INTERVUSE

IST-2000-28260

Integrated Radar, Flight Plan and Digital Video Data Fusion for SMGCS

Final Report

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Partners: Park Air Systems
Datacollect
Mannheim Airport

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	Comment
AFTN	Aeronautical Fixed Telecommunications Network
AIRCAT	Air traffic control data standard of Thomson CSF /Thales ATM
AMVU	Autonomous Machine Vision Unit
ANSP	Air Navigation Service Provider
ASR	Approach Surveillance Radar
ASTERIX	All-purpose Standard Eurocontrol Radar Information Exchange
ATC	Air Traffic Control
CWP	Controller Working Position
DKF	Discrete Kalman Filtering
EC	European Commission
FOV	Field of View
GPS	Global Positioning System
HMI	Human-Machine Interface
ICD	Interface Control Document
IP	Internet Protocol
ITI	Informatics and Telematics Institute
LAN	Local Area Network
MVP	Machine Vision Processor
NOVA	Division and product name of Park Air Systems AS
PAS	Park Air Systems AS
SDS	Surveillance Data Server
SMGCS	Surface Movement Guidance and Control System
SMR	Surface Movement Radar
SSR	Secondary Surveillance Radar
TCP	Transfer Control Protocol
VBED	Video-Based Event Detection
VD	Virtual Detector
VSDF	Video Sensor Data Fusion
WP	Work Package

1 PROJECT OVERVIEW

All deliverables within the INTERVUSE project have been produced and submitted to the EC. Prototype test bed systems have been installed and tested at Mannheim and Thessaloniki airports.

Following the determination of the system requirements and the submission of the corresponding deliverable "D1- Requirements/ System Architecture", the preparation of both sites was started. Ten cameras were installed at Mannheim airport in order to cover the whole area of the aerodrome. However, the full coverage of the airport using ten cameras was not feasible and consequently there were gaps between cameras. On the other hand, five cameras were installed at Thessaloniki airport to cover only a part (800 metres) of the main taxiway of the airport. The fields of view of five cameras were partially overlapped in order to avoid gaps between detectors of successive cameras.

In parallel, the VSDF server and the Test Analysis Client were developed as well as an algorithm for the calibration of cameras. Furthermore, an existing product from Park Air Systems AS was adapted with the necessary Controller HMI to suit the SMGCS application at each of the two INTERVUSE test sites. For each airport, an INTERVUSE Controller Working Position (CWP) was developed and configured to suit the requirements of the local air traffic controllers. A topological and topographical database was created to describe the layout of each aerodrome and the surrounding airspace.

The system was integrated and tested first at Mannheim airport. During the system integration work at Mannheim, all the cameras were re-adjusted to try to optimise for best coverage of the runways and taxiways. Furthermore, the sub-systems of INTERVUSE system were installed and the required connections between the sub-systems of the system and external sources (Radar, AFTN) were completed. Functional operability tests were carried out to check the correct function of the system and to demonstrate that the technical requirements, defined in "D1 Requirements and System Architecture", have been fulfilled.

The system was tested for two months at Mannheim airport and then all the equipment of INTERVUSE system was shipped to Thessaloniki airport. After the integration of the system at Thessaloniki airport, the INTERVUSE system was tested for four months until 19 February 2004 where the final review was held. The EC panel considered that the whole effort was successful and the performance of the system as gap filler in an A-SMGCS was more than satisfactory.

1.1 PROJECT PARTICIPANTS

The following table shows the list of participants and the roles of the partners involved in the INTERVUSE project.

Table 1-1: List of Participants

Participant Role	Participant No.	Participant Name	Participant Short Name	Country	Status*	Project Entry Date **	Project Exit Date
CO	1	**Centre for Research and Technology HELLAS/ Informatics and Telematics Institute** ***	ITI/CERTH	EL	C-F	1	32
CR	2	**DataCollect DVT GmbH**	DATA COLLECT	D	P	1	32
CR	3	**Rhein-Neckar Flugplatz GmbH, Mannheim**	AIRPORT MANNHEIM	D	P	1	32
CS	4	**Park Air Systems AS** ***	PAS	NO	C-T	17	32
CS	5	**H.A.N.D. GmbH** ***	HAND	D	P	1	13

* C-F = Financial and Administrative Co-ordinator
C-T = Technical Co-ordinator
P = Principal contractor
A = Assistant contractor

** Number indicates month of project plan (1 = first month, 32 = last month)

*** The participant H.A.N.D. GmbH, originally Participant No. 1 and Scientific Coordinator for the project, ceased trading in May 2002 (Month 13). ITI/CERTH, originally Participant No. 4 and Financial Coordinator, took over the overall administrative coordination of the project. Park Air Systems AS joined the project in November 2002 (Month 17).

2 PROJECT OBJECTIVES

IST INTERVUSE (IST-2000-28260) is a project for funding by the EC to support a new direction in surface movement ground control system (SMGCS) solutions, which is cost-effective, innovative, and suitable to fill blind spots in the SMGCS technology developed so far.

Air traffic management today faces two major bottlenecks in the capacity of manageable traffic load:

1. Limited airspace usage caused by restricted airways and corridors instead of free flight
2. Limited traffic throughput on ground caused by insufficient technical support with ground control systems.

For these reasons, the EC has sponsored a number of projects to improve European airspace and traffic management infrastructure and to increase worldwide competitiveness.

However, full-featured SMGCS has until now often turned out to be a multi-million Euro solution, mainly because of an expensive multiplicity of sensors such as SMR, Mode S squitter, GPS, and near-range radar networks. Installed sensors such as airport or long-range surveillance radar is also used, together with other important data sources like flight plan or airport management data.

Unfortunately, this expensive infrastructure not only restricts the number of users that can afford the expenses to less than 50 - while there is a need in Europe at least at 150 airports - it is also quite often incomplete in terms of surveillance. There is a lack of passive sensors, which can cover unsupervised blind spots (yards, parking stands, etc.).

INTERVUSE addresses these two disadvantages:

- Smaller users are enabled to set up a low-end SMGCS solution, eventually only for restricted surveillance purposes like some sections of the APRON only. The video sensors planned in this project are combined with surveillance radar and flight plan data. Both data sources are available at most European airports.
- The blind spots of large-scale SMGCS can be reduced or even removed by adding the scalable, modular outcome package of this project. Blind spots are supervised with passive video sensors for event detection, and synthetic traffic data - calculated and tracked by the video sensor data fusion (VSDF) - is available for these blind spots to integrate into the overall SMGCS ground situation representation via a local area network infrastructure.
- Available infrastructure of air traffic control is fully utilized within the project: radar tracking, flight plan data processing, and command and control displays are already fully available to the consortium.

For this purpose, intelligent digital video supervision with virtual detectors (VD) is used.

Virtual detectors and VD processing are to provide a situation-related set of event state vectors that are fed into the VSDF.

The VSDF utilizes time-variant DKF event tracking and probabilistic inference based on the state vector parameters' quality statistics. VSDF creates a synthetic representation of the supervised ground space without any need of active cooperation of the detected and tracked targets. The result of VSDF is a full-featured target track with an artificial identification. The VSDF output is looped back to the input processing to improve the detection logic.

Furthermore, this knowledge is made available to the radar tracking and flight plan data correlation units. Here the tracked targets are matched with available unique identifications or identification candidates (SSR codes, callsigns). Radar tracking and flight plan data processing is available technology to the consortium, so it has not to be developed from scratch.

A comprehensive traffic situation display system also exists within the consortium. It only requires adaptation and creation of suitable databases to suit the topological and topographical characteristics of each airport site.

Taking all these modules together, it forms a suitable, comparatively easy to implement, "low-end" solution for SMGCS.

As an alternative, since the whole planned architecture is modular and scalable by extensive usage of LAN technology, VD and VSDF could also be used solely to feed useful - and so far missing - track data into a total SMGCS, which could be set up by turnkey airport integrators and system providers.

To sum up: the following are the project objectives:

1. Provision of a low-cost solution for SMGCS by combination of radar tracking, flight plan processing and digital video processing (capable of integrating with SMR), which makes SMGCS affordable and thus available to a broader range of airports.
2. Provision of a scalable package of VBED and VSDF to cover blind spots in a total SMGCS.
3. Analysis of downgrading of digital video processing for various weather and light conditions with an online quality control and analysis module.
4. Combination of new sensors (digital cameras) into multi-sensor data fusion for SMGCS.
5. Combination of Discrete Kalman Filtering (DKF) - based tracking techniques with:
    - Video processing with virtual detectors
    - Event state vector extraction algorithms
    - Positioning techniques
    - State vector quality determination and error propagation
    - State vector accuracy/reliability probability estimation

