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RE	Restricted to a group specified by the consortium (incl. Commission Services)	
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4.1 EXECUTIVE SUMMARY

The ARGUS 3D - AiR GUidance and Surveillance 3D project is a 3 years FP7 Research project on Security, coordinated by Selex ES and represented by a consortium of 12 partners from five EU Member States (Italy, UK, Germany, Poland, Spain) including industries, research organizations, and end-users. The aim of ARGUS 3D has been the development of a low cost radar based system, integrated in a conventional Air Traffic Control System (ATC), capable of supporting the Air Traffic Control Operator (ATCO) by providing additional information on the nature of targets and their threat levels. The main objective has been to enhance the security of European citizens against possible terrorist threats that can be delivered by means a small and non cooperative aircraft.

In order to achieve this goal, the project has exploited innovative passive radar technologies, a conventional primary radar with altitude extraction capability and a new Data Processing capable of integrating conventional and innovative surveillance sensors. The integration of a PSR-3D sensor enhanced the capability of the ATC systems of getting 3D information also for NCTs; the introduction of passive radar sensors allowed both to extend the conventional surveillance coverage into areas typically not well catered for by current systems (considerably reducing if not completely removing the radar blind zones) and to improve the recognition capability of the ATC systems also for NTCs. The project developed a multisensor surveillance system which was tested in a simulated environment where the whole ARGUS-3D system with all the innovative surveillance sensors investigated during the project, was tested and in a real environment with actual targets during simulation sessions which gave the possibility to verify the real potentialities of the system, even in a reduced version (only for the PSR-3D and the FM Passive Radar), to reach the goal fixed by the project. The results of the tests were validated by a group of external experts and stakeholders. The tests demonstrated the capability of ARGUS-3D system to provide surveillance information not available in a conventional ATC system and, as a consequence, to improve the security of the ATM system by means of the provision of additional surveillance data.

4.1.1 PROJECT SUMMARY

4.1.1.1. CONTEXT

ARGUS-3D ("AiR GUidance and Surveillance 3D") was a collaborative Research Project co-funded by the EC under FP7 (Security topic), addressing ways to enhance the security of European citizens and European strategic assets by contrasting unpredictable and unexpected terrorist threats, which could be delivered by means of small and low-flying aircraft. In fact, the current Air Traffic Control systems are not able to fully assure the detection of such targets, particularly at low altitudes, and particular geographical areas (e.g. mountains), nor they are able to proactively identify non-cooperative targets.

These drawbacks in the currently used surveillance systems have recently generated awareness about the possibility of large-scale, terrorist offensive actions delivered against civil society by means of aircraft (a/c), that can be used either for carrying out "kinetic attacks" or for delivering chemical and/or biological pollutants. In this context, ARGUS-3D aimed to improve the existing Air Traffic Control systems and technologies for civil applications by developing new sensors with extended surveillance coverage and making them able to detect, recognize and track cooperative and non-cooperative targets (NTCs).

In particular ARGUS 3D activities focused on studying, designing and implementing an innovative, low-cost, multi-sensor, radar-based system for 3D air guidance and surveillance that integrated the conventional surveillance systems currently used for civil applications and two classes of non-conventional radar systems, in particular:

- 3D PSR sensors that would have enhanced the capability of the ATC systems of getting 3D information also for NCTs
- networks of multi-operational, high-performing passive/bistatic radar sensors, that would have widened the conventional surveillance coverage and improved the recognition capability of the ATC systems also for NTCs.

In order to reach the above mentioned objectives, the project consortium, led by SELEX ES and composed of 12 partners from 5 EU Member States (Italy, UK, Germany, Poland, Spain), comprised key players to ensure the availability of technologies, capabilities, technical and operational knowledge required for the multi-disciplinary goal of the project.

4.1.1.2 OBJECTIVES

The overall objective of the ARGUS 3D project was to enhance the security of European citizens, as well as of strategic assets by contrasting, on large areas, unpredictable and unexpected terrorist threats that could be delivered by means of small and low-flying (manned or unmanned) A/C.

The scientific and technical objective of ARGUS 3D project was studying, designing and implementing an innovative, low-cost, multi-sensor, radar-based system for 3D air guidance and surveillance (hereinafter referred to as "ARGUS 3D" system) that integrated conventional surveillance systems currently used for civil applications and two classes of non-conventional radar systems:

1. 3D PSR sensors, i.e. PSR with monopulse estimation capability in the vertical plane and therefore able to return the altitude information for any detected target;
2. networks of multi-operational, high-performing passive/bistatic radar sensors, which are a special form of radar receiver that detect and track objects by processing reflections from non-cooperative sources of illumination already available in the environment (e.g. commercial broadcast and communications signals).

The integration of a PSR-3D sensor enhanced the capability of the ATC systems of getting 3D information also for NCTs; the introduction of passive radar sensors allowed both to extend the conventional surveillance coverage into areas typically not well catered for by current systems (considerably reducing if not completely removing the radar blind zones) and to guarantee the detection in case of failure of the conventional surveillance system. In order to achieve the above mentioned scientific and technical objective, the project workplan was organised in different steps, each corresponding to one or several Work Packages (WP), in order to gather activities for each of the segments in the system:

STEP 1 The "full system" study:

WP2 - Integrated surveillance system study

STEP 2 System study and processing techniques for passive and bistatic radar network and for the PSR-3D:

WP3 - Enhanced PSR system for 3D information extraction

WP4 - Passive Radar network for extended area and performance

WP5 - Passive Radar network, which exploits single-frequency-networks as source of opportunity, for extended area and performance

WP6 - Bistatic Radar network for extending range and allowing detection of anomalies

WP7 - Multi-aspect observation allows improved classification and recognition

STEP 3 Design and implementation of an innovative Data Fusion and Management :

WP8 - Data fusion and management of integrated system information

STEP 4 The experimentation and evaluation:

WP9 - Test bed study

WP10 - Integration and validation

STEP 5 Dissemination and exploitation:

WP11 - Exploitation and dissemination

Each Work Package (WP) reached the foreseen objectives, in particular:

- **WP2** aims to design an integrated system to improve the recognition of non-cooperative threat target through more accurate information on target characteristics and/or on target positioning, including active and passive radar plots. This objective was reached through the following activities:
  - the identification of the main threats for the ATC system, currently in operation, and the evaluation of the risks associated to them
  - the definition of some scenarios in order to have a common input for all other technical WPs
  - the analysis of the system and operational requirements involving the User Group members and the ARGUS 3D partners
  - the design of the integrated ARGUS 3D system
- **WP3** aimed at studying and implementing solutions that make possible the extraction of the altitude information from a conventional PSR sensor, in order to obtain PSR systems able to perform a 3D localisation of the detected flying vehicles. This objective was reached through the following activities:
  - system studies concerning 3D PSR functionalities
  - studies and experimental issues related to upgraded 3D PSR sensor and parameter setting-up
  - Integration and validation of enhanced PSR system for 3D information extraction
- **WP4** aimed at studying and designing a network of passive radar, able to detect targets with different position and velocities. This objective was reached through the following activities:
  - System definition and processing techniques for a single multi-frequency passive radar based on the FM radio broadcast signals
  - System definition and processing techniques for a passive radar network based on the FM radio broadcast signals
- **WP5** aimed at developing a sensor concept for a passive radar receiver designed to utilise the emissions of digital single-frequency networks. This objective was reached through the design of all the components required for developing a sensor concept for a passive radar that utilizes single frequency network broadcast systems as illumination. WP5 also aimed at developing a network of passive-radar sensors for target localisation using single- frequency network illumination. This objective was reached through the definition and design of a radar-receiver - network interface, a net-centric data-collection and recording unit, a track generation from multistatic target plots based on plot-extraction from the range/Doppler pre-processed sensor data and a solution for real time display and recording of target tracks.
- **WP6** aimed at the development of bistatic radar network based on a single illuminator (TX) and on multiple receivers distributed over a large area. This objective was reached through the following activities:

