi	
	Th 30.05.	2	BETA				
	Th 30.05.	4	BETA				
11	Fr 31.05.	6	BETA	TEC	Alerts (a+b)	Jakobi	
12	Fr 31.05.	6	BETA	CEC	-	Jakobi	
	Fr 31.05.	1	BETA				
	Fr 31.05.	3	BETA				
	Fr 31.05.	4	Baseline				
13	Mo 03.06.	5	BETA	GEC	DLR aircraft	Jakobi / Klein	
14	Mo 03.06.	6	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Mo 03.06.	7	BETA				
15	Tu 04.06	3	BETA	GEC	DLR aircraft	Jakobi / Klein	
16	Tu 04.06	4	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Tu 04.06	7					
17	We 05.06.	2	BETA	GEC	DLR aircraft	Jakobi / Klein	
	We 05.06.	3					
	We 05.06.	5					
	We 05.06.	7					
18	Th 06.06.	1	BETA	GEC	DLR aircraft	Jakobi / Klein	
	Th 06.06.	2					
	Th 06.06.	5					
	Fr 07.07.	1					
	Fr 07.07.	2					
	Fr 07.07.	4					

19	Tu 11.06.	4	Baseline	CEC			
20	Tu 11.06	4	Baseline	GEC			
21	Tu 11.06	4	Baseline	TEC			
22	Mo 17.06.	3	Baseline	CEC			
23	Mo 17.06.	3	Baseline	GEC			
24	Mo 17.06.	3	Baseline	TEC			
25	Tu 18.06.	5	Baseline	CEC			
26	Tu 18.06.	5	Baseline	GEC			
27	Tu 18.06.	5	Baseline	TEC			
28	We 19.06.	1	Baseline	CEC			
29	We 19.06.	1	Baseline	GEC			
30	We 19.06.	1	Baseline	TEC			
31	24.06.	2	Baseline	CEC			
32	24.06.	2	Baseline	GEC			
33	24.06.	2	Baseline	TEC			
34	24.06.	6	Baseline	CEC			
35	24.06.	6	Baseline	GEC			
36	24.06.	6	Baseline	TEC			

Remarks:

A cell without a test run number marks a backup test run, which can be conducted if the respective previous planned test run could not take place. The cell will be filled with the test run number of the previous planned test run. The controller index column marks the availability of the controller.

The connected case studies (CS) refer to the terms in Table 6-6.

Table 6-3). After a test run with a associated case study the controller as well the co-pilot or follow-me driver will be interviewed with regard to the specific BETA function for example, ‘onboard HDD’, ‘datalink controlling’, and ‘alert function’. Additionally, the co-pilots or follow-me drivers are requested to fill in the NASA-TLX (workload), the SART (situation awareness), and the SUS (usability of the overall system). The respective scenarios, the measurements, the influence of BETA, and important comments are outlined in the following table:

Case Study	Scenario	Test Subjects	Measurements and instruments	Probable Influences of BETA	COMMENTS
1. Onboard HMI in aircraft	-A CSA Pilot will act as Co-Pilot in the DLR test aircraft and perform a gate to gate scenario (stand → taxiing → start → Landing → taxiing → final position) -Aircraft is equipped with onboard HMI -Data link communication is performed via an active BETA controller (GEC) and the CSA co-pilot -R/T com is used for back-up, landing and take-off clearance	Co-Pilot, Controller	-SART -NASA-TLX -SUS	-Graphical representation of own position at the aerodrome to the pilot -Graphically cleared route -Alphanumeric route -Detection of co-operative targets -Communication via data link	
2. Onboard HMI in Fire Engine	-Fire-fighter will monitor the onboard HMI in the stationary test van -Transmission of a route indicating an accident location	Fire fighter	-Standardised Questionnaire (Responsibility of AHA and still missing)	-Graphical representation of own position at the aerodrome -Graphically announced route -Textual route -Detection of co-operative targets -Communication via datalink	-Questionnaire from AHA has to be translated into Czech -Fire Brigade employee must be off duty (otherwise he/she is not allowed to leave the fire truck) - Interpreter also required.

Case Study	Scenario	Test Subjects	Measurements and instruments	Probable Influences of BETA	COMMENTS
3. Onboard HMI in Follow Me	-Transfer pilot HMI to follow-me car equipped with GP&C (would be good if leading a real a/c). -Transmission of a cleared taxi route belonging to a specific incoming a/c -Either real a/c or Test aircraft will be picked up by the artificial FM	FM-driver	-SART -NASA-TLX -SUS	-Graphical representation of own position at the aerodrome -Graphically announced route -Textual route -Detection of co-operative targets -Communication via data link	-Scenario has to be checked if possible
4. Alerts **a) Route Deviation**	-BETA Controller will act as GEC or TEC in a regular test run -Test Van or test a/c gets a taxi clearance via data link -Van or a/c deviates from cleared route (within a safe area) -Alert arises and controller has to react properly	Active BETA Controller (TEC)	-After a usual test run the active TEC controller will be interviewed to the alert	When an a/c or vehicle deviates from a pre-assigned route an alert arise at the control position	
4. Alerts **b) RWY incursion**	-Test Van or Test aircraft, and test car cause a runway incursion on a non-active runway -All involved Controller are informed of this situation -A non-active Controller or even an active Controller monitors the BETA Surveillance HMI			When an a/c or vehicle injures a restricted area an alert arise at the control position	

Table 6-6: Assessment of indicators during Case Studies

6.4 Test Equipment

- Test Observer Sheet (cf. 8.2.1)
- Set of questionnaires (NASA-TLX, SART, SRS, RSME, SUS, Acceptance, A-SMGCS questionnaire)
- Debriefing sheet

The following table represents all the test equipment needed dependent on the test condition 'BETA' vs. 'Baseline'.

No.	Test Equipment	Abbreviation	BETA	Baseline
all	Quick Access Recorder	QAR	X	X
1	Voice Button Counter	V-BC	X	X
1	Surveillance Logger		X	X
1	Flight plan data	FPL data	X	X
60	NASA-TLX questionnaire	NASA-TLX	X	X
60	SART questionnaire	SART	X	X
6	Acceptance questionnaire		X	
36	Debriefing sheet	DEB	X	
60	Test Observer Sheet	TPR	X	X
	Full BETA system		X	
1	HMI for Tower (2 Displays, Mouse, Keyboard)	BETA CWP	X	
2	HMI for VCR (4 Displays, 2 Mice, Keyboard)	BETA CWP (VCR)	X	
1	BETA Display in the Gate Management	BETA Display	X	
6	BETA Controller	BC	X	(X)
4	BETA Operator	BO	X	
2	BETA Observer	BOB	X	X
1	Operational Test Co-ordinator	OTC	X	
1	Technical Test Co-ordinator	TTC	X	
1	Pilot for test a/c		X	
4	CSA Co-Pilots		X	
1	Test Van Driver		X	
1	Fire-Fighter		X	
1	Test Car Driver		X	

Table 6-7: BETA Test Equipment and Human Actors involved

6.5 Test Staff

The following test staff is needed and provided by different BETA partners. The tasks of the human actors are described in the BETA Test Handbook **[3]**.

Persons	BETA Partner	Remarks
Operational Test Co-ordinator (OTC)	ANS CR	Located in the Tower
Technical Test Co-ordinator (TTC)	DLR	Located in the VCR
Airport Test Co-ordinator (ATO)	CSL	Located in Gate Management and VCR
BETA Operator (BO)	DLR, PAS, TATM, NLR	This role may be performed by the responsible persons for specific technical systems.
BETA Observer (BOB)	DLR	DLR is main observer. NLR will assess D-MAN output. AUEB interviews the controller regarding AHP method.
2x Test a/c pilot	DLR	
4x Test a/c Co-pilots	CSA	
1x Test Van Driver	DLR	
3x Test Car Driver	ANS CR	
2x Maintenance Car Driver	CSL	
5x Other Car	CSL	

***Table 6-8*: Test Staff Needed**

6.6 Test Arrangements and Tasks of Controller

Figure 6-2 and Figure 6-3 outline the installation of the BETA controller working position respectively the BETA surveillance display:

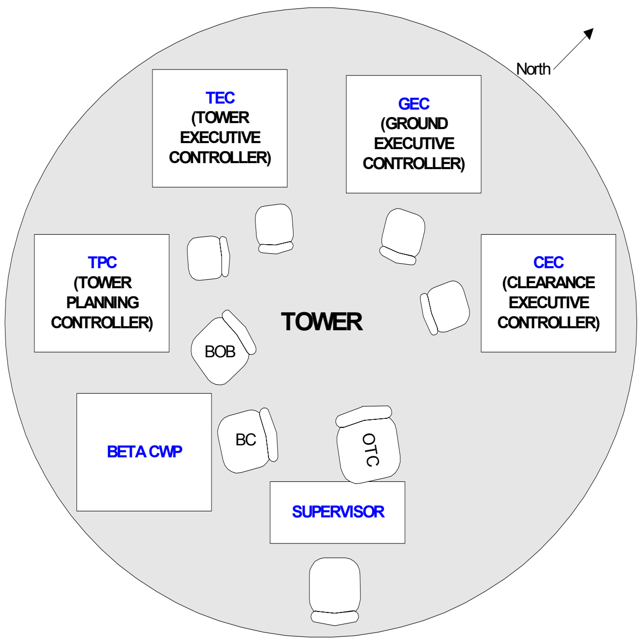


Figure 6-2: Tower Arrangement during Test Run

The work allocation in the Tower is defined as follows:

- **CEC (Cearance Executive Controller):**
  - Has responsibility about departing a/c only
  - Issues Departure clearence, i.e. SID(standart instrument departure) and SSR code
  - Has information about slot times,coordinates with FMP (Flow management point,which is located on ACC).