- Probabilistic inference

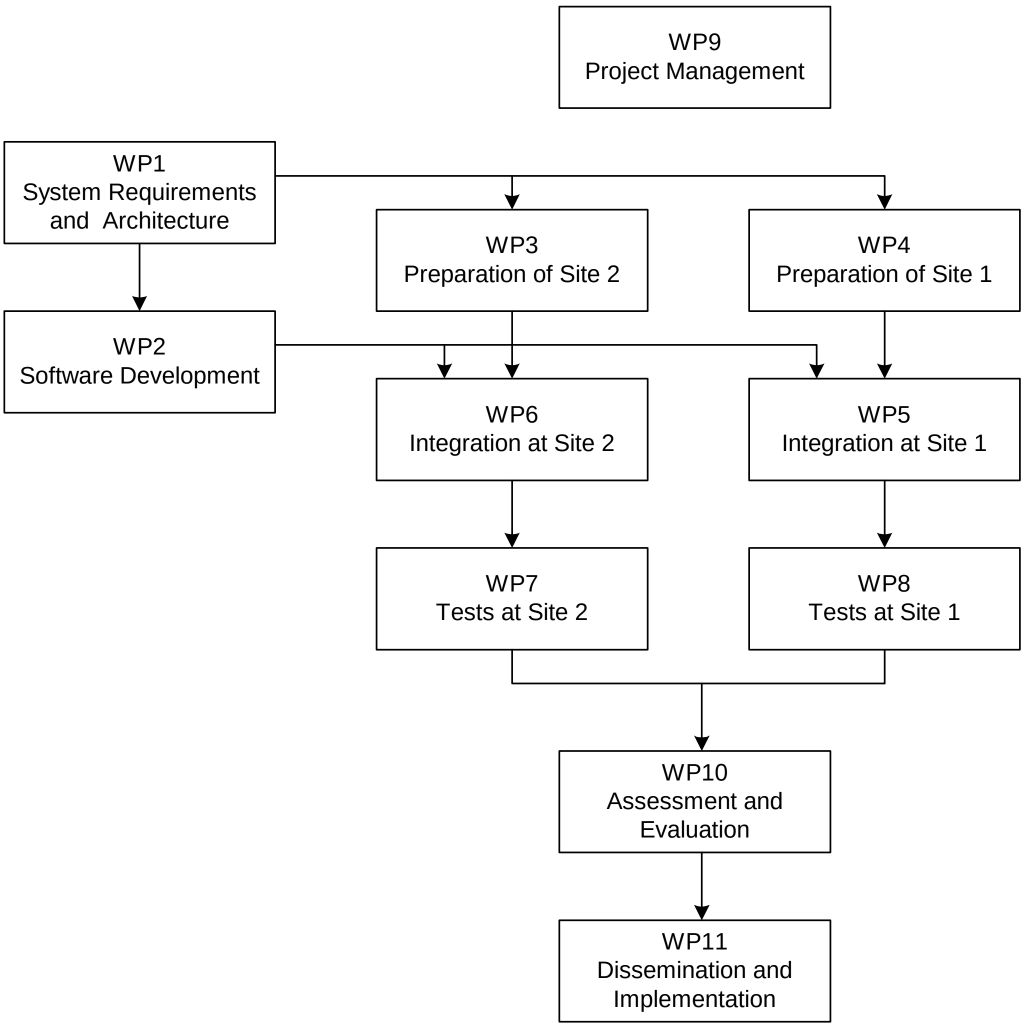
6. Provision of an intelligent tool / system solution to support safe transportation at airports.

3 APPROACH

In recent years, a number of EC co-funded projects have researched into SMGCS by combining quite expensive sensor arrays by a multi-sensor data fusion process to provide full situational awareness. As outlined in the project objectives, INTERVUSE adopted a slightly different approach: a comparatively low-cost set of sensors (digital video cameras) in a new positioning and data fusion architecture were developed and combined with existing airport systems and sensors (approach radar, flight plan data processing systems).

To achieve the objectives of the project, the work was structured into eleven work packages (WP) as shown in the following diagram:

Figure 3-1 Work Package Structure and Inter-relationships



The test sites were Mannheim (Site 1) and Thessaloniki (Site 2).

The diagram illustrates the systematic approach applied in order to achieve the objectives and to maximise the benefits associated with performing the project, which is shown by the links between the work packages.

The work plan was kept as simple as possible, concentrating on clearly defined tasks and responsibilities, and avoiding unnecessary organisational complexity. Each work package was designed so that a clear assignment to the project approach could be shown and that each partner's contribution in terms of responsibility could be defined. Each work package was led by one partner, who was responsible for the progress and quality of the work.

A brief description of all work packages follows:

- **WP1: System Requirements and Architecture**

  The aim of this WP was the elaboration of the project objectives, the development the system architecture and technical requirements and the overall system design for both test sites.

- **WP2: Software Development**

  This major WP encompassed:

  - Software design of the VSDF Server and all supporting modules, and development, testing and documentation according to the spiral software development model, guided and monitored by software development quality standards derived from the V model
  - Adaptation of existing industrial software to interface the specific ATC radar and flight plan sources at each of the two airports
  - Adaptation of interface with VSDF target data, correlation and data fusion
  - Adaptation of an existing industrial existing product with the necessary HMI to suit the SMGCS application at each of the two airports
  - Establishment of topological and topographical database describing each airport
  - Autonomous Machine Vision Unit (AMVU) and Virtual Detector configuration and enhancement of algorithms
  - Development of test analysis software and provision of recording and playback tools to assist in the operational evaluation
  - Laboratory integration and testing

- **WP3 and WP4: Preparation of Sites**

  The aim of these two WPs was to prepare each of the test sites by:

  - Instruction of the installation team

- Planning of site installation, video camera arrangement, server installation, CWP installation, and network cabling
- Civil works
- Installation of network infrastructure
- Test of infrastructure
- Sensor localisation and installation
- Sensor and VD configuration
- Performance of sensor operability tests

- **WP5 and WP6: Integration at Site**

  The purpose of these two WPs was to install and integrate the server and controller working position equipment at each of the test sites, to attach radar and flight plan data sources, and attach the video input to the servers. All interfaces were to be tested, as were the appropriate server processes. Configurable parameters were to be adjusted and a technical check of correct system operation performed.

- **WP7 and WP8: Tests at Site**

  The main tasks of these two WPs was the elaboration of suitable operational test criteria and the application of these criteria to extensive test sessions; the performance statistical analysis and the collection of analytical data based on the test procedures derived from the requirements of WP1. The proposed tests would include:

  - System robustness
  - System reliability
  - System usability
  - Controller support features
  - Test of infrastructure

  The analysis would include:

  - Influence of light degradation in various intervals
  - Influence of visibility degradation by fog and other degrading factors
  - Influence of aerodrome and aircraft lights
  - Influence factors on classification, feature extraction and position determination
  - Error propagation

  System and software bug fixing would be carried out to improve the test results.

- **WP9: Project Management**

  The tasks of the project management WP included:

  - Preparation, execution and post-processing of project meetings
  - Preparation, execution and post-processing of Project Reviews
  - Material procurement
  - Cost analysis and resource allocation
  - Data collection and report preparation
  - Cost and progress control
  - Preparation of project presentations

- **WP10: Assessment and Evaluation**

  The objective of this WP was to carry out an evaluation of the results achieved during the project, including not only the trials but also the lessons learnt during the development and integration, to draw up recommendations and guidelines for further work. The work package provided a continuous assessment of the project progress and achievements.

- **WP11: Dissemination and Implementation**

  In this WP, the parties would evaluate the market situation, the results of the project, their own position in the market, and the potentialities and risks of dissemination. The main goal was to find a promising strategy of marketing to win customers for the INTERVUSE technology and to make plans for the technological implementation. As a prerequisite for dissemination, internal system documentation would be produced.

Preparation of the sites was run at both sites in parallel to save time. Integration and testing of the full system was done sequentially, starting at Mannheim, because only one set of processing and display equipment was available. Sequencing the tests in this way gave a greater span of the year’s seasons for environmental testing.

The two airports were different in many aspects: size, airport infrastructure, user profile, weather conditions, light conditions, and geographic conditions. This provided a large number of conditional situations for environmental testing and thus improved the validation possibilities for the project.

For the environmental tests, a specific software package for statistical analysis was built and used. This package supported the tests with automatic data collection, time series of statistics, and correlation of environmental factors with the detection performance results.

4 PROJECT RESULTS AND ACHIEVEMENTS

The following paragraphs describe the results and achievements of INTERVUSE project from the scope of:

- Scientific/Technological quality and innovation
- Community added value and contribution to EU policies
- Contribution to Community social objectives
- Economic development and S&T prospects

4.1 SCIENTIFIC/TECHNOLOGICAL QUALITY AND INNOVATION

The technically most innovative aspects are mainly software-related:

- Digital video processing, feature and position extraction for aircraft position and movement detection based on the processing of virtual detectors and the extraction of detected event state vectors

- New sensor set of digital cameras and new processing for SMGCS with:
    - Virtual detector logic
    - Virtual detector logic improvement loop-back from VSDF
    - VSDF based on time variant Discrete Kalman Filtering (DKF) multiple event tracking and probability inference

- Multi-chain situation processing with:
    - VSDF of video data
    - Time invariant DKF position tracking of radar data
    - Time based correlation of flight plan information with video tracks
    - Video-track-to-radar-track correlation in common coverage sections (approaching aircraft, runway, identification label hand-over)

4.2 COMMUNITY ADDED VALUE AND CONTRIBUTION TO EU POLICIES

INTERVUSE is a project for funding by the EC to support a new direction in surface movement ground control system (SMGCS) solutions by using digital video cameras as a new sensor technology with a new set of data processing, which is cost-effective, innovative, and suitable to fill blind spots in the existing SMGCS technology.

The capacity improvement of air traffic in Europe is a central issue in the Community's infrastructure politics. Increasing numbers of movements at limited airports are a major bottleneck for this capacity, and at the same time a major risk of life-threatening traffic accidents.

SMGCS solutions target these goals of traffic capacity improvement and accident avoidance. New technology for SGMCS is therefore widely welcomed, especially if it is able to fill gaps in the total SMGCS solution. INTERVUSE supports this with the following expected results:

- The addition of new, comparatively low-cost passive sensing technology to SMGCS
- A potential SMGCS solution for smaller airports
- A candidate contributor to existing SMGCS solutions by adding a new technology module to survey otherwise hardly controllable airport areas, e.g. blind areas of SMR coverage, where active sensors are not sufficient and reliable, since not all aircraft and vehicles are equipped and there is no fall back in case of failure.