  - design of single bistatic radar and of a bistatic radar network, able to detect targets with different position and velocities
- **WP7** aimed at demonstrating the possibility of using a network of radar with high range resolution to increase NCTR capability compared to a single radar sensor. This objective was reached through the following activities:
  - design of a network of radar with high range resolution
  - develop algorithm detection and Tracking of a Non Cooperative threat on the basis of the radar network
  - develop a multi perspective target classifier, for the identification and classification of non-cooperative threat target
- **WP8** aimed at the implementation of different functionalities: merging function, consistency function, decision support function, data presentation function and a flight simulator and analysis tools. This objective was reached through the following activities:
  - studies and experimental issues related to new Data Fusion and Tracking (definition of requirements, algorithm calibration parameters, prototype development, integration)
  - studies and experimental issues related to new Consistency Function, Decision Support Function and Data Presentation, Flight Data Simulator and Analysis Tools
- **WP9** aimed at defining a test bed where controlled demonstration of the detectability of low-flying small-RCS air vehicles can be performed. This objective was reached through the following activities:
  - Definition of Test bed requirements and architecture
  - Test bed design and development
  - Planning of the demonstration and selection of ad hoc analysis for the validation of the results of the experimental demonstration and definition of a detailed Validation Plan
- **WP10** aimed to obtain the integrated ARGUS 3D prototype, incorporating all the types of sensors designed in previous WPs. This objective was reached through the following activities:
  - sub-system integration and tests
  - collection and processing data from the experimental prototype to validate the performance of the integrated system
  - system validation with User Group members
- **WP11** aimed to manage and valorise of the knowledge created within the project. This objective was reached through the following activities:
  - Creation of a user group
  - Dissemination activities (for more details see paragraph 3.4)
  - Elaboration of an Exploitation Plan (for more details see paragraph 3.4)

4.1.2 MAIN S&T RESULTS AND USE OF FOREGROUNDS

The following chapter aims at presenting the main scientific and technological results obtained during the project and also at providing an overview of how the foregrounds generated within ARGUS 3D will be used after the project end.

The main S&T achieved results for each WP are:

Integrated Surveillance System Study (WP2)

The study was focussed on the definition and analysis of possible sensible objectives and attack consequences from non cooperative targets, in order to understand the environment in which the ARGUS 3D system would have worked and the requested system performance characteristics in order to prevent the threat. In addition, a market analysis was realised in order to investigate the potential applications of project results in terms of market needs and applicability of the project results within the critical infrastructure sector.

The study was finalised with the definition of six operative scenarios, which have been used as starting point for the definition of the ARGUS 3D operational requirements, and consequently for the drafting of the system architecture, that was used as input by the other R&D activities. The scenarios, analysed by the different partners involved for the processing with its own innovative sensor (PSR-3D, FM Passive Radar, DAB Passive Radar and Bistatic Radar) were:

- Scenario 1: Small civil airport
- Scenario 2: Transponder out of service or switched off
- Scenario 3: Tracking of Ultra-Light Motorized
- Scenario 4: Small touristic aircraft
- Scenario 5: Commercial flights
- Scenario 6: PSR out of service

Moreover, for the demonstration of the capabilities of the ARGUS-3D system as realistic as possible but still in a simulated environment, the consortium felt the need to have a common scenario based on a realistic complex area where all the realistic conditions, such as geographic and electromagnetic environment, position and transmission power of FM and DVB-T transmitters, etc., were defined. In this way an additional scenario, named “Quasi-real Simulated Scenario”, was defined based on a realistic area with a complex environment (with the orography represented by the area around Rome) with the position and the characteristics of the transmitters defined and in which the airplane trajectories were defined in terms of position and velocity.

Enhanced PSR system for 3D information extraction (WP3)

WP3 aimed at studying a low cost solution to obtain an enhanced primary radar able to extract the altitude information from a detected air target (PSR-3D), improving the capabilities of the air traffic control management in presence of a growing number of aircraft, some of which may be non cooperative.

The activities focused on the investigation of the use of a monopulse technique for altitude extraction, and on the feasibility analysis of such feature on the ATCR 33S ENH primary radar. The outcome of such activity was the suggestion to use a G33 antenna with double fan type beams. The main goal of this study was to evaluate the implementation of this function by producing software modifications in the Radar Processor architecture, without requiring to employ any additional hardware and without disrupting the already implemented basic functionalities of the radar.

The developed functionality required the presence of two separated receiving and elaborating chains within the radar receiver, respectively dedicated to one of the two antenna beams. After separate detection processes, a Monopulse estimation, based on the amplitude of the samples received from the two beams, was performed to evaluate the target elevation angle.

The ATCR 33S ENH radar was already provided with the capability to receive and process separately these signals but only up to the first stages of the Radar Processor (the Digital Down Conversion). After the digital down conversion the two paths were combined and the signals were selected for the processing according to a user programmed Beam Selection Map. For this purpose a MatLab simulator was developed to receive both the data flows from the ATCR 33S ENH after the Digital Down Conversion and to simulate the basic functionalities of the Radar Processors separately for the two antenna beams, evaluating the elevation angles through a new algorithm which estimated the Monopulse Ratio.

The precision of this estimation was as good as the more calibrated the two receiving chains were. Hence a calibration system was foreseen in the simulation, using known reference levels provided by a Test Target and adjusting the amplitude of the samples received from the two beams. As future development, a calibration system could be accomplished using also the information provided by the MSSR, if present.

The application of the monopulse technique in the 3D PSR using a reflector antenna allowed to extract the altitude information only within a limited range of values: the monopulse estimation was based on the ratio between the samples provided by the Main and Auxiliary beams of the G33 antenna and the value of this ratio was associated to the corresponding elevation angle though a look up table, a function of the ratio between the two antenna patterns versus the elevation angle.

Since the correspondence between the value of monopulse ratio and the relevant elevation angle was bijective only inside a limited angle interval, the estimation was possible only inside a determined angle interval that, considering an antenna tilt of 2.6° (the case used as reference in this study) corresponded to the range between 0° and 4.3°. Obviously the upper limit increased for higher tilt values (the theoretical case of 3.5° tilt has been also evaluated) but a tilt of 2.6° was typically considered a good compromise between target detection and clutter rejection. Furthermore, for surveillance purposes the considered interval allowed to reveal with better probability of detection the altitude for low flying targets, especially in the descending path, when, in the absence of a cooperating information (MSSR or ADS-B) they may have represented an emergency situation.

After the estimation of the elevation angle, the final plot included the information about the aircraft altitude, by computing geometrical calculations based on the slant range and elevation of the target and taking also into account the radar signal propagation over a spherical surface. The surveillance information produced by the 3D PSR were combined with the information provided by other sensors (e. g. Passive Radars) by using a Data Fusion system which was part of the WP8 study.

The simulations performed in this study was produced by injecting target scenarios at RF level in the radar receiver by means of the RTG tool and recording the outputs from the first stages of the Radar Processor (soon after the Digital Down Conversion). The recorded files were processed off-line through the MatLab Radar Processor simulator to give in output the plot information which included the target altitude.

Two kind of scenarios were proposed in this study:

- a first group of simple “ad hoc” trajectories at different elevation angles, distances and SNR, to allow an easy comparison between the performances of the enhanced radar with the theoretical ones.
- a second group of more complex trajectories, whose results was used by the Data Fusion algorithm in WP8.

All the results obtained from the simulation were in line with the expected theoretical values. In general for all the considered simulations the obtained performances reflected the expected theoretical values and therefore this technique, if implemented in a real operative radar, can provide a useful information about the target trajectory, which can be further processed by the Data Management of the ARGUS-3D system, for alerting on the presence of emergency situations.

Passive Radar Network for Extended Area and Performance (WP4)

The ARGUS 3D system characteristics and processing techniques were completely defined for a single multi-frequency passive radar based on the FM radio broadcast signals. Specifically these include:

- the technique to optimally select the FM radio channels providing the best performance for the
- target detection and motion estimation;
- the technique to jointly exploit the signals available on multiple channels to achieve high detection
- capability and high reliability;
- the technique to optimally exploit multiple receiving channels, obtained by the use of multiple
- receiving antennas in place of the standard two (surveillance and reference) antennas.

The proposed processing techniques were extensively applied to simulated data sets generated according to the scenarios defined in the Integrated Surveillance System Study. The performed analysis had shown that the proposed Multi-Frequency operation was able to significantly improve the performance of the passive radar sensor (both in terms of target detection capability and localization accuracy) with respect to the passive sensor exploiting a single frequency channel. Specifically, for each considered scenario, the following considerations are in order.

When operating with a single FM channel, due to the highly time varying characteristics of the transmitted waveforms and of the propagation channel, it was very difficult to a priori identify a good performing channel for the whole radar operation; as a consequence, bad instantaneous characteristics of the selected waveform of opportunity might lead to unpredictable, unavoidable and inacceptable performance degradation.