- Has information about SID,SSR code and slot time is printed on paper strip
- Passes on information to APP about a/c,which are going to depart from RWY, which is not declared as RWY in use
- Sends REA message on request of crews
- Fills-in the shortened FPL of VFR flights without FPL and has to inform APP about such a flights(outbound flights)
- In case of manual coordination(in case of failure of FDP system) coordinates with ACC all departing flights
- Coordinates with GEC a request of crews about de-icing

- **GEC (Ground Executive Controller):**
  - Has responsibility about departing and arriving a/c(IFR and VFR)
  - Issues push-back and taxi clearence for departing a/c and taxi clearence and stand allocation for arriving a/c
  - Coordinates with Apron control,when there are some problems with stands(normaly stands are depicted on monitor of information system)
  - Decides about position of de-icing(according slot,type of a/c ,departure sequence and handling company)
  - Passes on stands of arriving a/c to Follow me
  - Coordinates with TPC towed a/c
  - Data about ARR and DEP a/c are in a form of a paper strip.

- **TEC (Tower Executive Controller):**
  - Issues Landing and Take-off clearance
  - Operates the RWY and TWY lights
  - During a night (from 9 p.m. to 7 a.m. local time) takes over duties of all positions
  - Issues clearance to cross or to enter RWY for arriving traffic (especially when RWY 24 is in use and a/c vacate on RWY 13)
  - Declares LVP (Low visibility procedures) according RVR and cloud base and operates AMS-1 (monitoring system for LVP)
  - Finishes LVP

- **TPC (Tower Planning Controller):**
  - Has responsibility and issues clearance for vehicles to enter and move on manoeuvring areas. Clearance for vehicles to enter RWY
  - Coordinates with TEC
  - Has responsibility and issues clearance for towed a/c (coordinates with GEC)
  - Operates FDP system, i.e. inputs time of departure into system
  - Coordinates with adjacent units
  - Fills-in shortened FPL for VFR flights without FPL (inbound flights) and takes over ETA of VFR flights from APP
  - Passes on information about inbound VFR flights to Apron control
  - Continuous listening of Tower frequency and TEC action to be able to start necessary coordination
  - Coordinates with APP all flights, which are going to depart from a RWY, which is not declared as RWY in use

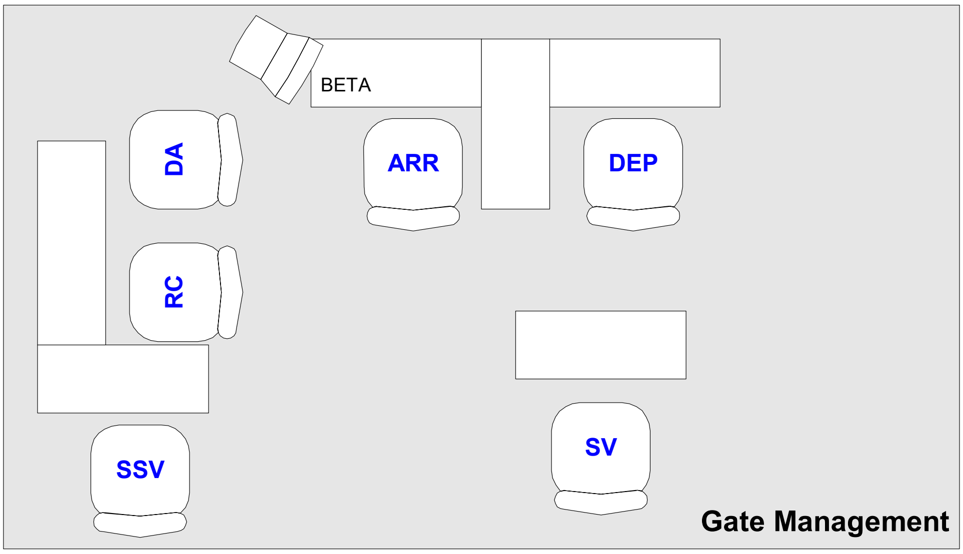


Figure 6-3: Apron Arrangement during Test Runs

The work allocation at the Gate Management is defined as follows:

- **Dispatch Arrivals:**
  - Stand allocation, Gate Management, Apron Management
- **Dispatch Departures:**
  - Gate Management, Apron Management
- **Dispatch Assistant:**
  - SITA update, Slot check, information systems AMIS, AGORA
- **Ramp Control:**
  - Apron Lighting Control, Winter Service
- **Supervisor:**
  - Operation Check, Emergency situations

7. Overall Performance Assessment

The objective of the overall i.e. comparative performance assessment is to provide an estimation of the relative position of the BETA system against the Baseline system, i.e. the currently used system, the performance of which in terms of the criteria is known.

A multicriteria method will be used in order to perform the comparative assessment of the BETA System. More specifically for the performance of the comparative assessment the Analytical Hierarchy Process (AHP) method, will be used. The AHP is selected because it has the ability to:

- Consider multiple criteria
- Quantify the evaluation indicators
- Express the relative importance of the various criteria
- Compile the opinions of various decision makers and identify “compromise” solutions
- Perform sensitivity analysis of the results.

The AHP [T. L. Saaty, 1990], provides a practical way to deal quantitatively with complex decision making problems. It also provides an effective framework for group decision-making, i.e. multiple decision makers, as well as for decision-making problems where only one decision maker is involved. “The AHP is a process of “systematic rationality ”: it enables us to consider a problem as a whole and to study the simultaneous interaction of its components within a hierarchy” [T. L. Saaty, 1990, Zografos et al 1996]. The AHP is based on three principles: 1) the principle of constructing hierarchies, 2) the principle of establishing priorities, and 3) the principle of logical consistency.

According to the method a complex decision making problem is decomposed hierarchically into its components. After the hierarchical decomposition of the problem has been completed a matrix of pair wise comparisons, expressing the relative importance of the elements in a given level of the hierarchy with respect to the elements in the level immediately above it, is constructed.

$$A = \begin{bmatrix} a_{11} & \cdots\cdots & a_{1k} & \cdots\cdots & a_{1n} \\ . & & . & & . \\ a_{l1} & & a_{lk} & & a_{\text{ln}} \\ . & & . & & . \\ a_{n1} & \cdots\cdots & a_{nk} & \cdots\cdots & a_{nn} \end{bmatrix}$$

The resulted pair wise comparisons matrix is positive and reciprocal (i.e., $a_{ij}>0$ and $a_{ij}=1/a_{ji}$). Finally the selection of the most preferred alternative is made based on the values of the priority vector of the lowest level of hierarchy.

One of the major advantages of AHP is the capability to identify errors in judgement and evaluate the consistency of the evaluators by calculating an index called *Consistency Ratio C.R.*

The calculation of C.R. is described by the following equations:

$$C.R. = \frac{C.I}{R.I.}$$

where $C.I. = \dfrac{\lambda_{max} - n}{n-1}$

C.I. = consistency index
λ_{max}= maximum eigenvalue of matrix A
n= matrix dimension
R.I.= Random Index computed as follows:
For each size of matrix n, random matrices were generated and their mean C.I. value called R.I. was computed

CR values greater than 0.10 declare inconsistency in judgement(s) and require the decision maker to reduce inconsistencies by revising judgements.

The application of the AHP for evaluating the BETA system requires the hierarchical decomposition of the problem. In Figure 7-1 the hierarchical decomposition of the BETA system for the second evaluation phase is presented. The evaluation problem at hand is decomposed into five levels. The first level consists of the assessment goal. The second level is composed of the various assessment criteria (objectives), the third level consists of the sub-criteria, while the fourth level consists of the indicators used for the quantification of the assessment criteria and sub-criteria. Finally, the fifth level of the hierarchy involves the two alternative systems under evaluation i.e. the BETA System and the Baseline System.