It is planned to implement INTERVUSE at international level. Besides the international ATC background in general, this is also reasonable because of testing conditions: INTERVUSE' sensing system is influenced by runway/taxiway infrastructure, weather, and lighting conditions - therefore it is useful to have test sites that differ as much as possible in these aspects.

The consortium has chosen Mannheim Airport and Thessaloniki airport as test sites. The Thessaloniki airport was associated to the project, not being a direct partner. However, they were closely related to the Greek party in this consortium, and they have a serious need for SMGCS because of foggy conditions from the nearby sea.

Mannheim, on the other hand, is a typical example where a small airport has partial SMGCS needs (obstructed runway and taxiway sections to the line of sight to the control tower), but hesitates to invest because of the large budget needed for SMGCS until now.

The consortium could have chosen more airports to join the group, but this would have increased the expense, and consortia with a higher number of participants tend to perform less efficiently.

4.3 CONTRIBUTION TO COMMUNITY SOCIAL OBJECTIVES

INTERVUSE addresses the improvement of European traffic services and life quality for citizens. As an additional sensing technology for SMGCS, INTERVUSE aims at

- Improvement of travel services at airports by increasing potential throughput, and
- Improvement of life quality by supporting accident avoidance.

By its excellent cost-benefit-ratio it increases the potential spectrum of SMGCS users to include smaller airports that cannot afford current expensive SMGCS solutions or that have only a limited scope of SMGCS tasks (like surveillance of a single out-of-sight taxiway), for which the installation of an SMR would be much too expensive.

4.4 ECONOMIC DEVELOPMENT AND S&T PROSPECTS

The commercial advantages of this project are rather straightforward:

- Surface movements are a major bottleneck for air traffic capacity and by this project gains a system solution for cost reduction.
- Comparatively low-cost sensors for SMGCS enlarge the range of potential users.
- This project is an important contribution to SMGCS improvement by covering blind areas in overall SMGCS coverage.
- A worldwide market is accessible in more than 80 countries, each with at least 5 airports with a need for SMGCS in various levels of complexity.
- ATC market actors involved in the consortium ensure ease of exploitation.
- An integrated solution into the operative system will be available from the project start on.
- Large project integrators and airport development companies will be interested in the technology, once its usability and reliability has been proven.

5 DELIVERABLES AND OTHER OUTPUTS

The following table shows the deliverables of INTERVUSE project as well as the leader and the number of each deliverable.

Table 5-1: List of Deliverables

No	Work Package	Deliverables	WP No.	Leader
D1	Requirements/ System Architecture	Final report on system requirements, architecture and design	1	CERTH/ITI
D2	Software Development	Report on software development	2	CERTH/ITI
D3	Preparation of Site 2	Site preparation report for Thessaloniki	3	CERTH/ITI
D4	Preparation of Site 1	Site preparation report for Mannheim	4	DATACOLLECT
D5	Integration at Site 1	Integration report for Mannheim	5	DATACOLLECT
D6	Integration at Site 2	Integration report for Thessaloniki	6	CERTH/ITI
D7	Tests at Site 2	Thessaloniki test report	7	CERTH/ITI
D8	Tests at Site 1	Mannheim test report	8	DATACOLLECT
D9	Project Management	D9-A Project Web Site D9-B Project Presentation D9-C Final Report	9	CERTH/ITI
	Assessment and Evaluation		10	CERTH/ITI
D11	Dissemination and Implementation	D11-A Dissemination and Use Plan D11-B Technology Implementation Plan	11	PAS

Each deliverable is briefly described in the following paragraphs.

5.1 D1: REQUIREMENTS/SYSTEM ARCHITECTURE

As it was decided in the Annual Review, there were many deficiencies in the previously submitted D1 (Requirement Document) regarding the system architecture. So, the document was revised and more details, concerning the system architecture were included. A revised D1 Deliverable was submitted to the Commission.

5.1.1 Introduction to System Requirements

The start of any system development is always the clarification of the requirements that shall be addressed and fulfilled by the properties and abilities of the created system.

The requirements of INTERVUSE are manifold. The current official sources of SMGCS requirements are the ICAO recommendations and EUROCAE specifications (see references). In addition, there are project-specific user requirements for each of the airports at which the INTERVUSE system will be tested and evaluated, and technical requirements that are specific to the chosen implementation. For this reason, the system requirements that have to be elaborated for INTERVUSE are grouped as follows:

1) The User Requirements (UR) for the system

   These are divided into:

   - Basic functional requirements
   - Performance requirements
   - Specific user requirements of Mannheim airport
   - Specific user requirements of Thessaloniki airport

2) The specific Technical Requirements (TR) of the chosen system architecture

   These are divided into specific technical requirements for:

   - Mannheim Airport
   - Thessaloniki Airport
   - Video Sensor System
   - Data Fusion System
   - Controller HMI
   - Test Analysis Client

In general terms the main requirements of the system are:

- Target detection and classification (size)
- Target position determination (coordinates)
- Target tracking (velocity)
- Target labelling (ID, type, flight plan)
- Runway situation monitoring (collision prediction, intrusion detection)
- Traffic situation display composition (targets, maps, support graphics)
- Flight data display
- User interaction handling

The requirements define the system's quality and reliability in terms of:

- Ability to detect all required types of target
- Accuracy and resolution
- Coverage
- Timeliness
- Presentation of information

The system will need to work in environmental conditions that may severely reduce visibility at an airport. In particular, the environmental conditions to cope with are:

- Changing light and shadows (day/night, sunlight/clouds) lights of aircraft and vehicles
- Fog
- Rain/thunderstorms
- Hail
- Snowfall
- Mounds of snow
- Ice deposits
- Strong winds
- Birds
- Line-of-sight shadowing by large objects

5.2 D2 SOFTWARE DEVELOPMENT

Document D2 was the deliverable produced under workpackage WP2 of the INTERVUSE Project. In compliance with Annex 1 of INTERVUSE project, this document describes the structure and the function of all software consisting INTERVUSE system. In addition to the software documentation of the developed and adapted modules, this document includes a HMI description, an interface control document for interfaces, as well as a general guideline about the installation of cameras and the set up of detector configuration.

The document describes the following software components that were designed and implemented during the INTERVUSE project:

- software adaptation for CWP.
- VSDF and SDS servers.
- Video event processing modules – Including a brief presentation of the Autoscope software, detailed presentation of the polling procedure and description of the software developed for the calibration of cameras.
- Test Analysis Client and its modules.

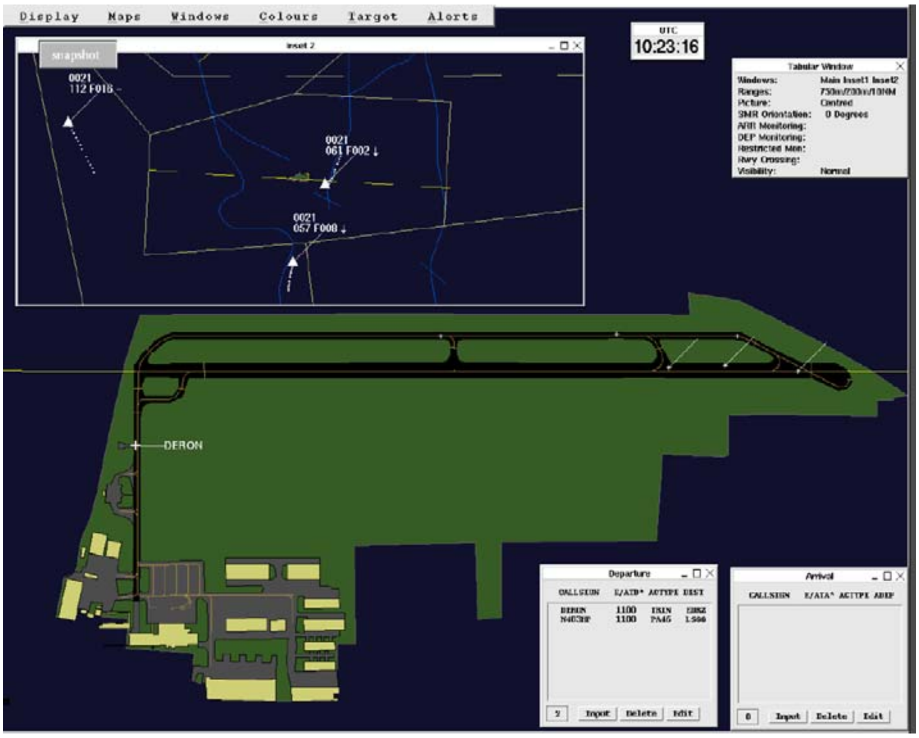
- Interface control documents describing interfaces between modules.

5.2.1 Software Adaptation for CWP

An existing product from Park Air Systems AS has been adapted with the necessary Controller HMI to suit the SMGCS application at each of the two INTERVUSE test sites, Mannheim Airport in Germany and Thessaloniki Airport in Greece.

For each airport, an INTERVUSE Controller Working Position (CWP) has been developed and configured to suit the requirements of the local air traffic controllers (Figure 5-1). A topological and topographical database has been created to describe the layout of each aerodrome and the surrounding airspace.