In contrast, the proposed MF approach allowed a mitigation of the effects due to temporary bad waveforms for radar purposes and a satisfactory recovery of single channel failures, thus making the PBR system more robust and reliable. This allowed to increase the expected radar coverage with respect to the SF case; the higher number of detections not only improved the track length and quality, but also made the tracking stage easier. Moreover, the introduction of the MF approach in the PBR system processing chain allowed a better detection of low RCS targets, thus enabling a more reliable and effective detection and tracking of ULM targets (characterized by small dimensions and low altitude). This particular objective was sometimes achieved using the SF approach, but it was clearly shown that in each considered case, and specifically when the SF strategy fails, the MF approach provided a consistent system performance enhancement that made this objective easier to be reached.

The localization performance was analyzed referring to the RMSE value between the estimated targets positions and the corresponding ground truth, noticing that the MF approach guaranteed a performance improvement keeping its characteristic of robustness respect to the strongly time-varying characteristics of the transmitted waveforms and of the channel propagation. Obviously the achievable performance in terms of DoA estimation accuracy highly depended on the number and the time-varying behaviour of the selected FM channels to be integrated.

Specifically, the performed analysis demonstrated that the MF detection performance was only slightly affected by the presence of a single bad performing channel in the set of jointly exploited FM channels. In contrast the DoA estimation accuracy might have significantly decreased when an FM channel with severe instantaneous characteristics was included in the average. However this accuracy decrease was lower than in the SF approach, where the use of a bad waveform (for radar purposes) could not be a priori avoided and led to high RMSE values. Furthermore advanced MF DoA estimation techniques were introduced to enhance the MF system performance by making it less affected by the instantaneous behaviour of the integrated FM channels. The analysis against simulated data sets was repeated using different multi-frequency configurations, i.e. exploiting different FM channels sets composed of a variable number of channels ranging between 2 and 4. The higher bound was set by practical considerations about the maximum number of "good performing" channels that were expected to be available (transmitted by the same transmitter) and by the design requirements on the receiving system complexity (maximum number of parallel receiving channels). The performed analysis demonstrated that, increasing the number of integrated channels, a better detection and localization performance was achieved; obviously this improvement was paid in terms of increased system complexity and computational load. However, it was noticed that a significant performance improvement was obtained when using 2 or 3 FM channels while only a limited additional improvement was achieved by further increasing the number of integrated channels. Based on the above considerations, the performed analysis gave some useful hints for the selection of the number of practical channels to be used: a multi-frequency configuration exploiting 3 FM channels was recognized to be a reasonable choice since it yields a good trade-off between achievable performance and system complexity. In conclusion, the presented analysis allowed to assess the effectiveness of the conceived single multifrequency passive radar sensor for surveillance purposes. Obviously the single passive sensor was intended to provide highly reliable performance at short ranges, whereas the extended area coverage could have been guaranteed by the formation of a full network of passive radar sensors. the system definition for a passive radar network, able to detect flying vehicles with different positions and velocities and measure their position and motion parameters.

A significant performance improvement could have been obtained by operating with multiple passive radar sensors properly distributed over the surveillance region, since this allowed to achieve the desired extended area coverage with better quality. In this regard, a key point that was investigated was the optimal dislocation of the passive radar sensors in a wide area, with reference to the positions of the existing FM radio broadcast transmitters in an assigned area. To this purpose the optimization process was based on the maximization of selected quality parameters, subject to proper constraints on the receiver position.

Different strategies were proposed for the optimal dislocation of the passive radar sensors in a wide area. With reference to the detection capability, an effective solution was mainly based on the maximization of the passive radar network coverage. According to this strategy, the number and the position of the passive sensors was optimized to guarantee a desired detection capability of targets flying in the considered wide area. The proposed strategy was tested against the simulated scenarios defined in WP2 which included the detailed description of the geographical characteristics as well as the transmitters positions in the considered area. This allowed to design proper passive radar network topologies for the selected case-studies based on the above strategy.

Aiming at exploiting a passive radar network, proper techniques were defined for the association of plots achieved by different passive radar sensors, based on the knowledge of the topology of both FM transmitters and passive sensors. A significant effort was devoted to the identification of proper strategies for the design of the network topology aimed at the maximization of the resulting localization capability. An overall performance assessment for a passive radar network based on FM radio transmissions was presented, exploiting all the outcomes of the conducted study. The analysis allowed to demonstrate the effectiveness of the proposed passive radar system for wide area surveillance applications. In fact, in the considered case-study, the designed FM-based passive radar network (exploiting the proposed processing techniques and optimization strategies) yielded remarkable performance in terms of radar coverage. Specifically, using 4 or 5 passive sensors properly dislocated over the surveillance region, 95% of the present targets were correctly detected at least by one bistatic couple. Moreover, while the considered network topology was optimized to maximize the radar coverage, a significant improvement was obtained with respect to the single bistatic couples also in terms of target localization capability. Specifically, this was guaranteed for targets contemporaneously detected by 3 or more passive radar sensors based on the joint exploitation of the resulting range measures. Obviously, the overall localization performance of the network might be further improved by including additional receivers whose positions can be optimized based on the optimization strategy. This would yield additional range measures to be exploited in the localization of a given target; moreover better geometries might be identified aiming at reducing the horizontal positioning accuracy (HDOP). This improvement is paid in terms of the increased system costs required to develop, field and maintain additional passive radar sensors.

Single-Frequency-Networks Passive Radar Network for Extended Area and Performance (WP5)

The use of Digital Audio Broadcast signals for passive radar target detection purposes was investigated and a processing scheme was proposed. The processing comprised the reconstruction of the transmitted signal by exact time synchronization and compensation of the impulse response of the transfer channel. Correlation processing and Fourier integration for time-difference of arrival measurements between the direct signals and the echo signals, as well as beam forming for direction measurements were applied. The viability of this approach was demonstrated with simulations of specific case studies, where continuous digital waveform signals were generated to emulate recordings from PCL systems. Suitable receiver locations for best areal coverage were determined using an optimization algorithm. Furthermore the method of multilateration was explored whereby the measurements of multiple target echo returns are exploited to increase the receiver's performance regarding accuracy and resolution. Suitable DAB-receiver locations within the ARGUS 3D scenarios data were identified using an optimization algorithm. Based on this scenarios, raw data was generated that emulates recorded data from a PCL –system concept.

A data processing approach was applied to the data, where the DAB signal structure can be exploited to obtain clean reference signal for radar purposes. The results showed that targets with a bistatic range of up to 100 km could be successfully detected and tracked in the range-Doppler as well as x-y-space. In this study a signal processing techniques for digital waveform signals was proposed that comprised the reconstruction of the transmitted signal by exact time synchronization and compensation of the impulse response of the transfer channel. Correlation processing and Fourier integration for time-difference of arrival measurements between the direct signals and the echo signals, as well as beam forming for direction were applied.

Bistatic Radar Network for Extending Range and Allowing Detection of Anomalies (WP6)

The activities required for the conceptual design of single bistatic radar, able to detect targets with different position and velocities, exploiting a single illuminator, and to plot the result in an opportune domain were realized.

The requirements of bistatic radar with one controlled transmitter were prepared, allowing to develop a simulation model of bistatic radar that was developed in SCILAB and C++ environments. Such model was tested with the received scenarios. Analysis of simulation results allowed to point out advantages and disadvantages and develop concept projects of the bistatic radar.

The requirements for bistatic radar network were prepared, allowing to develop simulation model of a bistatic radar network with single, common controlled transmitter. The software dedicated to simulate bistatic radar network properties in different scenarios was finished. Also, the simulations for seven scenarios were performed.

Bistatic receivers network can significantly improve estimation accuracy of 3D position and velocity of detected object. Estimation accuracy in bistatic receivers' network does not depend directly on particular accuracies that characterise individual bistatic receivers. By using the time-difference of arrival (TDOA) method the position accuracy was substantially improved in the areas where object's echo was received by three or more receivers, which allowed for precise position determination of the target in three dimensions. Bistatic receivers' network detected advantages were:

- Objects' position and velocity estimates in a network using hyperbolic positioning -TDOA was up to ten times more accurate than for individual receiver.