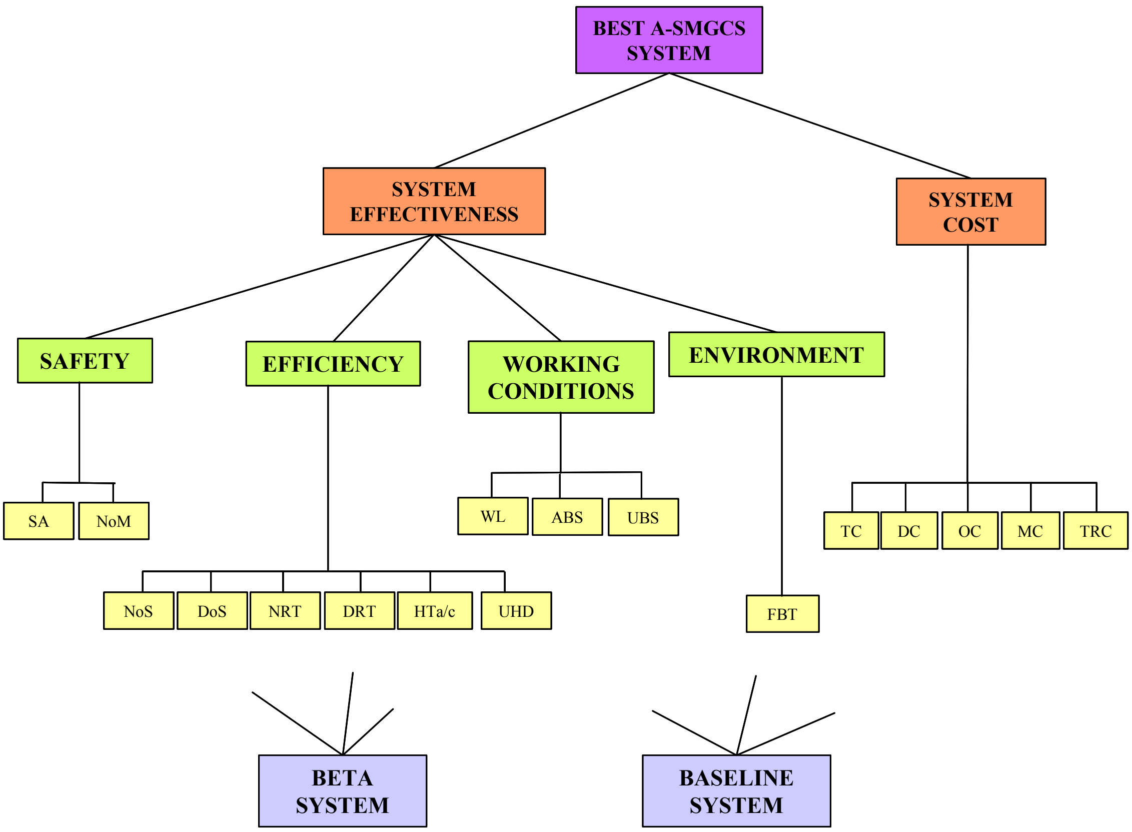


Figure 7-1 Hierarchical Decomposition of the BETA System Evaluation Problem

Table 7-1 that follows summarises the assessment criteria (objectives), the sub-criteria and the indicators measuring these criteria.

SYSTEM ASSESSMENT					
INDICATORS	SYSTEM PERFORMANCE CRITERIA				SYSTEM COST CRITERIA
	Safety	Efficiency	Working Conditions	Environnemental Impacts	Cost
Situation Awareness	√				
Number of misunder-standings	√				
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 each aircraft holding for line up at the RWY entry point		√			
Usability Head Down		√			
Level of workload			√		
Usability			√		
Acceptance			√		
Lower fuel burn while taxiing				√	
Transition Cost					√
Development Cost					√
Operational Cost					√
Maintenance Cost					√
Training Cost					√

Table 7-1 Characteristics of the Indicators

In order to collect the data required for the implementation of the AHP a methodological instrument has been developed (see Appendix G). The questionnaire was structured in a way such as to facilitate the experts to provide the necessary pairwise comparisons for the implementation of the AHP method. To collect these judgments one has constructed the tables of pairwise comparisons and interviewed an expert or a group of experts and to complete these tables by using the AHP ratio scale.

The pairwise comparisons covered all levels of the hierarchy from the top level to the bottom level containing the alternatives under evaluation. For instance, in the interviews within an assessment problem with a hierarchical decomposition similar to Figure 7-1 the following levels of comparisons had been performed: “How much more important is:

1. Criterion i than Criterion j with respect to the goal
2. Sub-criterion I than Sub-criterion j with respect to the criterion
3. Indicator I than Indicator j with respect to Criterion k
4. A SMGCS system i than A-SMGCS system j with respect to indicator k

At the final level of the comparisons there may be some of the indicators measured objectively without requiring any subjective judgments by an expert. Nevertheless, these objective measurements should be transformed to equivalent values of the AHP ratio scale. In addition to the pairwise tables, there is another type of tables (i.e. questions), where experts are requested to feel in their perception regarding the amount of knowledge the feel they have concerning the answer they have provided (Zografos et al 1997).

The input of the computational part of the methodology is the tables of pairwise comparisons. Some of the tables of pairwise comparisons are large. The large number of pairwise comparisons that must be performed implies a heavy burden of effort required by the interviewees. The length and complexity of this type of questionnaires dictated the use of interviews for the accurate collection of the required data. These interviews will be performed either through telephone, as they were carried out during the first evaluation phase of the BETA System, or through in person interviews. More specifically, the personal interviews may take place during the BETA test trials that will take place in Prague Airport for the second evaluation phase functional and operational performance assessment. Since the AHP has the ability to provide compromise solution, the judgement of different groups in terms of their expertise will be obtained i.e. air traffic controllers, airlines, airport authorities, etc.

The elaboration of the collected data (i.e. pairwise comparisons) will be performed using a software package i.e. Expert Choice (Expert Choice Inc. 1995).