Figure 5-1: CWP - Mannheim Airport



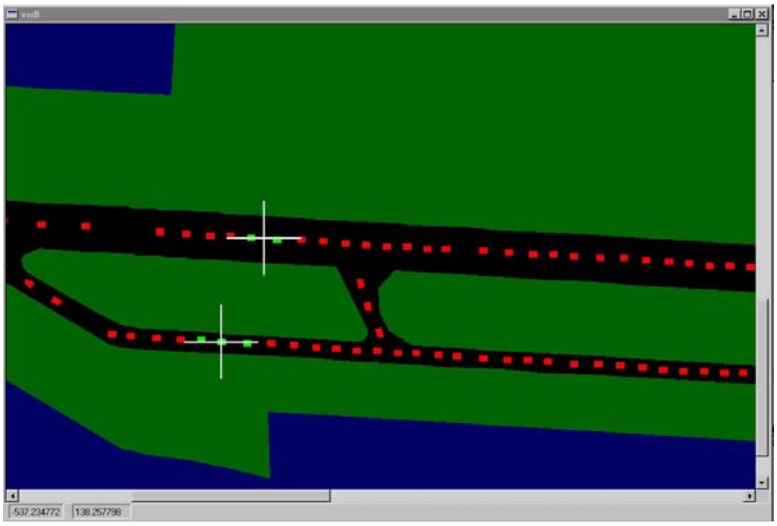
5.2.2 VSDF and SDS servers

The goal of the VSDF server is to collect data about the state of detectors from all AMVU units and process this data in order to extract observations (targets). Observations contain information about the position of targets, the date and time of detections and the size of targets. The communication between VSDF server and AMVU units is performed through the communication server installed in the same computer. The final results of the VSDF process are encoded in ASTERIX Cat.10 format and sent to the SDS for further process (tracking).

Furthermore VSDF server provides a Debug Window, which is an on-line module that graphically displays the output (detectors state, observations) generated by the VSDF on the airport map (Figure 5-2).

The VSDF application is a Win32 multithreaded application. It was developed using Microsoft Visual C++ in a Windows 2000 operating system. The user interface was designed using the Qt library. The application has been tested in Windows 2000 and Windows NT.

Figure 5-2: Overview of Debug Window



NOTE: Green rectangles indicate activated detectors; red rectangles indicate that the detectors are off. The white crosses are the observations calculated by the VSDF algorithm.

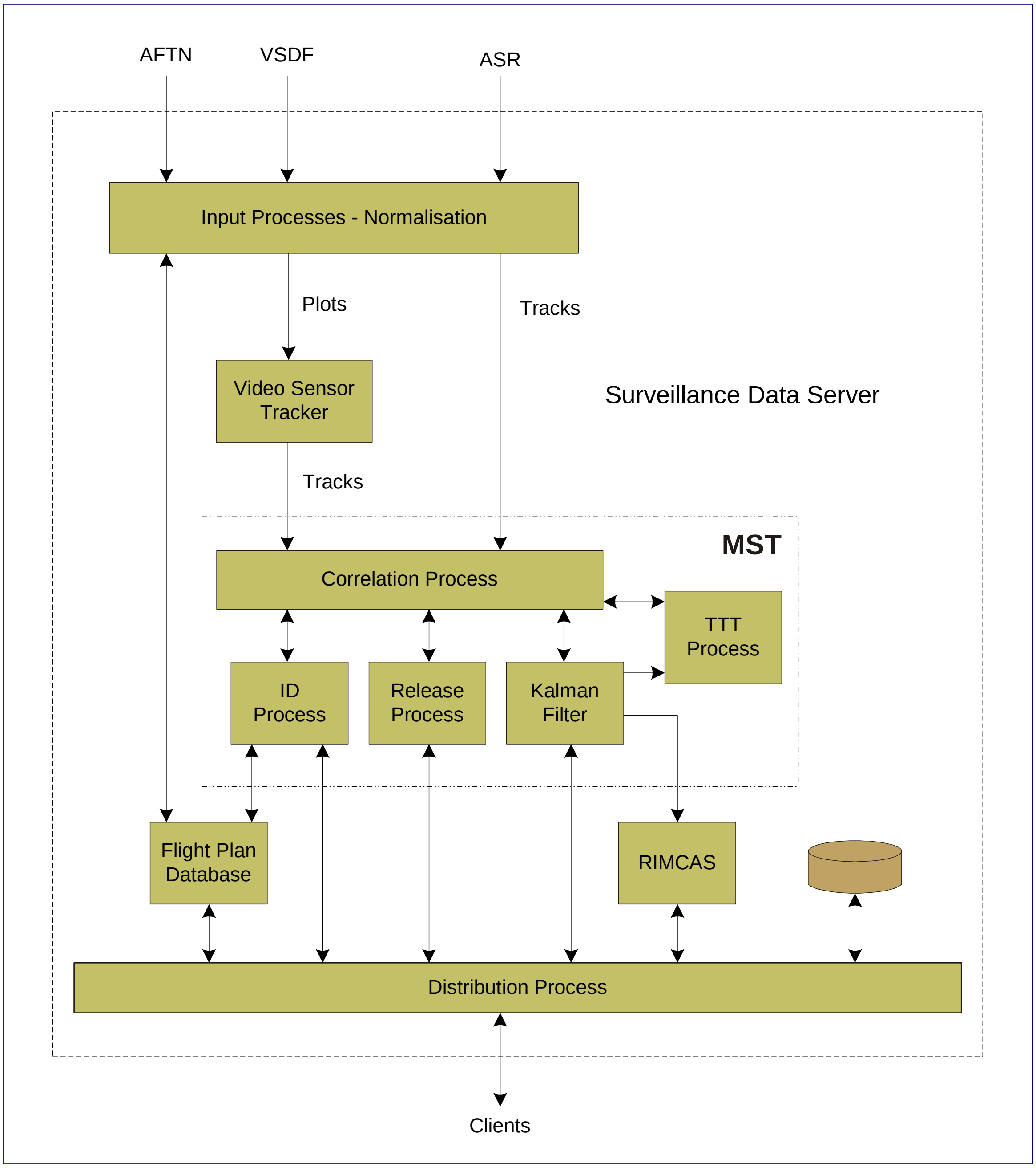
The Surveillance Data Server (SDS) consists of an SGI UNIX workstation, industrially packaged for 19-inch rack mounting. The application software, already developed by Park Air, provides a data collection and multi-sensor tracking capability.

The primary function of the SDS software is to gather data from surveillance sensor systems and, by a process of data fusion, calculate the best estimate of each target's position and identity, and distribute the resulting data to client processes. Flight plan information obtained via data communication from suitable sources can also be stored and distributed. The data fusion process links together all relevant information pertinent to a particular aircraft or vehicle movement. Based on the input data received from the attached sources, the SDS will maintain and distribute an integrated target table containing target reports with all available information relating to each target track in the system.

For INTERVUSE, the existing SDS software has been adapted to interface the approach surveillance radar (ASR) and flight plan sources at each of the two test site airports. In addition, a common interface based on the ASTERIX Category 10 data format has been developed for the communication of plot position data from the VSDF to the SDS.

The diagram below shows the main software processes of the SDS.

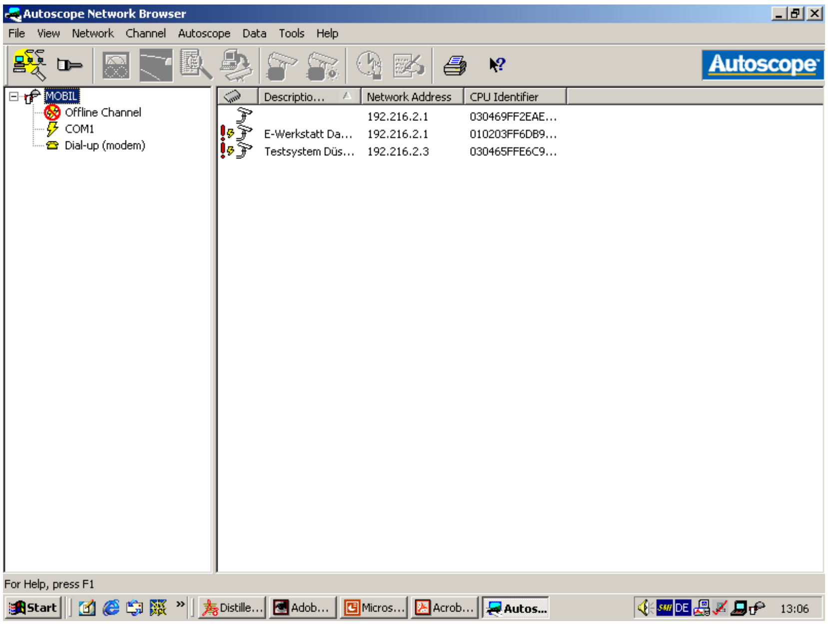
Figure 5-3: Surveillance Data Server Processes



5.2.3 Video Event Processing Modules

The Autoscope Solo ® Wide Area Video Vehicle Detection System (Autoscope Solo system) was used by the INTERVUSE project. The Autoscope system is a sophisticated traffic monitoring system, which uses machine vision processor technology to produce accurate traffic measurements. This system is based on a user-friendly PC software (Figure 5-4) that can be used to control sensors, configure and poll virtual detectors, obtain images (or differential video) through the RS-485 network etc.

Figure 5-4: Autoscope Network Browser



Calibration of each Autoscope sensor is required, so that any point - and in particular the center and the four corners of each Visual Detector (VD) defined at this sensor - can be converted from image coordinates (measured in pixels from the top left corner of the image) to and from ground coordinates (horizontal and vertical distances in meters from the ARP). For this reason a calibration algorithm that uses point and lines correspondences between the camera and the ground was developed.