- Position estimation error of objects that were detected by three or more bistatic receivers depended on object's echo time of arrival measurement accuracy for individual receivers, did not depend neither on object's location in the bistatic space, nor on azimuth measurement accuracy from transmitter and receiver. This allowed to effectively resolve problems related to the single bistatic receiver configuration such as:

- no detections of targets crossing the transmitter-receiver baseline,

- dependence of estimation error on object's position,
- high requirements on antenna system quality and stability.

For a single bistatic receiver configuration the repeatability and amplitude stability of antenna beams proved to be essential. In the networked configuration these requirements may be eased. When bistatic receivers were designed to work in a network the requirements for repeatability and stability of antenna's amplitude characteristics were less restrictive. The only parameter that had impact on object's position estimation was the bistatic distance measurement accuracy (the echo's time of arrival measurement accuracy).

By using the bistatic network architecture concept it was possible to adapt and adjust radar surveillance coverage to the requirements by appropriately positioning a number of bistatic receivers'. As a result the capabilities of an ATC radar were augmented and space coverage extended in selected areas. Around sensitive objects locations secured zones could also be created with increased detection capability and position measurement accuracy.

Multi-Aspect Observation for Improved Classification and Recognition (WP7)

In this WP, novel and suitable tools for the study of MS radar systems and their performances were developed. A network of radar with High Range Resolution was designed. The main results achieved were:

(a) resolving target velocity and position in 3D for any waveform and topology,

(b) multistatic ambiguity function derivation and new representation,

(c) Analysis of different potential network signals,

(d) analysis of the performance of the multistatic radar.

Target detection using a multistatic system was investigated, a number of approaches were studied, and target tracking algorithms were investigated exploiting different radar measurements. A number of techniques for the classification of a Non Cooperative Threats were studied. A new TFD algorithmic fusion method was prevented and evaluated on simulated data. It was shown that this method provided an effective method of achieving improved resolution, highly concentrated and readable representation without the auto-term distortion and cross-terms artefacts. Moreover this method allowed to determine whether or not a signal is multicomponent or not and also to decompose the signal in the time-frequency plane.

Data Fusion and Management of Integrated System Information (WP8)

This WP led to the development of different functionalities, namely the Merging Function, the Consistency Function, the Decision Support Function and the Data Display Function as well as the development of a flight data simulator and an analysis tool.

A "Merging Function" able to receive input measures structured according to the format defined within ARGUS 3D project and validated by consistency function block and to track manoeuvring aerial targets by elaborating measures (i.e. plots) provided by heterogeneous sensors was developed. The work showed how Data Fusion could effectively be extended to non conventional and low cost sensors. Plots from conventional and non conventional sensors have been fused with success enhancing the accuracy of the global estimate of the targets position. The study had observed as sometime the contribution of the measure of non conventional sensors had not been so decisive in the estimate of the fused track. This can be understandable when in the fusion algorithm were involved track fed with plots from PSR sensor and track from non conventional sensor. The better accuracy of a PSR sensor than a non conventional sensor forces the fusion process to weight more track from PSR. On the other side an important aspect highlighted by this study is the key role of non conventional sensors in case of targets at low altitude and out of the cover range of conventional sensors. In this situation the target is tracked the same thanks to the work of non conventional sensors that extend the cover volume of the sensors network enhancing the performance of the overall system. An important knowledge gained by this experience was that sensor declared accuracy was really fundamental for the output provided by the fusion algorithm. It was important to understand that the accuracy declared by the sensors were as important as the measure, in effect, both of them contributed with the same weight to the statistic distance evaluation. The above mentioned accuracy data were provided by sensors, together with the measure, in the form of a diagonal matrix in the cartesian domain. The choice to work in the cartesian domain was driven by the kinematics of the most targets that is linear in this domain.

The Consistency Function of the ARGUS 3D system aimed to reduce the amount of data in input of the subsequently data fusion. The Consistency Function also provided information about the functioning of the sensors, which provided the plots, and improved the tracking performance corresponding defined criteria. It mainly got three goals:

- To provide information about the functioning of the sensors.
- To restrain the number of plots in input to the merging process, executed in the new data fusion block.
- To improve the tracking performance.

The output of the Consistency Function were represented by the surveillance data provided from the different sensors, without any modification on the kinematic data, which had been able to pass the different checks; if a received data was valid, it would have been integrated into the new data fusion block for merging process. If a received data was invalid, because of a check fails, it would have been used for statistical information and in general discarded.

In comparison to former systems, the Consistency Function developed within ARGUS 3D project can be considered as an innovative tool respect to the already present front-end system.

The Consistency Function is able to exploit conventional and in particular innovative data, on which it is able to perform dedicated tests, which lead to a data usage improvement. Secondly the already mentioned reduction of the computational load of the data fusion block leads to a performance improvement.

The Decision Support Function (DF) aimed at providing warning messages to support the controller in the decision actions against possible terrorist threat was developed. The decision support function was development concentrated on the detection algorithms for aircraft to aircraft collision, aircraft to ground collision and deviation from flight path. This relied on statistical method to predict the flight of the aircraft within time frames provided for detection.

By means the developed Data Display it is possible to have awareness of the air traffic situation and of the alarms raised by ARGUS-3D system. Most of the visual elements introduced in this technical display are very similar to those of the Operational Display used by an ATCO and this should allow the easy understanding of the air situation picture and the effective evaluation of the improvement to the security of the ATC systems got by the project.

The Flight data simulator is a tool able to take some instructions as input and provide in output the trajectories of the aircraft that we want to analyse. By this tool is possible to define different targets in a defined environment. It is possible to obtain by simple instruction, a matrix with all the information about the generated target, in terms of time, position and velocity. The simulator also merge the generated track with the environment and is able to show all the target in a 3D picture. The obtained data can be a useful data in order to test the ARGUS 3D system or to create an environment very similar to the ARGUS 3D scenario.

The analysis tool was used in the validation phase in order to evaluate the performance of the ARGUS 3D system and was composed of a series of functions able to compare the ARGUS 3D system with the conventional ATC system and with the expected results, in order to give an overall characterization of the ARGUS 3D system. The main functions were:

- Detection probability, which was the main part of the analysis tool evaluation able to provide an overall detection probability of each sub-system of the ARGUS 3D system,

System coverage, which is a simulation software, in order to calculate the coverage of ARGUS 3D system, calculated basing on the desired detection probability of the target and a map of the coverage is provided basing on the scenario under test.

Test Bed Study (WP9)

The radar selected to test the altitude extraction function is the ATCR 33S-ENH installed at the SELEX-ES factory. In order to evaluate the performance of the PSR-3D for the calculation of the height of the targets, the altitude information provided by the secondary radar (SSR), co-mounted with the primary radar installed at SELEX-ES facilities, was used as reference values. The using of the secondary radar implied that also this sensor needed to be properly set in order to provide the correct value of the position (to be correlated with the position on the plan provided by the primary radar) and the altitude information to be compared with that provided by the PSR-3D prototype.

The setting activities of the PSR-3D and the preliminary tests on the real environment were realised in parallel in order to verify the capability of the innovative sensors in an operative scenario, with effect as clutter, reflection, etc., which were not taken into account previously during the study phase in the simulated environment (WP3). The zone around the two main airports of Rome was chosen for the tests since in that area the altitude of the airplane was lower in respect to other air space sector. Different setup tests were performed in controlled situations in order to verify the disturbance cancellation capability achievable with the FM-based PBR prototypes. For the planning of passive radar demonstration, different urban and rural sites were identified for the field test. Different tests and acquisition campaigns were performed in the identified sites; for each site, the following information were reported: short description of the site, receiver configuration, list of the analyzed FM radio channels with the corresponding measured power levels and cancellation values, list of the FM radio channels selected for PBR acquisitions.

The planning of acquisition length and required data storage was also conducted. Live Air Traffic Control (ATC) registrations were collected during the described acquisition campaigns.

Moreover, the Validation Plan to present the ARGUS-3D results to the final users and to receive from them a feedback on the results, respect to the expectations was defined.

Integration and Validation (WP10)

ARGUS-3D system is not an alternative system to the conventional ATC system, but its goal was to be totally integrated with a system for the Air Traffic Control in order to fulfil the gaps present in those systems and provide to the final users additional information for a better control of the flights and to make the user capable to be aware of the possible threats, perhaps not displayed in a conventional air situation picture.