8. Annex

8.1 Time Schedule and Test Protocols for Functional Tests

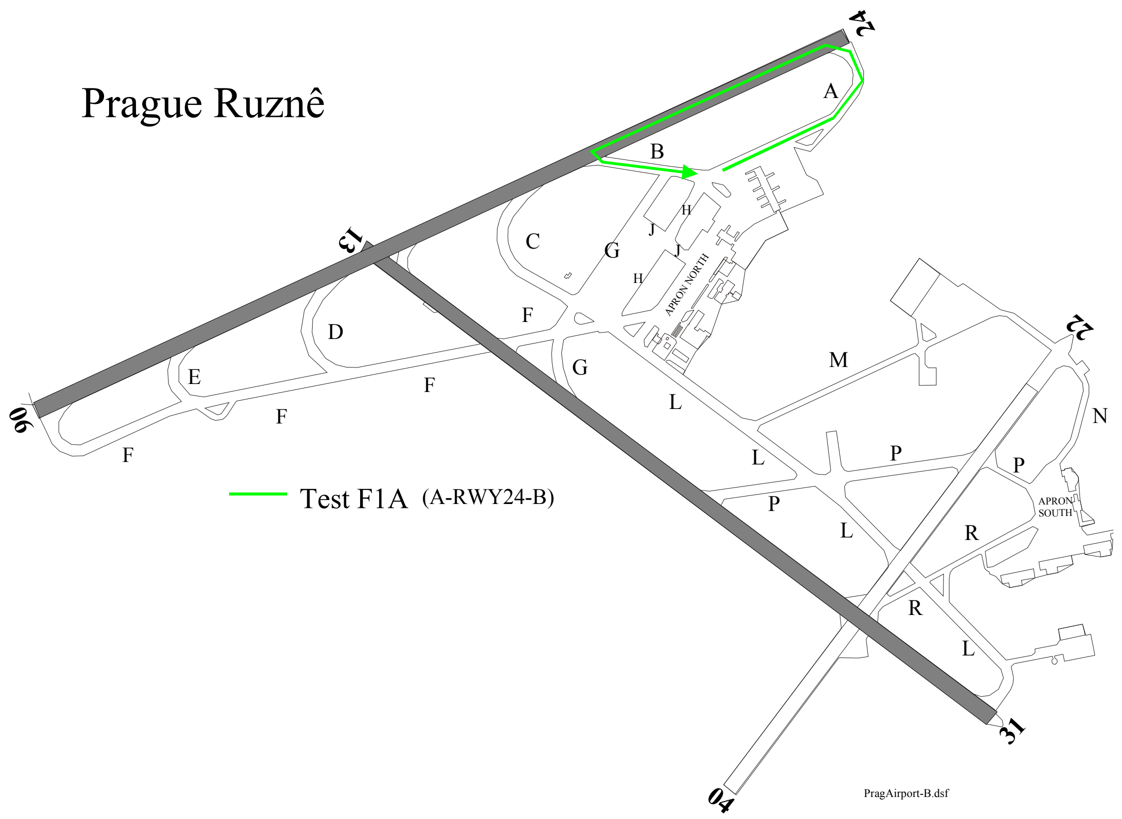
8.1.1 Time Schedule and Priority

Priority	Date	Test	Duration	
		F1:		**Surveillance Accuracy**
1	2002-05-13	F1A	60 min	Testing the NRN. Test Van on RWY24 and TWY Alpha and Bravo
2	2002-05-13	F1B	90 min	Testing the Surveillance Integrity Parameter of the SDS
3	2002-05-13	F1C	60 min	Elk Test on apron north
4	2002-05-14	F1D	120 min	Measuring of PRTOP for all sensors
		F2		**Surveillance Classification:**
5	2002-05-14	F2	120 min	Normal Traffic Recording (no specific procedure needed)
		F3		**Monitoring and Alert:**
	2002-05-14	F3A	30 min	Special Code Alert; this test is skipped (7500,7600,7700)
6	2002-05-14	F3B	120 min	Conflict alert, Stop bar Crossing, Area Infringement
7	2002-05-15	F1E	120 min	Measuring Target Report Latency (TRL) of the CWP display
		F5		**Guidance Performance:**
8	2002-05-15	F5A	300 min	On Board Guidance Test
		F4		**Planning Performance:**
9	2002-05-15	F4A	300 min	Hand over Test, Clearance Control Test, Clearance Control Test
10	2002-05-15	F1B	90 min	Testing the Surveillance Integrity Parameter of the SDS

8.1.2 Test Protocol

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	**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.**	**TBD**
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			**Test Van i.d.**						
Time			**BOB**						
Record i.d.									
Time	**Observation**								

Test F1A


Prague Ruznê
24
A
B
13
C
G
J
H
J
H
APRON NORTH
F
D
E
F
F
F
06
G
M
L
22
N
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P
P
APRON SOUTH
P
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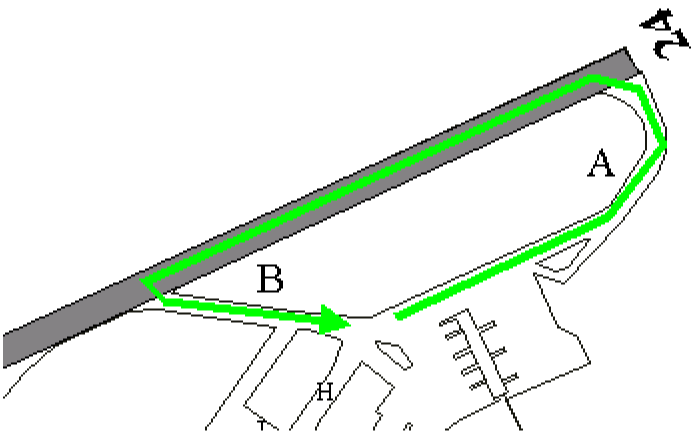
R
R
L
31
04
Test F1A (A-RWY24-B)
PragAirport-B.dsf

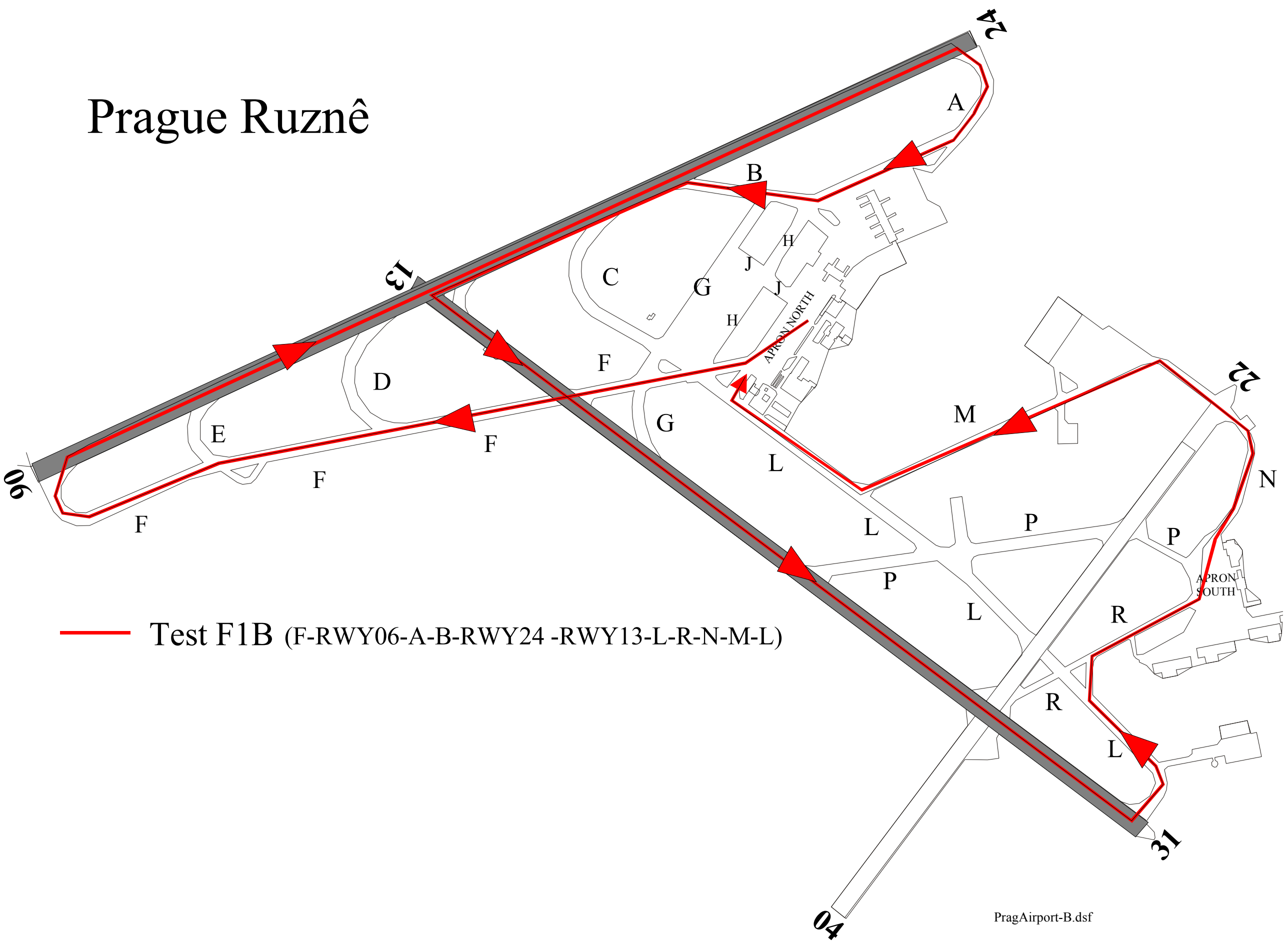

24
A
B
H

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-A-B-RWY24-RWY13-L-R-N-M-L-apron north 2. BGEC clears Test Van to taxi The Test Van proceeds on TWY' s with 30km/h and on RWY' s with maximum speed This test will be repeated for 2 times							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.**	**TBD**
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		**Test Van i.d.**			
Time		**BOB**			
Record i.d.					
Time	**Observation**				