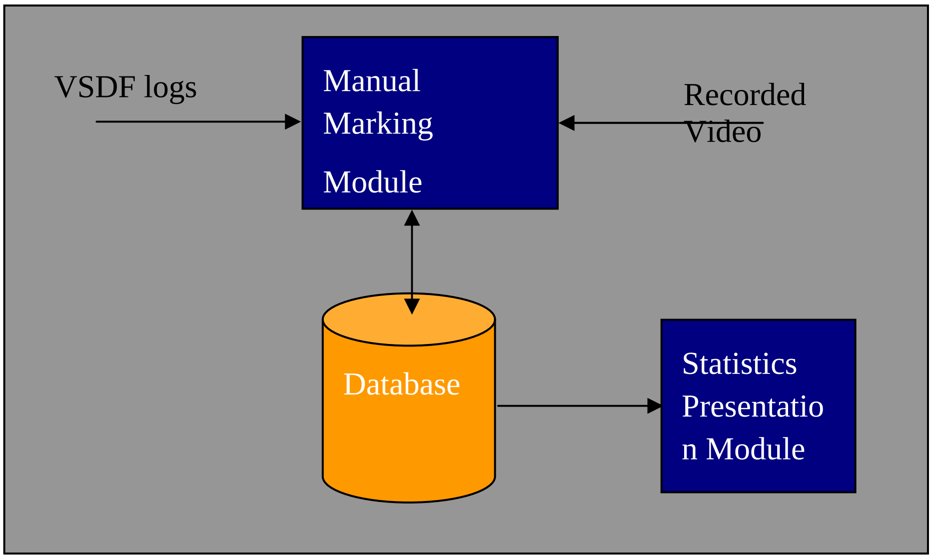
5.2.4 Test Analysis Client

For the environmental tests, a specific software package for statistical analysis was designed and implemented. This package processes all video detection data, determines the probability and quality of detection for the relevant video processing steps, and correlates these statistics with environmental factors, time, and system relevant events. The Test Analysis Client runs independently of the VSDF application, i.e. it runs offline, so it can be hosted in the same computer with the VSDF application or in any other computer.

The Test Analysis Client (see Figure 5-5) consists of three parts as shown in the figure below:

1) The Database
2) The Manual Marking Module
3) The Statistics Presentation Module

Figure 5-5: Test Analysis Architecture



The Test Analysis Client provides a means to evaluate the VSDF performance. The Manual Marking Module has as input the VSDF logs containing a continuous record of the system target reports and the video of the same time period that was recorded through the BNC connector of the Communication Interface Panel (Companel) of each Autoscope Solo Pro MVP by using a PC equipped with a video card. The expert user who runs the Manual Marking Module evaluates the VSDF logs by comparing them with the recorded video. The evaluation result for each observation is recorded as a database record. When the evaluation procedure is completed, the statistics presentation module uses the database records to provide statistical analysis of the VSDF performance, with respect to various environmental factors.

5.3 D3: Preparation of Site 2

This Work Package was concluded before the Annual Review, and resulted to the submission of Deliverable "D3-Site Preparation Report for Thessaloniki" to the Commission. This document was accepted by the reviewers during the Annual Review.

5.3.1 Overview of Installations at Thessaloniki

Five cameras were installed on existing buildings (one at the tower and four at the fire station) to monitor the taxiway A and the APRON entrances. The installation of cameras on buildings is considered as the optimum option, as preliminary tests have indicated that cameras should be placed as high as possible for reliable aircraft's detection. Specifically there are two significant advantages:

1. It is easier to avoid the inclusion of sky in the field of view of the cameras. It is well known from the camera specification that the existence of sky in the field of view should be avoided since significant luminance changes reduce its ability for reliable object detection.

2. The cameras are able to automatically determine the location on the ground corresponding to a detector location placed on a sensor (camera), after a specific calibration procedure, which is supported by the Autoscope software. The higher the position of the camera is, the larger the size of the objects in the camera, thus the more accurate the measurement of the objects' 3-D position, given a fixed resolution of the camera and focal length.

The cameras were mounted on a stable base, as strong winds may reduce their ability on detecting aircrafts (enhancing the number of false alarms) or cause various problems to their operation. Finally, it has also been concluded that five Single-Solo Communication Interface Panels (Com-Panels) will be required for these installations.

All the computers (servers and user machines) were installed at the 4th floor of the control tower. Finally, one CWP was installed at the 6th floor of the control tower, in the control room.

Three special interconnections were required for the three servers:

a) A synchronous serial modem was used to provide radar data to the SDS,

b) RS-232 interface for connection of the Autoscope camera network for the video sensor data fusion server and

c) A RS-232 serial connection was used to provide Flight plan data to the SDS.

5.4 D4: PREPARATION OF SITE 1

This Work Package was concluded before the Annual Review, and resulted to the submission of Deliverable "D4-Site Preparation Report for Mannheim" to the Commission. This document was accepted by the reviewers during the Annual Review.

The INTERVUSE system in Mannheim is using 10 cameras trying to cover the complete area of the APRON, exit B, C, and D and the taxiway to the main building located near the tower. The cameras located parallel to the taxiway are also able to monitor the runway (RWY09/RWY27).

5.5 D5: INTEGRATION AT SITE 1 (MANNHEIM)

After the conclusion of system integration at Mannheim, deliverable D5 was produced under workpackage WP5 of the INTERVUSE Project. This report describes the integration of all INTERVUSE software and hardware, as well as the attachment of data sources (Radar, Flight Plan, Video) to the servers, at the Mannheim Airport test site.

Based on the set of technical requirements established in deliverable D1 - the Requirements and System Architecture document - this document also describes the indicators and functional operability test procedures against which the INTERVUSE system was measured. It lists the test procedures and provides the results of the tests in tabular form.

5.5.1 Installation of Camera System

Installation of the video camera system was performed in 2002 under work package WP3. This work has been described in deliverable D3 - Site Preparation Report for Mannheim.

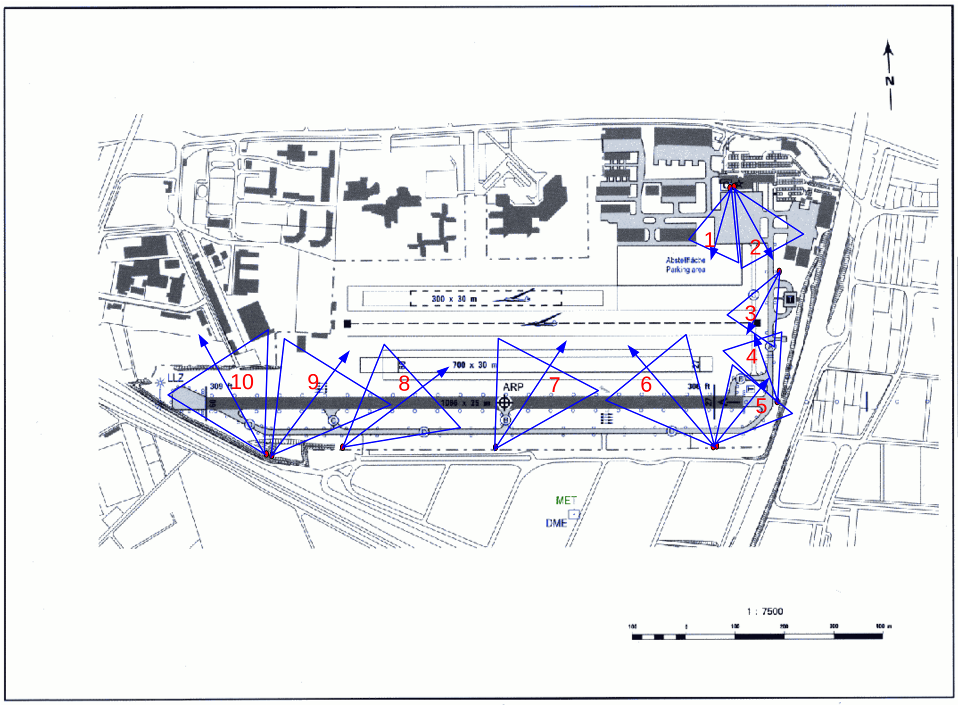
The INTERVUSE system in Mannheim is using 10 cameras to try to cover the complete area of the APRON, exits B, C, and D, and the taxiway F to the main building located near the control tower. It was intended that the cameras located parallel to the taxiway should also be able to monitor parts of the runway (RWY09-27).

This would mostly permit the user to continuously track the aircraft after exiting the RWY to the main building.

During the system integration work at Mannheim, all the cameras were re-adjusted to try to optimise for best coverage of the runways and taxiways. Two of the cameras were moved and the angles and field of view (FOV) of all cameras were adjusted prior to calibration of the MVP system.

For the functional operability tests, all the MVPs at Mannheim were fully functional.

Figure 5-6: Location and FOV of Cameras at Mannheim



5.5.2 NOVA System Installation

The NOVA processing and display equipment from Park Air Systems was installed in the control tower at Mannheim airport.

The equipment comprised the following items:

- One (1) Surveillance Data Server (SDS)

- Three (3) Controller Working Positions (CWP)
- One (1) Technical Control and Monitoring System (TECAMS)
- One (1) Recording and Playback System (RPS) including tape storage unit (AUX)

In addition, a separate LINUX computer was provided to perform conversion of serial Aircat500 data to TCP/IP protocol for LAN communication.

One INTERVUSE CWP was installed in the Visual Control Room (VCR) on the desk adjacent to the controllers working area. The rest of the equipment was installed in the room one floor below the visual control room. This room has windows all around, which provide an excellent view of the entire aerodrome.

A detailed description of the Mannheim Installations can be found in Deliverable D5-Integration Report for Mannheim.

Figure 5-7: INTERVUSE Equipment Room at Mannheim

5.6 D6: INTEGRATION AT SITE 2 (THESSALONIKI)

After the conclusion of system integration at Thessaloniki, deliverable D6 was produced under workpackage WP6 of the INTERVUSE Project. This report describes the integration of all INTERVUSE software and hardware, as well as the attachment of data sources (Radar, Flight Plan, Video) to the servers, at the Thessaloniki Airport test site.