The key element in the ARGUS-3D system was the Data Fusion, named Merging Function (MF), capable to allow the integration of the ARGUS-3D system in an Air Traffic Management system. In order to allow a correct integration among the different sensors and the data management and within this last sub-system, several Interface Control Documents were defined. The interface definition made the system usable in any ATC system, by means of a suitable conversion of the data format. Several Matlab simulated scenarios were defined and used as input data to the system. The goal of the simulation was to reproduce a situation as similar as possible to a real one, on which it was possible to verify the capabilities of the innovative technologies investigated in this project. With this scope, the “Quasi-real simulated scenario” represented the most realistic situation within which it was possible to verify the potentialities of a system capable to integrate innovative and conventional surveillance sensors. These tests demonstrated the capability of ARGUS-3D system to provide surveillance information not available in a conventional ATC system and, as a consequence, to improve the security of the ATM system by means the provision of additional surveillance data in base of which the system provided the alarms to support the final user for the activation of the suitable countermeasures.

The two Validation sessions organised in Rome at ENAV (January 2013) and Finmeccanica premises (February 2013) were very productive and showed that the ARGUS 3D approach, with further developments, could be applicable at different contests, including Air Traffic Control and Air Defence. The presence, during the validation session, of people coming from different fields (military or civil) showed that security is a issue both for military and civil application. Moreover, the use of innovative solutions, like presented in ARGUS 3D, could cover some gaps that the current operative systems have. Obviously, the possibility to use this innovative sensors in operative systems needs further investigation and developments, but ARGUS 3D, with its experiments, proved the feasibility of the concept to use passive radar as gap filler of conventional surveillance and defence system. to present the ARGUS-3D results to the final users and to receive from them a feedback on the results, respect to the expectations.

The Validation process took into account results coming from simulation of the ARGUS-3D system and results coming from an operative demonstrator that uses real data. The validation on simulated data allowed to have a whole overview of full ARGUS-3D system because it exploited all the sensors studied and simulated in the project. The validation on real data allowed the users to verify the performance, on a reduced version of the system, in an operative scenario with real targets and real environment, also with the use of a cooperative target.

4.1.3 IMPACTS AND DISSEMINATION ACTIVITIES AND EXPLOITATION OF RESULTS

4.1.3.1 DISSEMINATION ACTIVITIES

The ARGUS 3D dissemination methodology was organized around the following key objectives:

- Raising Awareness amongst the key players within the air traffic / radar industry;
- Engaging the entire consortium according to each partners expertise and interest;
- Creating an operative and efficient Dissemination Team in charge of handling key issues;
- Effectively disseminating project results to target audiences.

All partners were mobilized in order to disseminate relevant information on ARGUS3D, using their existing dissemination channels. ECONET, the partner in charge of this Work Package (WP11) supervised and coordinated the dissemination efforts made by all partners, supporting them when necessary.

<u>ARGUS 3D COMMUNITY</u>

The Consortium designated a team – so-called Dissemination Team - of members dedicated to the implementation of established dissemination models and guidelines. The Dissemination Team consisted of one representative from each partner organization and was responsible to effectively disseminate project results to the widest possible audience, in order to generate a critical mass around the project, dissemination relevant information on ARGUS3D project results and initiatives, and establish the project as a well-known initiative within the ATM field. The balanced approach adopted by the entire consortium helped to extend the dissemination activities into local, national, and international levels. The following functions of the Dissemination Team were defined:

- Help contact and refer potentially new end users and external partners
- Contribute contents to the ARGUS3D public website (new contents, relevant events, news, links, etc.)
- Produce and distribute press releases, articles, contents for the brochures
- Organize opportunities for the involvement of external actors in the project's activities
- organize and promote focused events

ARGUS 3D partners decided to create a specific sub-group in order to screen quickly and efficiently both the stakeholders and the information which needed to be sent to them and validate it. As a result, it was defined an Authorization Committee composed of SELEX ES, ECONET & UNIROMA1 (one representative of each one), which was entitled to:

- Monitor all stakeholders decide on their acceptance as members of the External Advisory Group (EAG)
- Act as a filter of the information to be provided to these entities to avoid any conflict of interest within the consortium
- Match expertise of EAG members with the needs of each WP, as identified by the Project Coordinator and the WP Leaders.

from 2011 onwards, this list was further developed by all the project members

149 organizations

During the first year of the project, an initial group of organisations, so-called External Advisory Group (EAG or User Group) was identified, based on the contact networks of all the partners of the project. The External Advisory Group consisted of a number of experts and organizations operating within the ATM arena and responsible (at different levels) for the security of European citizens. The EAG helped the ARGUS3D partners to articulate demands in user terms and facilitate the development of an efficient security system. It was also involved, at the beginning of the project in the definition of ARGUS 3D specifications as well as in the testing, evaluation and validation of the system prototype and was able to freely contribute to other project activities.

During the project, it acted as a "consultant body", freely contributing to the project activities, reading selected documents delivered by the project, and giving suggestions and indications based on the expertise and interests of its members. It also took an active part in the Validation Event (01st February 2013, Rome, Italy, Finmeccanica premises). During this meeting, the technical ARGUS 3D team presented to the users the results of the project, including both the results on the simulated data and the results on real Data acquisition. The participants, coming from different companies and background, comments and discusses the results, asking to the technicians further details and curiosities and providing valuable feedback on the developed prototype, in particular on the following issues:

- Usability of the system in terms of performance, costs and final user/area of application (civil or military);
- Possibility to increase air defence coverage exploiting passive radar;
- Possible application in different contests: maritime surveillance, big events, etc.

Members of the EAG were also invited to participate to the two ARGUS 3D workshops (Berlin, September 2011 and Madrid, February 2013) through specific email campaigns and were associated to the drafting of the Exploitation Plan.

<u>ONLINE COMMUNITIES & COMMUNITY AGGREGATION</u>

<u>Social networks: LinkedIn & Twitter</u>

To foster community activities related to ARGUS 3D and reach a wide range of entities and people working in the many different fields of relevance to the project, ECONET and the Dissemination Team joined over 20 different groups within LinkedIn and posting information on the project reaching an aggregated total of over 150.000 members. These groups aimed to inform its members of the important news in relation to the project and its partners (events, achievements etc.) and to arise interest to relevant stakeholder and start discussions.

These LinkedIn campaigns were also complemented by similar actions via other conversational social media channels such as Twitter, by involving all project partners and encouraging them to use their existing accounts and diffusion channels for the benefits of ARGUS 3D.

DISSEMINATION MATERIALS AND TOOLS

Website

The ARGUS 3D Website (www.argus3d.eu)was implemented and continuously updated ever since, by ECONET. The main webpages composing the site are:

- Public Pages where the project summary, the results achieved the description of the consortium and the EAG, the events related to Argus 3D, as well as the news can be found
- Restricted Community Pages / Intranet where all members of the ARGUS3D Community (namely the project partners and the members of the EAG) were able to access the project intranet portal

The ARGUS 3D website played an important role within the ARGUS3D community since it served as the main information tool to disseminate project results and news. It provided a wide array of functionalities including: document uploading/downloading, news, and more importantly serves as the communication hub for the ARGUS Community (partners, EAG, shareholders). From June 2012 onwards, a statistical monitoring incorporated to the website(Google Analytics), in order to collect user statistics and detailed information about the Community in order to support its management. As a result, at the end of the project (February 2013), over 1196 people located in over 70 countries had visited the website.

ARGUS 3D logo

Since the beginning of the project, ARGUS 3D project identity was linked to a graphically coherent and consistent representation of the ARGUS 3D logo on project results and documentation. All the material diffused to entities and people outside the consortium (presentations, newsletters, deliverables (both public and restricted), leaflets, etc.) made use of the logo and were consistent with its style (fonts, colors etc.).

Leaflet, Brochure, Booklet, Poster

The ARGUS 3D partners realized several types of material for dissemination:

- ARGUS 3D Leaflet in which the project's goals and expected results were described and the consortium partners listed.
- ARGUS3D brochure dedicated to the future end users of the ARGUS3D technologies and solutions was designed and printed in order to summarize the project objectives, R&D activites, and expected results.
- ARGUS 3D booklet, prepared at the end of the project (January 2013), focused on the commercial and technological deliverables of the project, describing these different outputs and how they can be used within the ARGUS3D community and the ATM/ radar market in general.

- ARGUS 3D Poster: to promote the ARGUS3D project during the workshop and its side event: the World ATM Congress 2013.

This material was used as a communication and diffusion tool during all the events of the project, diffused within the social networks and media channels and by the partners to all the entities contacted as a means of expanding the EAG.