Test F1B


Prague Ruznê
24
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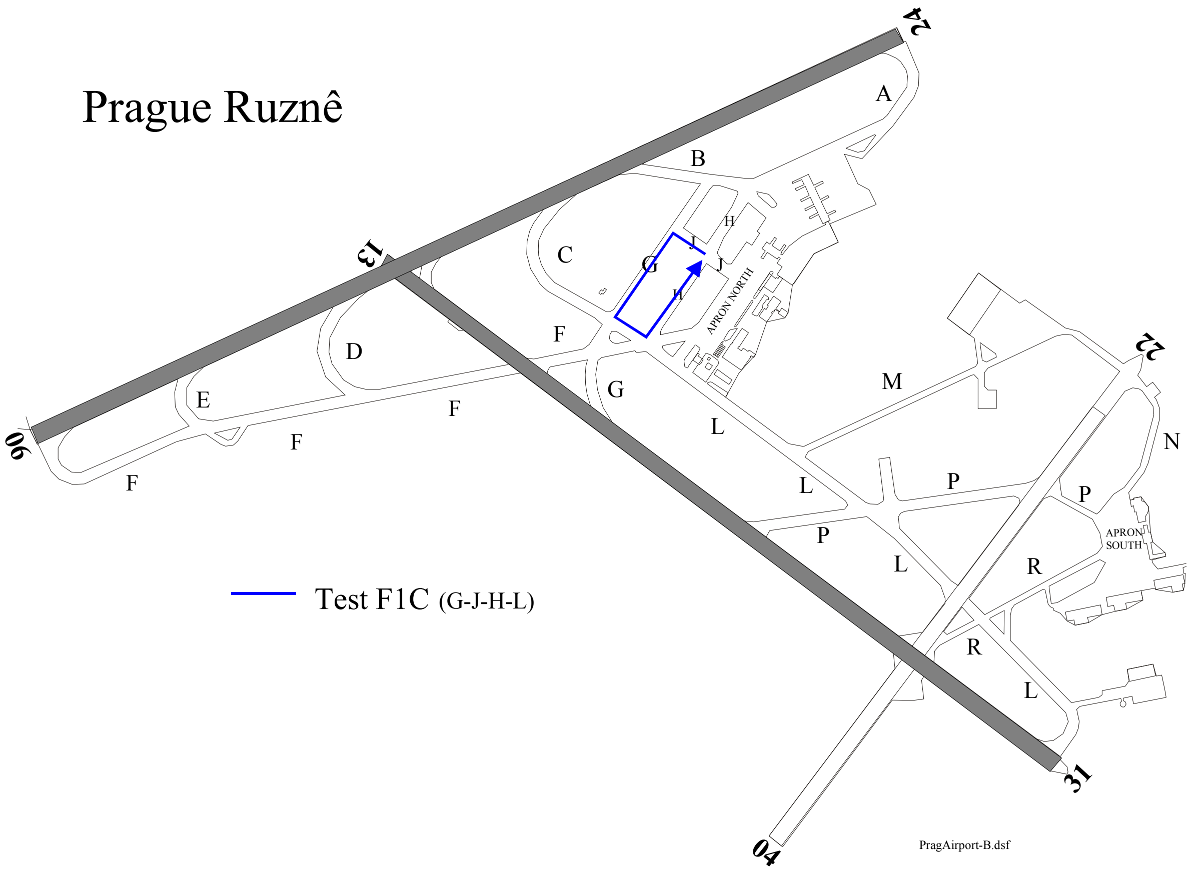
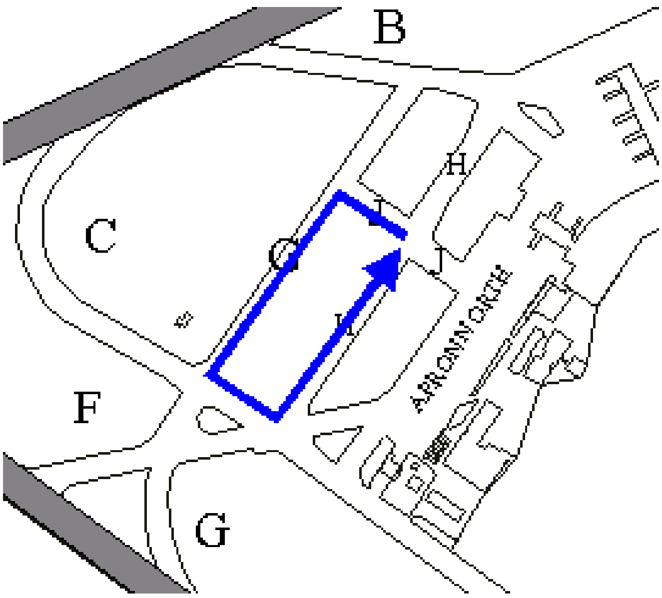
M
N
P
R
APRON NORTH
APRON SOUTH
Test F1B (F-RWY06-A-B-RWY24 -RWY13-L-R-N-M-L)
PragAirport-B.dsf

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-H-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.**	**TBD**
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		**Test van id.**							
Time		**BOB**							
Record id.									
Time	**Observation**								

Test F1C (Elk Test)





F1D	**Surveillance accuracy**						**CS**	Version 1.0
Title	Measuring of Position Renewal Time Out Period (PRTOP)							**Remark**
Scenario	1. Connect only one sensor to the SDS 2. Switch off the sensor by software tool 3. Switch on the sensor and start stopwatch 4. Stop stopwatch if the target reappeared on the HMI Repeat this test for all sensors for at least 5 times							
Aim	Measuring the PRTOP after reconnect the sensor							
Success criteria	The target reappears within several seconds							
Duration	90 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		**Test van id.**						
Time		**BOB**						
Record id.								
	Observation							
Time								
	1.	SMR PRTOP						
	1.1	Only SMR is connected to the SDS					SMR	Targets are displayed
	1.2	Disconnect SMR from SDS by software						
	1.3	Reconnect SMR to SDS by software						
	1.4	Target reappears after seconds						
	2	ASR PRTOP						
	2.1	Only ASR is connected to the SDS					ASR	Targets are displayed
	2.2	Disconnect ASR from SDS by software						
	2.3	Reconnect ASR to SDS by software						
	2.4	Target reappears after seconds						
	3	ASCS PRTOP						
	3.1	Only ASCS is connected to the SDS					ASCS	Targets are displayed
	3.2	Disconnect ASCS from SDS by software						
	3.3	Reconnect ASCS to SDS by software						
	3.4	Target reappears after seconds						
	4	NRN PRTOP						
	4.1	Only NRN is connected to the SDS					NRN	Targets are displayed
	4.2	Disconnect NRN from SDS by software						
	4.3	Reconnect NRN to SDS by software						
	4.4	Target reappears after seconds						
	5	GP&C PRTOP						
	5.1	Only GP&C is connected to the SDS					GP&C	Targets are displayed
	5.2	Disconnect GP&C from SDS by software						
	5.3	Reconnect GP&C to SDS by software						
	5.4	Target reappears after seconds						

F1D	Surveillance accuracy			CS	Version 1.0
Title	Measuring of Position Renewal Time Out Period (PRTOP)				**Remark**
Actual data					
Date		**Test van id.**			
Time		**BOB**			
Time					
	1.	SMR PRTOP Measuring			
	1.1	PRTOP =			
	1.2	PRTOP =			
	1.3	PRTOP =			
	1.4	PRTOP =			
	1.5	PRTOP =			
	2.	ASR PRTOP Measuring			
	2.1	PRTOP =			
	2.2	PRTOP =			
	2.3	PRTOP =			
	2.4	PRTOP =			
	2.5	PRTOP =			
	3.	ASCS PRTOP Measuring			
	3.1	PRTOP =			
	3.2	PRTOP =			
	3.3	PRTOP =			
	3.4	PRTOP =			
	3.5	PRTOP =			
	4.	NRN PRTOP Measuring			
	4.1	PRTOP =			
	4.2	PRTOP =			
	4.3	PRTOP =			
	4.4	PRTOP =			
	4.5	PRTOP =			
	5.	GP&C PRTOP Measuring			
	5.1	PRTOP =			
	5.2	PRTOP =			
	5.3	PRTOP =			
	5.4	PRTOP =			
	5.5	PRTOP =			

F1E	**Surveillance accuracy**						**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. The position has to be identified in the vicinity at the airfield and on the CWP (Threshold or corner). 2. Find the corresponding position at the CWP 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								
Success criteria									
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			**Test van id.**						
Time			**BOB**						
Record id.									
	Observation								
Time									
	1.	TRL =							
	2.	TRL =							
	3.	TRL =							
	4.	TRL =							
	5.	TRL =							
	6.	TRL =							
	7.	TRL =							
	8.	TRL =							
	9.	TRL =							
	10.	TRL =							

F2	**Surveillance Classification**						**CS**	Version 1.0
Title	Measuring the Target Detection on the CWP							**Remark**
Scenario	1. Observe the CWP 2. Count the detected targets 3. Count the not detected targets 4. Count the false detected targets 5. Count the identified targets 6. Count the number of not continuously tracked targets							If necessary locate the Test Van find a position.
Aim	Prove the detection and identification at the CWP							
Success criteria	All targets should be detected and identified and no false targets detected/ identified							
Duration	60 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	**no**	**NASA TLX**			no		
	Blind Shield	no	**Test Report**			**yes**		
			Debriefing note			yes		
Actual data								
Date			**Test van id.**					
Time			**BOB**					
Record id.								
	Observation							
Time								
	1.	No of detected targets					PD	
	2	No of non detected targets						
	3	No of false detected targets					PFD	
	4	No of identified targets					PID	
	5	No of false classification of targets					PFC	
	6	No of not continuously tracked targets						