Based on the set of technical requirements established in deliverable D1 - the Requirements and System Architecture document - this document also describes the indicators and functional operability test procedures against which the INTERVUSE system was measured. It lists the test procedures and provides the results of the tests in tabular form.

5.6.1 Installation of Camera System

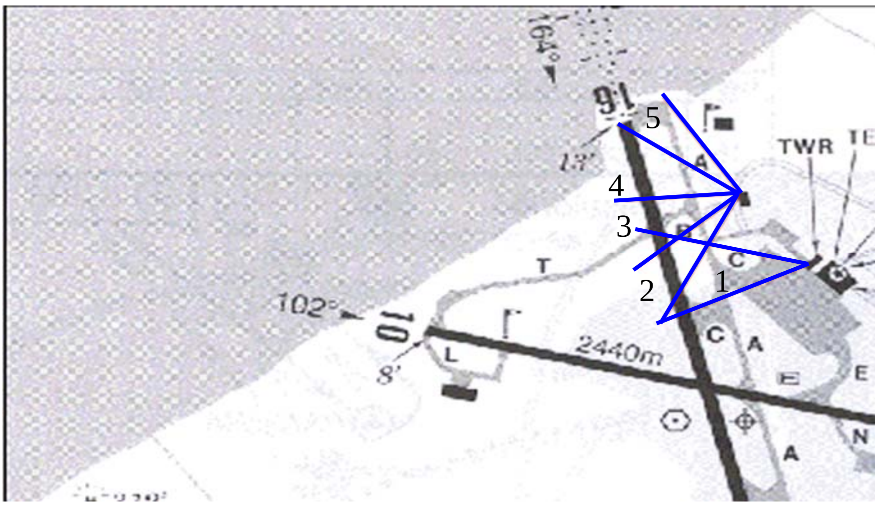
Installation of the video camera system was performed in 2002 under work package WP3. This work has been described in deliverable D3 - Site Preparation Report for Thessaloniki.

The INTERVUSE system in Thessaloniki is using 5 cameras to cover a portion of the main Taxiway A and part of the Apron. Cameras were located on the control tower roof and on the roof of the fire station. It was intended that the cameras located on the fire station should also be able to monitor the north end of Runway 16-34.

During the system integration work at Thessaloniki, all the cameras were re-adjusted to try to optimise for best coverage of the taxiway and runway. Two additional cameras were installed and the angles and field of view (FOV) of all cameras were adjusted prior to calibration of the MVP system.

For the functional operability tests, all the MVPs at Thessaloniki were fully functional.

Figure 5-8: Location and FOV of Cameras at Thessaloniki

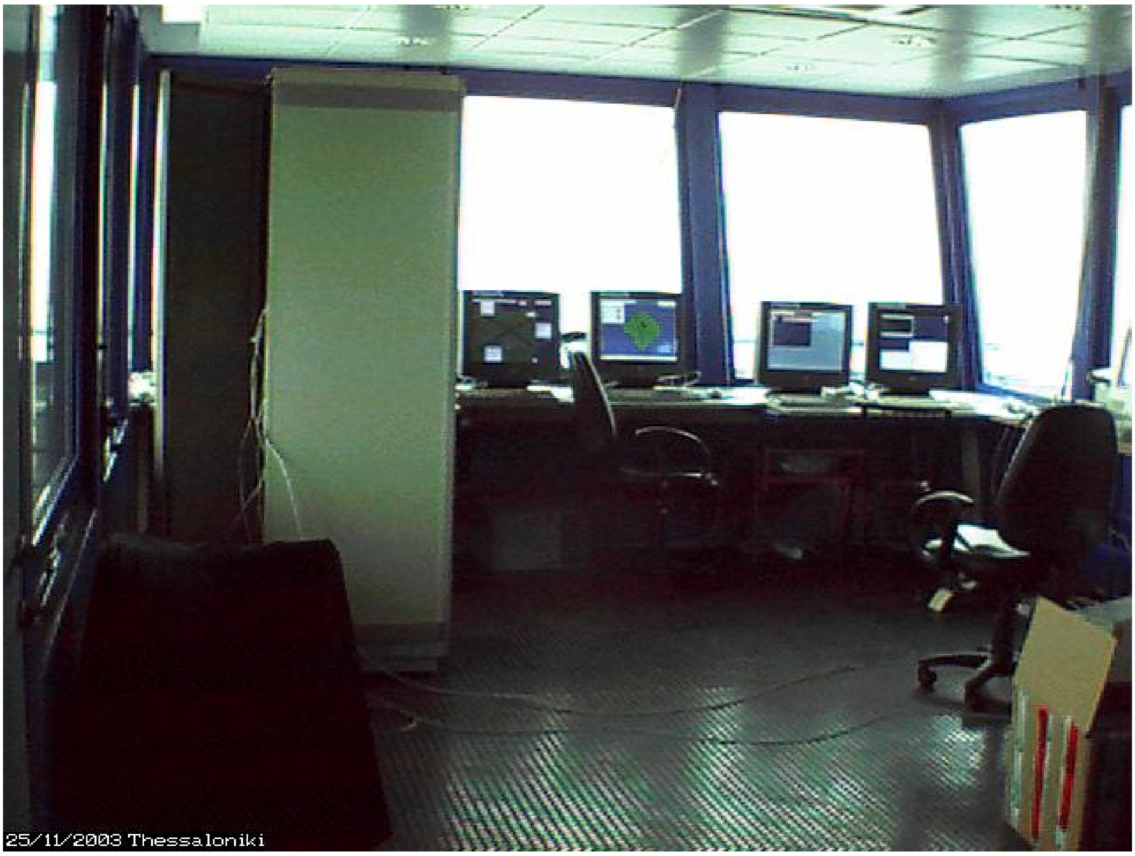


5.6.2 NOVA System Installation

NOVA processing and display equipment from Park Air Systems was installed in the control tower at Thessaloniki airport. The installed equipment was the same as in Mannheim.

A detailed description of the Thessaloniki Installations can be found in Deliverable D6-Integration Report for Thessaloniki.

Figure 5-9: INTERVUSE Equipment Room at Thessaloniki



5.7 TESTS AT SITE 2 (THESSALONIKI)

Deliverable D7 is the deliverable produced under workpackage WP7 of the INTERVUSE Project. Based on the set of operational (user) requirements established in deliverable D1 - the Requirements and System Architecture document - this document describes the test plan and test procedures against which the INTERVUSE system was measured, and it provides the results of the tests in tabular form.

Deliverable D7 contains:

- An introduction providing background information, an overall description of the operational testing and its objectives, and an introduction to the test report structure.
- A presentation of the detectors configuration used
- Definition of general conditions for testing.
- Tabulated test procedures and the test results. This part lists the user requirements for an A-SMGCS and indicates to what extent each requirement is achievable by INTERVUSE.
- An analysis and evaluation of the results of specific performance tests.

- A subjective assessment of the system performance and usability.

5.8 D8: Tests at Site 1 (Mannheim)

Deliverable D8 is the deliverable produced under workpackage WP8 of the INTERVUSE Project. Based on the set of operational (user) requirements established in deliverable D1 - the Requirements and System Architecture document - this document describes the test plan and test procedures against which the INTERVUSE system was measured, and it provides the results of the tests in tabular form.

The structure of Deliverable D8 follows that of Deliverable D7.

5.9 D9: Project Management

In total, there were eleven meetings of the INTERVUSE consortium and details are provided in Section 12. The main results in this Work package can be summarized in the following subsections:

5.9.1 D9-A Project Web Site

The INTERVUSE web site (www.iti.gr/intervuse/) contains information about the project as well as a few demonstration videos. This site has been updated after the INTERVUSE Contract Amendment, to reflect the necessary changes in the project.

5.9.2 D9-B Project Presentation

Deliverable D9-B ("Project Presentation"), which was submitted to the Commission before the Annual Review, consists of a CD-copy of the content of the leaflet and the Web site.

5.9.3 D9-C Final Report

This report.

5.10 D10: Assessment and Evaluation

The assessment and evaluation of the system was carried out during the integration and test phases at Mannheim and Thessaloniki. The produced test results are summarized in Deliverables D7 and D8.
The results of the subjective assessment of the system performance and usability are as follows:

5.10.1 Subjective Assessment of the System Performance at Mannheim

Considerable problems were observed at Mannheim, due to the placement of cameras. Based on the experience gained in testing at Mannheim, it was agreed that it would have been advantageous to mount the cameras higher above the aerodrome surface in order to reduce shadowing and multiple detections and to give a more homogeneous background to avoid unwanted detections. Though this was not possible for Mannheim, it is useful knowledge for future applications.

By increasing the size of the VDs, false detections on the taxiway and apron were reduced, and some improvement to tracking performance was demonstrated in these areas. However, the VDs will need further adjustment and optimisation before full operational testing could be carried out.

Perhaps the most significant observation is that reliable coverage of the runway is not feasible with a camera system, alone. As a gap-filler in an A-SMGCS to cover apron areas and sections of taxiway, the system already shows great potential.

5.10.2 Subjective Assessment of the System Performance and Usability at Thessaloniki

Based on the results observed at Mannheim, the cameras at Thessaloniki were placed on high buildings, in order to achieve a similar or even larger viewing angle than in Mannheim. Considering the fact that for some cameras (e.g. the control tower camera) the monitored taxiway is very far from the camera, this seems to be a strong requirement in order to have good calibration results and to minimize possible occlusions.