PRESS RELEASES AND ON-LINE REFERENCES

Special media coverage has been sought by the partners (newspapers, magazines and online news sites) in order to inform the public at a regional, national and European level:

- On line references: Coinciding with the Intermediate and Final ARGUS3D workshops, various articles were published within websites dedicated to R&D, regional development, or security, as well as other complementary E.U. initiatives dedicated to these topics.
- 2012-3 Press Release Campaign: from August 2012 onwards, a wide-range pan-consortium press release marketing campaign was implemented by all partners of the project.

ARGUS 3D INTERNATIONAL WORKSHOPS

Two ARGUS 3D international initiatives were planned during the project execution phase in order to disseminated and share the project results with the relevant communities. The strategy adopted by the consortium was to link both these events to other high level international conferences.

The two conferences which were selected and within which the ARGUS3D workshops were organized are the following:

1. The 6th Future Security Conference (Berlin, 5-7 September 2011) hosted ARGUS3D's Intermediary International Workshop focusing on the scientific results of the project's research activities.
2. The 2013 World ATM Congress (Madrid, 12-14 February 2013) hosted ARGUS3D's Final International Workshop which focused on the technical and commercial results of the project and the opportunity for further exploitation of the deliverables and technologies developed.

The impact of all the above mentioned dissemination activities can be summarised with the following:

- More than 1.000 visitors of ARGUS3D website since June 2012
- The visitors of the website come from more than 70 different countries all over the world
- 2 ARGUS3D international events and 1 Validation Event organized with more than 100 attendees in total
- Wide distribution of brochures and leaflets in several events around Europe
- Several on-line references to ARGUS3D project (newsletters, social networks, etc.)
- More than 500 people contacted through direct e-mail campaigns
- Specific campaigns through LinkedIn including a target of more than 190.000 profiles

- Press coverage with over 30 publishers contacted and 7 informative articles published in 4 different countries.

4.1.3.2 EXPLOITATION OF RESULTS

The ARGUS 3D project developed marketable tangible final results, namely a low-cost interoperable radar-based system concept able to identify all kinds of non-cooperative targets (potential threats) by combining conventional surveillance systems currently used for civil applications (primary radar, secondary radar, ABDS) and two classes of non-conventional radar systems: 3D PSR sensors and Networks of passive/bistatic radar sensor.

ARGUS 3D technologies will allow a more effective surveillance capability in a strategic, security-related field. This means that ARGUS 3D project may contribute to:

- The reduction of the current European dependence on USA security industry / technology.
- The increase of competitiveness of EU industry in security-related technologies/ applications.

The results obtained by ARGUS 3D also constitutes the basis for a new generation of air surveillance systems for civil applications such as civil engineering structures monitoring, thus enabling EU industry to reinforce its position in this market sector.

ARGUS-3D system demonstrated the capability to improve the performance of the ATM system, guaranteeing:

- An extension of the coverage for specific zones where the conventional sensors had some difficulties to detect the target, due to the orography of the area or in general due to technical aspects;
- The capability to provide an estimation of the altitude for those targets for which this information was not available;
- The capability to provide the same air situation picture present in the conventional ATC system, but with the additional information provided by the passive radar networks and by the Data Management, in terms of fused information and alarms;
- The capability to provide surveillance information without interruption in case of different typologies of detection (conventional and innovative);
- The control of the flight, in case of missing of data provided by conventional surveillance sensors;
- The updating of the final user about the dangerous situation detected by the passive radar network and unknown to the “conventional” ATCO;
- Suitable security level and an adequate reaction time upon detection of the intruder, by means an extension of the sensitive area boundaries.

A sound exploitation strategy was elaborated in order to maximise the awareness and utilisation of the ARGUS 3D system and to achieve the previously mentioned impacts.

Some of the results obtained by ARGUS 3D were considered exploitable for their main characteristics and added value. In particular:

- The PSR (primary surveillance radar)-3D is an innovative and low-cost technology capable of fully localizing detected targets and of interest of companies and Public Regulation Agencies operating in the ATM and Security fields
- The Data Management display is able to process the data coming from the network of innovative sensors and to integrate the ARGUS-3D system with the conventional ATC system. This software would be of interest of companies and Public Regulation Agencies operating in the ATM, Security fields, Software and Airlines fields
- The FM-based passive radar technology is a network of FM-based passive radar (for medium/long-range surveillance) able to detect targets with different positions and velocities and particularly interesting for the technology and research fields
- The Bistatic Radar, a technology which can improve the accuracy of object position estimation and extend ATC radar coverage reducing blind increase safety in sensitive areas. The field of its application is mainly the ATM sector
- The Passive Radar Technology which is a Single-Frequency-Networks Passive Radar Network for Extended Area and Performance enabling the exploitation of different types of illuminating sources like digital TV and digital radio broadcast signals together with data processing to provide a clean reference signal for radar purposes. The field of its application is mainly the Research sector
- The Multistatic algorithm providing a multi-aspect observation for improved classification and recognition in order to offer increased radar systems coverage, improved classification, and greater accuracy of parameters estimation. The field of its application is mainly the Research sector

Starting from these results, the large companies within ARGUS 3D will seek to exploit the developed technologies internally to generate new products or business lines, inform future R+D planning and strengthen technical capacities and externally via licensing or co-exploitation. Industrial partners will use their significant presence in relevant markets and networks to give weight and exposure to the ARGUS 3D results relevant to exploitation activities, both to generate new customers, collaborations or networks and to reinforce existing links and commercial collaborations.

The SME partners will seek to develop new products, business plans and contacts in the marketplace, to increase technical capacity, to improve their company profile and develop new services. They will seek opportunities for co-exploitation of projects results. The SME partners will focus on network building, raising their profile and seeking opportunities for commercial linking and co-exploitation of project results or provision of innovative services in their current area of operation. They will be able to exploit the project activities to leverage company growth through an improved high-tech reputation for the company, new opportunities for collaboration and new service offers that can open new markets.

The SME partners with expertise in the software development wish to build upon the project results and to exploit them to strengthen their position in a niche market as that of ATC/ATM systems (heavily monopolized by large players such as SELEX-ES, BAE Systems or Thales). They will investigate options in new markets where they will be able to transfer the technology acquired during the project development, without discarding the possibility of continuing collaboration with one or more of the existing consortium partners.

The academic partners and research partners will exploit the project results through publication and promotion of the ARGUS 3D results, leading to new funding opportunities and stronger capacity for attracting research funding. They will have access through the project results to new collaboration opportunities and new research activities. They will also link to or from spin-off enterprises. The academic partners are interested in using newly gained foreground knowledge as input to further research, scientific publications and advanced teaching purposes as well as using the project results to initiate further research in ATC / ATM and other related areas.

The Research Institutes will also seed to increase their prestige and secure their position within the research community as cutting-edge technological providers. They can use the results to develop partnerships with existing or new contact networks, particularly national public bodies due to their familiarity and close links with governmental activities.

A joint exploitation strategy has been also explored but at the current stage is not foreseen, because partners are planning to exploit the results within their current lines of business and products.

Basically, the ARGUS 3D approach, with further developments, could be applicable at different contests, including Air Traffic Control and Air Defence. This was one of the result of the Validation session which thanks to the presence of people coming from both military and civil fields showed that the security is a issue both for military and civil application. Moreover, the use of innovative solutions could cover some gaps that the current operative systems have. In particular, the possibility to extend the ATC system coverage exploiting innovative radar sensors was mainly related to two different aspects:

1. performance of the innovative sensors (compared with the conventional sensors and with the ICAO normative)
2. cost of the innovative solution respect to the conventional approach.

Concerning the performance, the presented results showed that, in some cases, the passive radar can improve the performance of the ATC system in terms of coverage, but they have some limits in terms of accuracy and precision in the localization due to the transmitters of opportunity used as transmitters. The system can provide good performance in terms of coverage (more than 60 km) but poor performance in terms of accuracy (from 400m to 2000m) that is not applicable in ATC contest.

In terms of cost, while the commercial cost of a primary radar can be of the order of the million of Euros, because it assure a wide coverage (up to 300 NM) and a good precision in all the air space under the radar visibility, the commercial cost for the passive radar is not defined yet because it is now coming on the market and its demand is still poor since its field of application is not yet clearly defined. The possibility to use one or two passive radar to cover areas of about 40km x 40 km (in the blind zone of ATC system) could be taken into account both for safety and security aspects, because in this case the user can reduce the cost for system of one order of magnitude. Instead, considering the limited coverage of a single passive radar, in order to cover wide areas could be more appropriate the use of a conventional PSR. In any case, it is possible consider the use of passive radar for safety and security purpose when the area to be covered is small (e.g. with limits due to geographical obstacles like mountains) and it is not possible to install a conventional primary radar.