F3A	**Alerting Performance Test**						**CS**	Version 1.0
Title	Check special code alert						✔	**Remark**
Scenario	1. Locate the Test Van in front of the tower 2. Test SSR code 7500 2.1 BGOC gives the clearance for SSR code 7500 2.2 BETA Driver switches on the Mode-S with code 7500 2.3 BO observes the CWP if the alarm is indicated 3. Test SSR code 7600 3.1 BGOC gives the clearance for SSR code 7600 3.2 BETA Driver switches on the Mode-S with code 7500 3.3 BO observes the CWP if the alarm is indicated 4. Test SSR code 7500 4.1 BGOC gives the clearance for SSR code 7500 4.2 BETA Driver switches on the Mode-S with code 7500 4.3 BO observes the CWP if the alarm is indicated							SSR code switching with accordance to the ATC authorities
Aim	Checking if the special code alerts are indicated on CWP							
Success criteria	Alerting functions are working							
Duration	30 minutes							
Meteo								
Traffic	Normal traffic							
Active sensors	**SMR NRN**		**ASR GP&C**	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**		
			Debriefing note			yes		
Actual data								
Date			**Test van id.**					
Time			**BOB**					
Record id.								
	Observation							
Time								
	1.	Test SSR code 7500 – Emergency						Checked
	2	Test SSR code 7600 – Hijack						Checked
	3	Test SSR code 7700 – Radio Com Failure						Checked

F3B	**Alerting Performance Test**						**CS**	Version 1.0
Title	Check conflict alert						✔	**Remark**
Scenario	1. Check conflict alert with specific procedure 2. Check restricted area alert with specific procedure 3. Check stop bar crossing alert with specific procedure							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 visbility							
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**		
				Debriefing note		yes		
Actual data								
Date			**Test van id.**					
Time			**BOB**					
Record id.								
	Observation							
Time								
	1.	Check conflict alert						Checked
	2	Check restricted area alert						Checked
	3	Check stop bar crossing alert						Checked

F4	Testing Planning Performance Parameters						**CS**	Version 1.0	
Title	Check clearance control, hand over control, taxi plans						✔	**Remark**	
Scenario	1. Check clearance control 2. Check hand over control 3. Check taxi plan computation							Test procedures will be outlined by PAS and NLR	
Aim	Checking the functionality of the planning parameters								
Success criteria	Planning functions are working								
Duration	120 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**			
			Debriefing note			yes			
Actual data									
Date			**Test van id.**						
Time			**BOB**						
Record id.									
	Observation								
Time									
	1.	Check clearance control							
	1.1	Number of Alerts raised of non-conformance to clearance						Check by PAS	
	1.2	Number of Alerts raised of non-conformance to clearance						Check by PAS	
	1.3	Number of warnings asking that clearance is due						Check by PAS	
	1.4	Number of false warnings						Check by PAS	
	1.5	Number of alerts raised due to incoherent set of plans						Check by PAS	
	1.6	Number of false alerts on incoherent plans						Check by PAS	
	2.	Check hand over control							
	2.1	Ability of forced shoot/assume hand-over						Check by PAS	
		Ability of alerts on uncontrolled aircraft						Check by PAS	
	3	Check taxi plan computation							
	3.1	Taxi Plan Computation Rate					TPCR	Check by PAS	
	3.2	Taxi Plan Computation Response Time					TPCRT	Check by PAS	
	3.3	Taxi Plan Prediction Accuracy					TTPA	No test	
	3.4	Ability to cover most common taxi routes						Check by PAS	

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 3. Taxi routes are displayed at the onboard HMI in a proper way							
Duration	180 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		**Test van id.**						
Time		**BOB**						
Record id.								
	Observation							
Time								

		Procedure	Operator at the Test Van	Operator at the CWP	Check
	1	Start Up			
	1.1		Request Start Up		CWP received
	1.2			Cleared Start Up	HMI clearance received
	1.3		WILCO		CWP WILCO received
	2	Push Back			
	2.1		Request Push Back		CWP received
	2.2			Cleared Push Back	HMI clearance received
	2.3		WILCO		CWP WILCO received
	3	Request Taxi			
	3.1		Request Taxi		CWP received
	3.2			Transmit Taxi Routing	HMI Taxi routing shown
	3.3		WILCO		CWP WILCO received
	4	Crossing RWY			
	4.1		Request Crossing		CWP received
	4.2			Cleared To Cross	HMI clearance received
	4.3		WILCO		CWP WILCO received
	5	Lining Up			
	5.1		Request Line Up		CWP received
	5.2			Cleared for Line UP	HMI clearance received
	5.3		WILCO		CWP WILCO received
	6	Take Off			
	6.1		Request Take Off		CWP received
	6.2			Cleared for Take Of	HMI clearance received
	6.3		WILCO		CWP WILCO received

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		**Test van id.**			
Time		**BOB**			
Record id.					
	Observation				
Time					

		Procedure	**Operator at the Test Van**	**Operator at the CWP**	**Check**
	1	Landing			
	1.1		Request Taxi		CWP received
	1.2			Transmit Taxi Routing	HMI Taxi routing shown
	1.3		WILCO		CWP WILCO received
	2	Crossing RWY			
	2.1		Request Crossing		CWP received
	2.2			Cleared To Cross	HMI Taxi routing shown
	2.3		WILCO		CWP WILCO received

Test Protocol and Questionnaires for Operational Tests

8.2 Test Observer Sheet and Questionnaires for Operational Tests

8.2.1 Test Observer Sheet

BETA	**Test Observer Sheet** Operational Test at Prague I	Sheet number

BETA Observer (BOB) ....

Date: 2002-	Test Run No. ☐	UTC Start Time: ☐ UTC End Time: ☐

Airport Side Conditions RWY in Use:					☐ BETA ☐ Baseline
Outbound:	☐ 24	☐ 06	☐ 31	☐ 13	☐ CEC ☐ GEC ☐ TEC
Inbound:	☐ 24	☐ 06	☐ 31	☐ 13	Controller: 1 2 3 4 5 6
Weather Conditions:					☐ Non-active
VIS:	Wind Direction:		Wind Speed:		☐ Co-Pilot
Further Comments:					☐ Follow Me Driver ☐ Fire Fighter

Operational Test Co –Ordinator	Technical Test Co –Ordinator	Airport Test Co –Ordinator
OTC	TTC	ATO

Target of interest is not labelled. Target of interest is not detected.	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
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All information needed for controlling is available in the EFS.	EFS +	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
	EFS -	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
D-MAN sequence proposal are executed.	DMAN +	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
		☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
	DMAN -	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
Number of gazes outside:	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
Comments by the controller							
Observations							

8.2.2 Questionnaires

A: Biographical Questionnaire

Subject (Controller, Follow me, etc)**:**	**Date:**
Test Run:	**Sheet number:**

The questions below serve to give us some background information on you, your training background, and your experience with computers. Please note that all personal information will be treated confidently and can not be traced back to any particular person.

Personal information

Age: ☐ female ☐ male

Native Language:

Education

Current Employer:

Trained as:

Year of training (Beginning - End):

Professional Experience (in years):

Licences:

Computer Experience

Computer experience since (year):

Weekly time spent with computer (in hrs):

B: System Usability Scale

Subject (Controller, Follow me, etc)**:**	**Date:**
Test Run:	**Sheet number:**

Please read carefully through the list of statements on the BETA A-SMGCS. Indicate to which extent you agree with this statement by putting a cross on a scale from 1 (strongly disagree) to 5 (strongly agree).