At Mannheim, we had observed that configurations with smaller detectors resulted in many false alarms, which as we all agreed made the system unusable by the controllers. Similar configurations performed much better in Thessaloniki, especially when the wind was not very strong. This is mainly due to the fact that the cameras are better mounted on more solid bases than in Mannheim. Such configurations, which combine many smaller sensitive detectors with an OR gate (see Deliverable D6) are the only solution to be able to efficiently detect the diverse traffic observed in the Thessaloniki airport: detection of small vehicles requires smaller and lower-placed detectors, while detection of large aircraft requires detectors placed higher than the taxiway on the camera image.

The test results presented in this report have been obtained with such a configuration, which proved to be very efficient. As a backup, a configuration with large detectors that is able to efficiently detect larger objects (but has problems with smaller objects) under strong wind is also available.

Accurate detection of aircraft on the runway will require using additional cameras since a) the viewing angle is not very large, and b) having to use many detectors to detect the diverse traffic does not permit using the same cameras to detect objects on the runway. These additional cameras would have to be placed at the other side of the runway, so that occlusions from objects at the taxiway could be minimized.

The Thessaloniki airport controllers showed significant interest in the INTERVUSE system. The chief of the air traffic controllers, Mr. Syrpos, and another controller, Mr. Pashos, have been participating in the testing and evaluation of the system.

The system was tested in Thessaloniki under all visibility conditions (1-4), including extreme conditions like strong winds, heavy fog and snow. The conclusions are as follows:

1. Under heavy fog, tests have shown that, although the cameras can be very sensitive and are able re-calibrate themselves to perform in different illumination conditions, we have experienced situations where the human eye was able to vaguely see an aircraft, but no detectors were activated. However, we have observed the system performance under heavy fog only for one day, and the number of aircraft that have been moving during this period was fewer than five. If the cameras were mounted at positions close to the taxiway (as in Mannheim – this is not true in Thessaloniki), the advantages of the INTERVUSE system would be evident. Nevertheless, camera images from positions that are far from the tower may still be useful for controllers.
2. Under heavy wind, the system becomes more sensitive to false alarms. This situation was also observed at Mannheim. The proposed solutions are:
    - Better mounting of the cameras at their locations may significantly reduce false alarms
    - Using larger detectors, which become less sensitive, thus false alarms are reduced. This worked quite well for the installation at Mannheim, however in Thessaloniki, large detectors have significant difficulties in detecting smaller objects (e.g. small vehicles or very small aircraft), so the system performance is somewhat degraded. The difference with Mannheim is that the traffic is much more diverse, thus more detectors have to be used and their sensitivity has to be increased.
3. Under snow conditions, no significant problems were observed (the taxiways and runways were kept clean).
4. Under heavy rain conditions, false alarms sometimes occur due to clouds of water that are produced, especially during landings.
5. If the sun is in a camera’s field of view, false alarms may be produced from reflections at the camera’s shield. To diminish this effect, tape can be used to mask out the sky region from the camera images.
6. Under night conditions, the detectors are primarily triggered by the lights of the aircraft. Although the performance is quite satisfactory, in some large aircraft the existence of lights on the wings and the tail may generate double targets at the VSDF. In addition, vehicles not equipped with a roof-light are very likely not to trigger some detectors.

5.11 D11: DISSEMINATION AND IMPLEMENTATION

The main results in this Work package can be summarized in the following subsections:

5.11.1 D11-A - Dissemination and Use plan

Deliverable D11A is a deliverable produced under workpackage WP11 of the INTERVUSE Project. It is a report describing the planned dissemination and use activities to be carried out during the project. A new version of this document was produced and submitted to the

Commission to replace the previously submitted deliverable, submitted before the Amendment of the INTERVUSE Contract. The plans set out at this document are partly only a statement of intentions. The implementation of these intentions will be considered further after the end of the project as described in the Technological Implementation Plan.

This document contains the following:

- An introduction with background information and an introduction to the structure of the Dissemination and Use Plan
- A general description of the INTERVUSE dissemination approach, which describes the project's objectives and advances and states the expected project results
- Individual partner’s planned contributions to the dissemination and use activities
- A summary and brief overview of the market situation for SMGCS support tools
- A summary and some general conclusions about the dissemination and use activities
- Information gathered by a market survey conducted early in the INTERVUSE project
- The INTERVUSE leaflet, which gives a brief presentation of the project

5.11.2 D11-B Technology Implementation Plan

The eTip document was submitted electronically to the Commission, providing information about:

- Project's actual outcome
- Broad dissemination and use intentions for the expected outputs
- Quantified Data on the dissemination and use of the project results
- Contribution to developing S&T co-operation at international level; European added value
- Contribution to policy design or implementation
- Improving the quality of life in the Community
- Describing the three main project results, namely:
    - A prototype Video Sensor Data Fusion software
    - A prototype Test Analysis Client software
    - An improved product for airport surveillance

5.11.3 Publications and Presentations

Park Air has presented the INTERVUSE project at the NOVA Users’ Conference in Paris in October, in order to assess the interest of Air Navigation Service Providers (ANSPs) in the application of video camera technology for aerodrome surveillance. Feedback from the

ANSPs and other potential customers will provide the bases for a decision on implementation of the INTERVUSE technology in as part of a future product portfolio.

Park Air Systems will present the INTERVUSE system and its results to potential customers at the ATC Maastricht exhibition as well as at other International workshops and conferences.

Also, a paper that describes the INTERVUSE project and its results has been presented in the ITS-Europe Conference in Budapest (the paper is included as an Appendix to this document). Furthermore a paper has been submitted to the “IEEE Intelligent Systems” journal focusing on the use of INTERVUSE system as gap filler for A-SMGCS.

5.11.4 Broad Dissemination and Use Intentions for the Expected Outputs

There are four main target groups for dissemination and use:

1) Civil Aviation Authorities / Air Navigation Service Providers
2) Commercial Airports
3) Military Airports
4) Private Airports

In view of this, the following dissemination activities will be undertaken:

1) Dissemination to existing contacts and customers of ATC systems through invitations to the test site as well as visits and mailings.
2) Dissemination to the responsible persons of civil aviation authorities and airports through exhibitions, publications, conferences, mailings, research and technical events as well as research collaboration forums.
3) Dissemination through the INTERVUSE web site (www.iti.gr/intervuse) and the INTERVUSE leaflet, which will be distributed by the partners at various national and international events. These dissemination actions will be carried out by the consortium as a whole and by each individual partner.

6 PROJECT MANAGEMENT AND CO-ORDINATION ASPECTS

The INTERVUSE project started at July 2001. During the first year of the project the following work has been completed:

1. The Requirements and the Dissemination and Use Plan deliverables had been finalized and submitted.
2. A set of 10 cameras has been installed at Manheim airport and 3 cameras have been installed at Thessaloniki airport. The Autoscope software was available from the camera's provider (Datacollect) to configure detector configurations for tracking changes that are produced by aircraft movements. The system can then constantly poll the cameras to detect corresponding events.
3. Significant progress was achieved with the development of a test analysis module that was planned to test the performance of the basic system.

Unfortunately, one of the project partners, H.A.N.D. Gmbh (Germany), applied for insolvency at July 2002. H.A.N.D. specialized in ATC and ATM systems and was the Scientific Co-ordinator of the project. The remaining partners that are involved in system developing (ITI, DataCollect) looked for a new partner who specialized in surface movement ground control systems in order to replace H.A.N.D. Park Air Systems agreed to assume this role after a meeting in Thessaloniki at 16/09/2002.

The annual review took place in Brussels on 22 October 2002. The project officer and the re-viewers decided unanimously for the continuation of INTERVUSE project and agreed to a seven months extension until 31 December 2003. The commission also confirmed the replacement of HAND by Park Air Systems.

Furthermore, Park Air agreed to take on the role of Technical Coordinator in the project, leaving ITI its task of Administrative and Financial Coordinator. Ralf Heidger continued to participate in the project as a subcontractor of ITI offering consulting services.

Besides, during this period the new consortium of INTERVUSE project submitted an application asking for the amendment of INTERVUSE IST-28260 contract, which was accepted at February 2003. An additional two-month extension (until February 2003) was also provided to the project, so that the testing in the Thessaloniki could successfully be completed.

All deliverables were produced and delivered to the EC. Prototype systems were installed and tested at Mannheim and Thessaloniki airports. Extensive testing was carried out at both airports and the test results were recorded and compared with a set of user requirements for A-SMGCS. Evaluation of the results indicates that there is a potential for using video sensing technology, at least as a gap-filler, in an A-SMGCS. Some further product refinement will be necessary in order to achieve the required reliability and surveillance data integrity.

The final review of the project was held on 19 February 2004 at Thessaloniki airport, where the system was demonstrated to European Commission Officials. The EC panel considered that the whole effort was successful and the performance of the system as a gap filler in an A-SMGCS was more than satisfactory.

7 OUTLOOK

This paragraph provides a short description on how the results and achievements of the project have benefited each partner and how the partners intend to use and exploit these further.

7.1 CENTER FOR RESEARCH AND TECHNOLOGY HELLAS

The main motivation of **CERTH/ITI** for participating in INTERVUSE is the resulting contact with industry and the consequent ability to link the activities of Research Organisations and Industry, which is one of the main purposes of the organisation. ITI intends to use the experience acquired by its collaboration with industry in order to found a spin-off company, in the future, which will exploit the result of its basic research. Such a spin-off company will produce and distribute innovative high technology products based on research results and results from R&D projects.