The project demonstrated that passive radars can be used as an alternative to conventional Primary radars for applications in which other solutions are too expensive, as well as, passive radars can be used as a complement of the existing operating systems. Despite this, the possibility of using these innovative sensors in actual operative systems needs further investigation and developments but, in any case, ARGUS3D has proved that the concept of using passive radar as gap filler for conventional surveillance and defence systems has great interest for many applications and is highly feasible both from a technical and operational point of view.

4.1.4 ADDRESS OF PROJECT PUBLIC WEBSITE AND RELEVANT CONTACT DETAILS

PROJECT WEBSITE ADDRESS: www.argus3d.eu

RELEVANT CONTACT DETAILS:

Partner n°	Company short name	Country	Role	First Name	Surname	Telephone	Fax	Email
1	SELEX ES	Italy	Project Coordinator	Giuliano	D'Auria	+39 06 4150 4448	+39 06 4150 2043	giuliano.dauria@selex-es.com
2	SESM	Italy	Company Scientific Representative	Roberta	Cardinali	+39 06 4150 4847	+39 06 4150 4889	rcardinali@sesm.it
3	UNIROMA1	Italy	Company representative	Pierfrancesco	Lombardo	+39 06 44585472	+39 06 4873300	lombardo@infocom.uniroma1.it
4	BUMAR	Poland	Company representative	Miroslaw	Sankowski	+48 58 3418 007	+48 58 3418 007	Miroslaw.Sankowski@bumar.com
5	UCL	UK	Company representative	Karl	Woodbridge	+44 20 76793969	+44 20 73889325	k.woodbridge@ee.ucl.ac.uk
6	FRAUNHOFER	Germany	Company representative	Heiner	Kuschel	+49 228 9435 389	+49 228 9345 627	heiner.kuschel@fhr.fraunhofer.de
7	ENAV	Italy	Company representative	Damiano	Neri	+39 06 8166 2732		damiano.neri@enav.it
8	ECONET	Spain	Company representative	Mayte	Carracedo	+34 616 078 772		mayte.carracedo@econet-consultants.com
9	DRTS	UK	Company representative	Ana	Muriel	+44 (0) 33 00 88 15 88	+44 (0) 33 00 88 15 89	ana.muriel@drts.co.uk
10	ISO	Germany	Company representative	Christoph	Hartz	+49 911 99594 0	+49 911 99594 129	christoph.hartz@isogmbh.de
11	REDHADA	Spain	Company representative	Pablo	Alonso	+34 983 378466		projects@redhada.com
12	CTECH	Italy	Company representative	Paolo	Salvatore	+39 06 3326 8972	+39 06 3326 7022	p.salvatore@ciaotech.com

4.2 USE AND DISSEMINATION OF FOREGROUND

SECTION A (PUBLIC)

Publications (peer reviewed)

LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES											
No.	DOI	Title	Main actor	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Date of publication	Relevant pages	Permanent identifiers (if applicable)	Is open access provided to this publication?
1 (DIET)	Not available at the moment	Multi-Frequency Integration in FM Radio Based Passive Bistatic Radar. Part II: Direction of Arrival Estimation	F. Colone, C. Bongioanni, P. Lombardo	*IEEE Aerospace and Electronic Systems Magazine*	Monthly Magazine	IEEE A&E Systems Magazine	n.a.	May 2013 (TBC)	n.a.	n.a.	NO
2 (DIET)	Not available at the moment	Multi-Frequency Integration in FM Radio Based Passive Bistatic Radar. Part I: Target Detection	F. Colone, C. Bongioanni, P. Lombardo	*IEEE Aerospace and Electronic Systems Magazine*	Monthly Magazine	IEEE A&E Systems Magazine	n.a.	October 2013 (TBC)	n.a.	n.a.	NO
3 (DIET)	Not available at the moment	Passive radar components of ARGUS 3D	H. Kuschel, P. Lombardo et alii	*IEEE Aerospace and Electronic Systems Magazine*	Monthly Magazine	IEEE A&E Systems Magazine	n.a.	TBC	n.a.	n.a.	NO

LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES											
No.	DOI	Title	Main actor	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Date of publication	Relevant pages	Permanent identifiers (if applicable)	Is open access provided to this publication?
4 (BUMAR)	No DOI	Modelling and evaluation of bistatic radar systems' capabilities	Tadeusz Nowak, Mateusz Mazur, Jarosław Pędziwiatr, Andrzej Nalewaja, Mirosław Sankowski	Elektronika-Konstrukcje, Technologie, Zastosowania	LII, nr 12/2011	SIGMA-NOT	Elektronika-Konstrukcje, Technologie, Zastosowania	December 2011	81-85	ISSN 0033-2089	Only extra paid online access: http://sigma-not.pl/publikacja-64784-modelling-and-evaluation-of-bistatic-radar-systems--capabilities-elektronika-konstrukcje-technologie-zastosowania-2011-12.html Publisher's licensing agreement would not permit publishing in a repository
5 (UCL)	n.a.	Multistatic Radar Systems Resolution Analysis	Mounir Adjrad and Karl Woodbridge	DSP Journal	Bi-monthly	Elsevier	n.a.	February 2013 (tbc/still going through reviews)	n.a.	n.a.	Yes
6 (UCL)	n.a.	GNSS-Based Multistatic Radar Resolution Analysis	Mounir Adjrad and Karl Woodbridge	EEE. Trans. Geosciences. Remote Sensing	Monthly	IEEE	n.a.	February 2013 (tbc/still going through reviews)	n.a.	n.a.	Yes

LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES											
No.	DOI	Title	Main actor	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Date of publication	Relevant pages	Permanent identifiers (if applicable)	Is open access provided to this publication?
7 (UCL)	n.a.	Multistatic Non-Cooperative Air Target classification	Mounir Adjrad and Karl Woodbridge	EEE. Trans. Geosciences. Remote Sensing	Monthly	IEEE	n.a.	February 2013 (tbc/still going through reviews)	n.a.	n.a.	Yes
8 (BUMAR)	10.1109/ MIKON.2012.6233527	Capabilities of a bistatic receivers' network using hyperbolic positioning method	Mazur, M.; Sankowski, M.; Nowak, T.; Nalewaja, A.; Pedziwiatr, J.	Conference PUBLICATION IEEE Conference Publications	Vol.1	Military University of Technology- paper version IEEE	Mikon proceedings	May 21-23 2012	357-360	ISBN 978-1-61284-1436-8 (paper versión)	http://ieeexplore.ieee.org , access for members or extra paid Publisher's licensing agreement would not permit publishing in a repository

LIST OF DISSEMINATION ACTIVITIES								
No.	Type of activities	Main Leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
1	Events	**FRAUNHOFER** DIET (INFOCOM) SELEX ECONET ENAV CTECH	Future Security 2011	05/09/11 to 07/09/11	Berlin, Germany	Professional	200+	International
2	Events	SELEX ECONET	World ATM Congress 2013	12/02/2013 to 14/02/2013	Madrid, Spain	Professional	3.000+	International
3	Events	SELEX	HOMSEC 2013 Trade[1]	12/03/2013 to 15/03/2013	Madrid, Spain	Professional	3.000+	International
4	Events	SELEX	Argus 3D Validation day	01/02/2013	Rome	Users	30	International
5	Direct e-mailing Campaigns	ALL PARTNERS	E-mailing campaign promoting the ARGUS3D workshops and/or Distribution ARGUS3D information (brochure) to User Group Members/prospects	Jan/Feb 2013	N.A.	Professional	500+	International
6	Events	DIET (INFOCOM)	2013 IEEE Radar Conference[2]	29 April – 3 May, 2013	Ottawa, Canada	Professional Academic	200+	International
7	Events	DIET (INFOCOM)	Tyrrhenian Workshop 2012 on Advances in Radar and Remote Sensing (Paper presentation)	12-14 September 2012	Napoli, Italy	Professional Academic	100+	EU
8	Events	DIET (INFOCOM)	Future Radar Technology Conference	19/09/2012	Rome, Italy	Professional Academic	n.a.	EU
9	Events	DIET (INFOCOM)	2012 IEEE GOLD Remote Sensing	June, 4-5, 2012	Rome, Italy	Professional Academic	100+	EU

[1] Forthcoming activity to be developed after the official end of the project, but already organized.
[2] Forthcoming activity to be developed after the official end of the project, but already organized.