	Strongly disagree				**Strongly agree**
1. I think that I would like to use this system frequently.	1	2	3	4	5
2. I found the system unnecessarily complex.	1	2	3	4	5
3. I thought the system was easy to use.	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system.	1	2	3	4	5
5. I found the various functions in this system were well integrated.	1	2	3	4	5
6. I thought there was too much inconsistency in this system.	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly.	1	2	3	4	5
8. I found the system very difficult to use.	1	2	3	4	5
9. I felt very confident using the system.	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with the system.	1	2	3	4	5

If you have any additional comments, please add them here:

C: SART DATA CAPTURE SHEET

Subject (Controller, Follow me, etc)**:**	**Date:**
Test Run:	**Sheet number:**

SART SCALE (❸ = 3-D SART Dimension)

❸ 1. Demand on Attentional Resources ❸ How demanding is the task on your attentional resources? Is it excessively demanding (high) or minimally demanding (low)?	*low* *high*
2. Instability of Situation How changeable is the situation? Is the situation highly unstable and likely to change suddenly (high), or is it very stable and straight forward (low)?	*low* *high*
3. Complexity of Situation How complicated is the situation? Is it complex with many interrelated components (high) or is it simple and straightforward (low)?	*low* *high*
4. Variability of Situation How many variables are changing in the situation? Are there a large number of factors varying (high) or are there very few variables changing (low)?	*low* *high*
❸ 5. Supply of Attentional Resources ❸ How much of your attentional resources are you supplying to the situation? Are you making the greatest possible effort (high) or giving very little attention (low)?	*low* *high*
6. Arousal How aroused are you in the situation? Are you alert and ready for activity (high) or do you have a low degree of alertness (low)?	*low* *high*
7. Concentration of Attention How much are you concentrating on the situation? Are you bringing all your thoughts to bear (high) or is your attention elsewhere (low)?	*low* *high*
8. Division of Attention How much is your attention divided in the situation? Are you concentrating on many aspects of the situation (high) or focussed on only one (low)?	*low* *high*
9. Spare Mental Capacity How much mental capacity do you have to spare in this situation? Do you have sufficient to attend to many new variables (high) or nothing to spare at all (low?)	*low* *high*
❸ 10. Understanding of Situation ❸ How well do you understand the situation? Do you understand almost everything (high) or virtually nothing (low)?	*low* *high*
11. Information Quantity How much information have you gained about the situation? Have you received and understood a great deal of knowledge (high) or very little (low)?	*low* *high*
12. Information Quality How good is the information you have gained about the situation? Is the knowledge communicated very useful (high) or is it of very little use (low)?	*low* *high*
13. Familiarity with Situation How familiar are you with the situation? Do you have a great deal of relevant experience (high) or is it a new situation (low)?	*low* *high*
14. Situational Awareness How good was your awareness of the situation? Do you have a complete (high) or a poor grasp of the situation (low)?	*low* *high*

D: NASA TLX RATING SHEET

Subject (Controller, Follow me, etc)**:**	**Date:**
Test Run:	**Sheet number:**

INSTRUCTIONS: On each scale, place a mark that represents the magnitude of that factor in the task you just performed.

LOW HIGH

MENTAL DEMAND

LOW HIGH

PHYSICAL DEMAND

LOW HIGH

TEMPORAL DEMAND

PERFECT FAILURE

PERFORMANCE

LOW HIGH

EFFORT

LOW HIGH

FRUSTRATION

NASA TLX RATING SCALE DEFINITIONS

Title	Endpoints	Description
MENTAL DEMAND	*Low / High*	How much mental activity and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	*Low / High*	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	*Low / High*	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	*Perfect / Failure*	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
EFFORT	*Low / High*	How hard did you have to work (mentally and physically) to accomplish you level of performance?
FRUSTRATION LEVEL	*Low / High*	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

E: Assessment of BETA A-SMGCS benefits

Controller: 1 2 3 4 5 6 7	Date:
	Sheet number:

Please read carefully through the list of statements on the BETA A-SMGCS. Indicate to which extent you agree with this statement by putting a cross on a scale from 1 (strongly disagree) to 5 (strongly agree).

	Strongly disagree				Strongly agree
1. The control of aircraft in the test run was very safe. Comments (if any):	1	2	3	4	5
2. BETA A-SMGCS will reduce air pollution. Comments (if any):	1	2	3	4	5
3. BETA A-SMGCS will reduce costs for airports. Comments (if any):	1	2	3	4	5
4. BETA A-SMGCS will reduce costs for airlines. Comments (if any):	1	2	3	4	5
5. BETA A-SMGCS will reduce costs for ATC providers. Comments (if any):	1	2	3	4	5
6. BETA A-SMGCS will reduce costs for passengers. Comments (if any):	1	2	3	4	5
7. I think that the BETA A-SMGCS increases airport capacity. Comments (if any):	1	2	3	4	5
8. In my opinion, the use of the BETA system endangers safety at the airport. Comments (if any):	1	2	3	4	5

9. The control of aircraft with the BETA system was very efficient.
Comments (if any):

1	2	3	4	5

10. I think that the BETA system helped me to maintain good situation awareness.
Comments (if any):

1	2	3	4	5

11. The use of the BETA system makes the controller's job more difficult.
Comments (if any):

1	2	3	4	5

12. The use of the BETA system makes the controller's job more boring.
Comments (if any):

1	2	3	4	5

13. With the BETA system, it was easier to separate aircraft safely.
Comments (if any):

1	2	3	4	5

14. The BETA system made it easier to detect potentially problematic situations.
Comments (if any):

1	2	3	4	5

15. BETA A-SMGCS will not reduce waiting times for aircraft at the airport.
Comments (if any):

1	2	3	4	5

F: Acceptance Questionnaires

Controller: 1 2 3 4 5 6 7	**Date:**
	Sheet number:

Your opinion is very important for the evaluation of BETA. Consequently, we would like you to answer the enclosed questions giving your individual opinion and personal experience with BETA as implemented in this field test. All the individual data of this test, including this questionnaire will be treated in ***strict confidence***.

Instructions

Please start with filling out **your personal identity** at the top of this page.

The questionnaire contains relevant questions and a number of statements on aspects of the ATC tasks you performed during the field tests. Most questions are self-explanatory. In a number of cases you will be asked to decide on how much you agree or disagree with a statement, by making a cross in the box that comes closest to your opinion, as shown below.

Example: Towers should be built even higher to give a better view to the controllers.

strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☒	☐

The cross mark means that you agree with the idea that towers should be built even higher.

Please answer all the items in the order that they are given, but do not cross-check your answers to previous. Where applicable, please put any comments to explain your decisions further in the free spaces below the items (overleaf with reference to question number if necessary).

Please: work on your own - do not discuss any questions with your colleagues while filling in the questionnaire (you can, of course, discuss them later).

Thank you very much for your co-operation and contribution

General

1. The concept of operations for BETA is difficult to understand.					
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

2. The BETA procedures were easy to work with.					
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

3. It is easy to learn to work with BETA.					
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

4. The BETA system will not fundamentally change the way that controllers work.					
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

5. The BETA system requires a re-distribution of tasks within the controller team.					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

6. Using BETA makes you think differently about the controller tasks.					
strongly Disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

7. The BETA system changes routine communication tasks					
strongly disagree	Disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

8. This field test changed my attitude towards BETA.					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

<u>Stress</u>

9. You had a good picture of the traffic under your control during the BETA field tests.					
strongly disagree	disagree	slightly disagree	Slightly Agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

10. The BETA system makes the controller's job boring.					
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

<u>Level of Service</u>

11. BETA enabled you to handle more traffic.					
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

12. BETA enabled you to provide the pilots a better level of service.					
strongly disagree	Disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

13. BETA enabled you to execute your tasks more effectively.					
strongly disagree	Disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

Safety

14. Working with BETA makes you feel safer.					
strongly disagree	Disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

15. The introduction of BETA will increase the potential of human error.					
strongly disagree	Disagree	slightly disagree	Slightly agree	agree	Strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

16. The types of human error associated with BETA are different than those associated with normal work.					
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
☐	☐	☐	☐	☐	☐
Comment:					

Training

17. There was enough training to get familiar with the BETA procedures.					
strongly disagree ☐	disagree ☐	slightly disagree ☐	slightly agree ☐	agree ☐	strongly agree ☐
Comment:					

18. There was enough training on the HMI, its rules and its mechanisms.					
strongly disagree ☐	disagree ☐	slightly disagree ☐	slightly agree ☐	agree ☐	strongly agree ☐
Comment:					

19. The work environment (seating, lighting) was comfortable.					
strongly disagree ☐	disagree ☐	slightly disagree ☐	slightly agree ☐	agree ☐	strongly agree ☐
Comment:					

20. There were distractions/disturbances from other activities (e.g. visitors) during the tests.					
strongly disagree ☐	disagree ☐	slightly disagree ☐	slightly agree ☐	agree ☐	strongly agree ☐
Comment:					

21. What were the three best things about these field tests?
1.
2.
3.

22. What were the three worst things about these field tests?
1.
2.
3.

End of this questionnaire, thank you for your co-operation.

G: Overall Assessment Questionnaire

Age:

- 20-29 years ☐
- 30-39 years ☐
- 40-49 years ☐
- 50 & over ☐

Experience:

- 5 years or less ☐
- 6-10 years ☐
- 11-15 years ☐
- 16-20 years ☐
- 21-25 years ☐
- 26 & over ☐

Education (Check highest attained):

- 0-12 years ☐
- 12-16 years ☐
- Over 16 years ☐

Area of expertise:

- Engineering ☐
- Management ☐
- Other ☐ Please specify: ______________________

General Job Description:

- Airline Manager ☐
- Air Traffic Controller ☐
- Airport Manager ☐
- Pilot ☐

Military Officer ☐

Academia ☐

Other ☐ Please specify: ______________________

Specific Area of Concentration:

A-SMGCS Design/Operation ☐

Safety ☐

Airport Design/Operation ☐

Other ☐ Please specify: __________________________

Degree of Risk Aversion:

How much of a risk taker are you? If someone presents a problem to you and you are not sure about the answer how often will you give an answer even under uncertainty?