Currently, ITI has neither the means nor the experience for marketing and distributing the SMGCS product that have been produced in the INTERVUSE project. Therefore, ITI believes that Park Air Systems, which has years of experience in marketing of ATC systems, should be responsible for this task. This also implies that ITI will not be responsible for offering training or maintenance for the system, or for supporting future extensions of the system. This role will be the responsibility of Park Air Systems, however further collaboration with Park Air is possible, with specific agreements, after the end of the project.

Number of grants for technical training / postgraduate studies was offered during the INTERVUSE project. In this way, ITI expects to improve its current knowledge of computer vision and tracking algorithms, Kalman filtering and statistical analysis related algorithms in general and as a result enhance its standing in the scientific community. Knowledge about installing, configuring and using real-time video-based feature tracking systems could lead to potential future extensions for other applications, which are also based on feature tracking. In addition, the development of tools for the test analysis software module enhances the Institute’s know-how on designing, implementing and efficiently accessing Oracle databases and building graphical user interfaces using Qt toolkit. Finally, the general knowledge about ATC systems that has been acquired from this project could potentially lead to further collaboration with airports (and particularly the Thessaloniki Airport) on improving other aspects of ATC systems.

CERTH-ITI already participates in a number of national and international research and technical events, aiming to disseminate the results of its R&D efforts in the national and international research and industrial community. ITI intends to publish the results of the INTERVUSE project in well-known and widely read international scientific journals. CERTH/ITI is participating in a large number of research collaboration forums, like the COST211quat, whose objectives include video coding, video segmentation, content and feature extraction, audio-visual content identification and content-based visual database query and indexing. ITI will communicate to all participants of these collaboration forums the results of the INTERVUSE project.

7.2 PARK AIR SYSTEMS

The new INTERVUSE technology could be easily be integrated into Park Air Systems' family of ATC and SMGCS products. It would be introduced into the ATC market both as a stand-alone solution in combination with ATC radar, SMR, and flight plan processing, and as an add-on module for existing or large-scale A-SMGCS solutions. Park Air could then improve its competitiveness by having the ability to offer an integrated solution for ground control, tower and approach control in one powerful communicating environment.

With this product, project integrators / airport development companies can be addressed as well as the end-users, such as airport authorities and air navigation service providers.

The sales department of Park Air Systems has grown steadily and continuously over the past years. Because of the foreseeable improvement of the market opportunities, Park Air will continue to invest in improving its sales capability. On the one hand, the internal activities for marketing and public relations will be improved; on the other hand, the technical sales engineering for the production of high-quality proposals will be increased.

As far as the dissemination activities are concerned, existing regular customers with existing operational reference installations are of great importance. This is of significance for developing new business with these customers as well as for the presentation of reference systems to potential new customers.

To summarise, Park Air intends to use the following advertising devices and publication means for dissemination:

- **Exhibitions**

  The product resulting from the INTERVUSE project will be presented at various exhibitions and conferences. Each year, Park Air participates at the ATC Maastricht exhibition, the conference of the International Federation of Air Traffic Controllers' Associations (IFATCA), the Farnborough International Air Show, the Inter Airport Asia exhibition, and others. Furthermore, Park Air holds an annual workshop for users of NOVA A-SMGCS equipment.

- **Customer Presentation**

  The INTERVUSE HMI can be presented to existing and new customers by Park Air Systems on-site or at the Park Air premises. A portable demonstration system will be available. As far as the entire system including the camera installations is concerned, potential customers could be invited to the test site for a thorough presentation of the system.

- **Internet**

  A further means to present Park Air Systems and its products to a wide public is through its web site. The INTERVUSE project will be presented to existing and potential NOVA customers through the Park Air Systems electronic newsletter "Air Ways". In addition, there would be a permanent link to the INTERVUSE web site in order to make a more detailed description of the concept available to interested parties.

- **INTERVUSE Leaflet**

  The INTERVUSE leaflet (see Appendix 2: INTERVUSE Leaflet) will be distributed to cooperation partners and customers, and it could be used for mailing. Furthermore, the leaflet can be made available at air traffic control exhibitions and conferences, for example at the ATC Maastricht exhibition and the IFATCA conferences.

- **Agents**

  Park Air Systems has agencies in more than 80 countries. Each agent has close contact with potential customers locally and will be able to promote the product.

7.3 DATACOLLECT

DataCollect increases its range of addressable users of the proposed sensing technology into a new market. Until now, its technology has been applied to street traffic only. With the prospects of INTERVUSE it will be extended to the ATC market, and as a later step, eventually also into vessel traffic management and harbour control. This can be achieved with a collaborating company of DataCollect in the Netherlands, Tec Traffic Systems, which has business relations to Dutch harbour control administrations.

Regarding to the INTERVUSE project, DataCollect has supplied and supported the video sensors for detecting the objects on the runways and taxiways.

DataCollect will supply and inform all its worldwide partners which are using this kind of sensors from DataCollect about this new application of the video sensors. In February 2002, DataCollect attended a marketing meeting in Spain informing all partners about the INTERVUSE project and its potential. In April 2002, DataCollect attended the world biggest traffic show INTERTRAFFIC 2002 in Amsterdam informing the visitors about the INTERVUSE project.

7.4 AIRPORT MANNHEIM

Mannheim Airport intends to continue to use the resulting system both for demonstration and surveillance purposes.

8 CONCLUSIONS

The project results indicate that INTERVUSE technology can achieve most of the performance requirements of a Surface Movement Radar (SMR). Specifically, the strengths of the system are:

- No radiation
- Lower cost
- Provision of video
- Higher update rate

While its weaknesses are:

- Limited coverage,
- Poor detection under heavy fog conditions and
- False detections due to
    - Occlusions or
    - Sudden changes in light conditions.

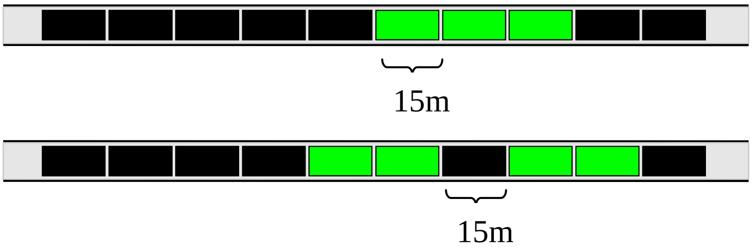
Tests at both Thessaloniki and Mannheim airports also showed that video cameras can provide a useful contribution to airport surveillance and that the technology developed in INTERVUSE project has the potential to be a gap-filler to complement Surface Movement Radar (SMR).

At Mannheim Airport, where ten cameras were installed in order to cover the whole area of the airport (APRON, runway and taxiways), there were significant problems to the tracker of the system due to the gaps between cameras. The track should be continuous, without gaps in its description of the movement of the tracked object on the airport surface. The continuity is required so that the Air Traffic Controllers can be sure that an object that a few seconds ago was in a certain position is the same object at a different position. This is especially true when the controller is not able to see the aircraft because of bad weather, low visibility, at night or because his view is blocked due to the airport layout. Unfortunately, the full coverage of the airport, without gaps between cameras, requires a large number of cameras, thus the cost of the system is significantly increased. However, as a gap-filler in an A-SMGCS to cover APRON and sections of taxiway the system showed great potential.

Furthermore, tests at Mannheim led to important conclusions regarding the installation of cameras and the set up of virtual detectors. Specifically, cameras should be mounted as high as possible and close to the area to be surveyed in order to reduce shadowing and occlusion effects. The camera mount should be also reinforced to prevent camera movements (e.g. due to strong wind) increasing false detections to an unacceptable level. Additionally, the existence of horizon in the camera's field of view should be avoided since cameras are sensitive to sudden changes in light conditions. It was noted also that the sensitivity of each virtual detector is proportional to the number of pixels changing from scan to scan, which means that small detectors are the most sensitive. However a compromise was necessary in order to reduce unwanted detections to an acceptable level. Finally, cameras fields of view should partially overlap in order to avoid gaps between virtual detectors of different cameras and, in turn, tracking problems.

At Thessaloniki airport, gaps between cameras were avoided and the cameras were installed as high as possible to perform better detection. Furthermore, tests at Thessaloniki airport showed that the use of small detectors is preferable for the detection of cars (follow-me cars, ambulances etc) than the use of large detectors, which are not able to detect small targets. However, many small detectors are likely to be activated by different features of the same aircraft, providing multiple targets to the system and creating serious problems to the tracker. This problem was solved by replacing large detectors with many small detectors, which are connected with an OR gate. Whenever one or more of these detectors are activated the OR gate indicates the existence of a target. The result of this replacement is that the final detector (OR gate) covers the same area as a large detector but it is also enough sensitive to detect small targets. As far as the accuracy and the resolution of the system are concerned, both depend exclusively on the length of virtual detectors and the calibration of cameras. A good compromise for the length of virtual detectors is 15m, which allows discriminating between targets that are separated by 15m or more and provides a theoretical obtainable accuracy of 7.5m (the centre of the detector is considered as the position of the target).

Figure 8-1: Virtual Detector Length



Tests at Thessaloniki airport also showed that false detection error was around 1.5% and the missed detection error was around 4% (these figures are based on the results of Test Analysis Client, a tool which was developed during the project aiming to evaluate the performance of the system).

In future, the VSDF server, which is a Windows application, could be redeveloped for Unix operating system. Prerequisite for this development is the existence of Autoscope Software Development Kit for Unix, since for the time being Autoscope Software Development Kit is only available for Windows. Finally, we should note that the original application field of Autoscope detection system is road traffic monitoring and statistics. The software of cameras is proprietary of the company and allowed neither knowledge nor control of the image-processing algorithm. Some modifications on this algorithm in order to adapt Autoscope detection system on the requirements of airport ground traffic could improve significantly the performance of INTERVUSE system.