I will never try to guess ☐

About 20% of the times ☐

About 40% of the times ☐

About 60% of the times ☐

About 80% of the times ☐

I will always try to guess ☐

Let's assume that we have a panel of judges and we want to determine the judgement ability of each of the panel members. Effectively what we want to do is to be able to give more credibility (weight) to the decisions of the best judges and less weight to the worst judges. One theory states that the weight (W) assigned to a judge should depend on the consistency of his/her decisions, the knowledge that he/she posses of the topic in question as well as his/her personal balance. The term personal balance, refers to the relative absence from specific biases in a patters of choices a judge makes.

Expressed in simple terms:

$$W = K_A + K_B + K_C$$

W = weight assigned to judge's decision
K_A = factor expressing the importance of consistency of the judge's decision
K_B = factor expressing the importance of knowledge of the judge concerning the topic in question
K_C = factor expressing the importance of the judge's personal balance

1. Do you feel that K_A K_B and K_C have equal importance? Please fill in the proper blank.

Yes ______
No ______

2. If your answer is no; on a scale of 0 (no value) to 100 (maximum value) what would you rate each of the three factors?

K_A (consistency) ________
K_B (knowledge) ________
K_C (personal balance) ________

Total = 100

AHP PAIRWISE COMPARISONS TABLES

First Level:

Quest.: How much more important is the Effectiveness of an A-SMGCS system in determining its overall performance as compared to its Cost?

Identification of the best A-SMGCS in terms of its Overall Performance	System Effectiveness	Cost
System Effectiveness	1	
Cost		1

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	2	3	4	5

Second Level:

Quest.: How much more important is the contribution of sub-criterion "safety" in determining the effectiveness of an A-SMGCS system as compared to the contribution of sub-criterion "efficiency"?

System Effectiveness	Safety	Efficiency	Working Conditions	Environment
Safety	1			
Efficiency		1		
Working Conditions			1	
Environment				1

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	2	3	4	5

Third Level:

Quest.: How much more important is the contribution of indicator "Situational Awareness" in determining the performance of an A-SMGCS system in terms of safety as compared to the contribution of indicator "Number of Misunderstandings"?

Safety	Situational Awareness	Number of misunderstandings
Situational Awareness	1	
Number of misunderstandings		1

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	**2**	**3**	**4**	**5**

Quest.: How much more important is the contribution of indicator "Traffic delays" in determining the performance of an A-SMGCS system in terms of efficiency as compared to the contribution of indicator "RWY occupancy time"?

Efficiency	Number of R/T Commu-nication	Duration of R/T Commu-nication	Number of stops of a/c during taxiing	Duration of stops during taxiing	Holding time for each aircraft holding for line up at the RWY entry point	Usability Head Down
Number of R/T Communication	1					
Duration of R/T Communication		1				
Number of stops of a/c during taxiing			1			
Duration of stops during taxiing				1		
Holding time for each aircraft holding for line up at the RWY entry point					1	
Usability Head Down						1

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	**2**	**3**	**4**	**5**

Quest.: How much more important is the contribution of indicator "Level of workload" in determining the performance of an A-SMGCS system in terms of working conditions as compared to the contribution of indicator "Acceptance of the System"?

Working Conditions	Level of workload	Acceptance of the System	Usability of the of the System
Level of workload	1		
Acceptance of the System		1	
Usability of the System			1

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	2	3	4	5

Quest.: How much more important is the contribution of indicator "Development Cost" in determining the cost of an A-SMGCS system as compared to the contribution of indicator "Transition Cost"?

System Cost	Development Cost	Transition Cost	Operational Cost	Maintenance Cost	Training Cost
Development Cost	1				
Transition Cost		1			
Operational Cost			1		
Maintenance Cost				1	
Training Cost					1

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	2	3	4	5

Fourth Level:

Safety Indicators

Quest.: How does BETA system performs in terms of the indicator "Situational awareness" as compared to the performance of the Baseline System?

Alternative System	Situational Awareness	Number of misunderstandings	**Alternative System**
BETA System			**Baseline System**

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	2	3	4	5

Efficiency Indicators

Quest.: *How does BETA system performs in terms of the indicator "Traffic Delays" as compared to the performance of the Baseline System?*

Alternative System	Number of R/T Commu-nication	Duration of R/T Commu-nication	Number of stops of a/c during taxiing	Duration of stops during taxiing	Holding time for each aircraft holding for line up at the RWY entry point	Usability Head Down	**Alternative System**
BETA System							**Baseline System**

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	2	3	4	5

Working Conditions Indicators

Quest.: *How does BETA system performs in terms of the indicator "Level of workload" as compared to the performance of the Baseline System?*

Alternative System	Level of workload	Acceptance of the System	Usability of the of the System	**Alternative System**
BETA System				**Baseline System**

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	2	3	4	5

Cost Indicators

Quest.: How does BETA system performs in terms of the indicator "Development Cost" as compared to the performance of the Baseline System?

Alternative System	Development Cost	Transition Cost	Operational Cost	Maintenance Cost	Training Costs	**Alternative System**
BETA System						Baseline System

Please rate the amount of knowledge you feel that you have, concerning the answer:

1	2	3	4	5

H: Misunderstandings Measurement Tool (NLR)[3]

[3] Is still missing.

8.2.3 Debriefing Sheet for single BETA functions

1. What comments do you have regarding the **Surveillance Display**?

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2. What comments do you have regarding the **EFS**?

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3. What comments do you have regarding the new **Handover** procedure?

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4. What comments do you have regarding the **clearance monitoring alerts**?

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5. What comments do you have regarding the **routing function**?

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6. What comments do you have regarding the **data link clearances**?

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7. What comments do you have regarding the **D-MAN**?

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8. What comments do you have regarding the **route deviation alert function**?

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9. What comments do you have regarding the **RWY incursion alert function**?

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10. What comments do you have regarding the **panning alerts**?

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8.4 List of Figures

8.5 List of Tables

8.6 Acronyms and Abbreviations

A/c	Aircraft
ACC	Area Control Centre
ADS-B	Automatic Dependence Surveillance Broadcast
APN	Apron Control (responsible for the apron areas)
APP	Approach Control
ARMI	Aircraft Registration Mark Identification
AS	A-SMGCS Airborne System
ASCII	American Standard Code for Information Interchange
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATOPS	A-SMGCS Testing of Operational Procedures by Simulation (EC project of 4th Framework Programme)
ATS	Air Traffic Services Authority
BETA	Operational Benefit Evaluation by Testing an A-SMGCS
BWE	Research Airport Braunschweig
CD	Clearance Delivery
CNS	Communication, Navigation, Surveillance
CS	Case Study
CWP	Controller Working Position
DAS	Daten-Anzeige-System (Data Display System)
DEB	Debriefing
DEFAMM	Demonstration Facilities for Airport Movement Management (EC project of 4th Framework Programme)
DGPS	Differential Global Positioning System
D-MAN	Departure Manager
EFPS	Electronic Flight Progress Strip
EOBT	Estimated Off Block Time
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FP	Flight Plan
FPS	Flight Progress Strip
GND	Ground Control (normally: ATC responsible for Start-up clearance and outbound traffic)
GP&C	Global Positioning and Communication System
H	Hypothesis
HAM	Hamburg Airport

HMI	Human Machine Interface
ID	Identification Code (e.g. Registration Mark, 24Bit Aircraft Address, Flight No.)
IFR	Instrument Flight Rules
MASPS	Minimum Aviation System Performance Standards
MTOW	Maximum Take-off Weight
NRN	Nearrange Radar Network
OC	Operational Concept
ON	Observer's Notes
PRG	Airport Prague Ruzyně
PSR	Primary Surveillance Radar
QAR	Quick Access Recorder
QUE	Questionnaire
R/T	Radio Telephony
RTS	Regular Traffic Study
RWY	Runway
SAGAT	Situation Awareness Global Assessment Technique
SART	Situation Awareness Rating Technique
SDS	Surveillance Data Server
Squawk	Transponder Mode a/c Code
SSR	Secondary Surveillance Radar
SUC	Start-Up controller/Clearance Delivery
TWR	Tower Control (normally: ATC for RWY and inbound traffic)
TWY	Taxiway
V-BC	Voice Button Counter
VDL	VHF Data Link
VEX	Video Extractor
VFR	Visual Flight Rules
VIP	Very Important Person
VIS	Visibility
WP	Work package

Table 8-1: Acronyms and Abbreviations