LIST OF DISSEMINATION ACTIVITIES								
No.	Type of activities	Main Leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
10	Events	DIET (INFOCOM)	European Microwave Week 2011	09/10/11 to 14/10/11	Manchester, United Kingdom	Professional Academic	n.a.	EU
11	Events	DIET (INFOCOM) UCL FRAUNHOFER	Radarcon 2011 IEEE - AESS	23/05/11 to 27/05/11	Kansas City, USA	Professional Academic	200+	International
12	Events	DIET (INFOCOM)	Seminar at CASD (Centro Alti Studi per la Difesa – Ministry of Defence)	18/01/2010	Rome, Italy	Academic	200+	Italy
13	Events	DIET (INFOCOM)	Seminars/tutorial lectures during radar courses of master degree in Communication Engineering (University of Rome “La Sapienza”)	Various during 2012	Rome, Italy	Academic	50+	Italy
14	Events	DIET (INFOCOM)	Seminars/tutorial lectures during Ph.D. courses in Remote Sensing (University of Rome “La Sapienza”)	Various during 2012	Rome, Italy	Academic	15+	Italy
15	2.0 Networking	ALL PARTNERS	Promotion of the ARGUS3D Results in twitter and/or Linkedin	Jan/Feb 2013	on-line	General Public	200.000+	International
16	Events	BUMAR	IEEE AP/AES/MTT Poland Charter	04/06/12	Gdansk, Poland	Professional	10+	Poland
17	Events	BUMAR	Mikon 2012	21/05/12 to 23/05/12	Warsaw, Poland	Professional	300+	Poland
18	Events	BUMAR	PIERS 2012, Progress In Electromagnetics Research Symposium.	27/03/12 to 30/03/12	Kuala Lumpur, Malaysia	Academic	30+	International
19	Events	BUMAR	Bumar conference for potential customers and partners	19/01/12	Warsaw, Poland	Professional	18	Poland
20	Events	UCL	IEEE WOSSPA2011 (Conference)	9-11/05/11	Algeria	Professional Academic	200+	International

LIST OF DISSEMINATION ACTIVITIES								
No.	Type of activities	Main Leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
21	Events	UCL	CIE International Conference on Radar2011 (Conference)	24-27/10/11	China	Professional Academic	300+	International
22	Events	UCL	IEEE RADARCON2012 (Conference)	7-11/05/12	USA	Professional Academic	250+	International
23	Events	UCL	IET International Conference on Radar Systems Radar 2012 (Conference)	22-25/10/12	UK	Professional Academic	300+	International
24	Events	FRAUNHOFER	FHR-PCL-Focus days	03/05/11 to 04/05/11	Bonn, Germany	Academic	n.a.	Germany
25	Other	ECONET DRTS CTECH	Client face to face meetings	2012/2013	Spain, UK, Italy	General public	15+	Spain, UK,Italy
26	Events	ECONET	Infoday FP7-TRANSPORT	08/05/2012	Madrid, Spain	General public	50+	Spain
27	Events	ECONET	Info-Day 6th Call for Proposals FP7 Transport	26/06/2012	Madrid, Spain	General public	200+	Spain
28	Events	ECONET	6th FP7 Conference in Spain	29/11/2012	Zaragoza, Spain	General public	500+	Spain
29	Events	ECONET	Infoday "Transport Sector EU Funding opportunities" (DGTT, Ministerio de Fomento)	11/06/2012	Madrid, Spain	General public	50+	Spain
30	Events	ECONET	2020Horizon Seminars (7 seminars)	Various: 2, 3, 4, 10, 11, 17 and 18 October 2012	Spain: Valladolid, Mérida, Sevilla, Valencia, Madrid, Málaga and Vigo	General public	200+	Spain
31	Events	DRTS	Complex Systems Society meeting	Sept. 12	London, United Kingdom	Professional	100+	UK
32	Events	DRTS	WSO2Con 2103	Sept. 12	London, United Kingdom	Professional	300+	UK
33	Events	DRTS ISO	Web Startups workshop	Feb'13	London, United Kingdom	Professional	30+	UK

SECTION B (CONFIDENTIAL OR PUBLIC: CONFIDENTIAL INFORMATION MARKED CLEARLY)

LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS,UTILITY MODELS, ETC.					
Type of IP Rights	Confidential	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant(s) (as on the application)
n.a	n.a	n.a	n.a	n.a	n.a

OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND								
Type of Exploitable Foreground	Description of Exploitable Foreground	Confidential	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable for commercial use or any other use	Patents or other IPR exploitation (licences)	Owner and Other Beneficiary(s) involved
Direct	PSR-3D	NO	n.a.	Innovative and low-cost primary surveillance radar (PSR) capable of fully localizing detected targets	ATM	n.a.	None	SELEX SESM
Direct	Data Management	NO	n.a.	The new Data Management display is able to process the data coming from the network of innovative sensors and to integrate the ARGUS-3D system with the conventional ATC system.	ATM Software	n.a.	None	SELEX ISO REDHADA
Indirect	FM-based passive radar technology	NO	n.a.	Network of FM-based passive radar (for medium/long-range surveillance)/Technology	Research	n.a.	None	FRAUNHOFER
Indirect	Bistatic Radar	NO	n.a.	Bistatic radar technology	ATM	n.a.	None	BUMAR

OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND								
Type of Exploitable Foreground	Description of Exploitable Foreground	Confidential	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Titemtable for commercial use or any other use	Patents or other IPR exploitation (licences)	Owner and Other Beneficiary(s) involved
Indirect	Single-Frequency-Networks Passive Radar Network for Extended Area and Performance	NO	n.a.	Passive Radar Technology	Research	n.a.	None	DIET
Indirect	Multistatic algorithm	NO	n.a.	Multi-aspect observation for improved classification and recognition	Research	n.a.	None	UCL

ADDITIONAL TEMPLATE B2: OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND	
Description of Exploitable Foreground	Explain of the Exploitable Foreground
PSR-3D The PSR-3D is an innovative and low-cost primary surveillance radar (PSR) capable of fully localizing detected targets	The PSR-3D prototype studied in the ARGUS-3D project is a promising starting point for an enhanced system capable of supporting the ATCO in the security domain. The system has room for improvement, especially through the use of dedicated antennas with appropriate beams.
Data Management The new Data Management display is able to process the data coming from the network of innovative sensors and to integrate the ARGUS-3D system with the conventional ATC system, in order to achieve the overall objective of providing an innovative, low-cost, multi-sensor, radar-based system for 3D air guidance and surveillance enhancing the security of ATM.	The new display shows the air traffic data together with the additional information concerning the non-cooperative target as the altitude provided by the PSR-3D, the position provided by the innovative surveillance sensors, the alarm levels of the possible threats and their confidence levels, etc. The new Data Management opens the way for a possible future integration between the ARGUS-3D system and conventional ATC systems for security domain applications.
FM-based passive radar technology System definition and processing techniques for a multi-frequency passive radar network based on FM radio broadcast signals.	The FM-based passive radar technology can be applied to a range of future applications to enhance the air target recognition capability of the surveillance systems, with a significant reduction of development/maintenance costs and of electro-magnetic emissions.

ADDITIONAL TEMPLATE B2: OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND	
Description of Exploitable Foreground	Explain of the Exploitable Foreground
Bistatic Radar The bistatic radar technology developed in the ARGUS 3D project gives ability to improve the accuracy of object position estimation and to extend ATC radar coverage reducing blind increase safety in sensitive areas allowing the following advantages over current systems: improvement of coverage of ATC radar and reduction of blind zones; Improvement of position and velocity estimation for high and low altitude objects; Low cost of receivers due to their simplicity.	The ARGUS 3D partners expect bistatic network technology to be applied to a range of future applications in control and security applications to improve safety of transportation, citizens and infrastructur
Passive Radar Technology Single-Frequency-Networks Passive Radar Network for Extended Area and Performance	Passive radar (PCL) technology, as seen by the ARGUS 3D partners and user group participants, is expected to provide a low cost upgrade of the air picture and vital gap filling target reports in critical air situations like terrorist activities. Future applications of PCL technology will be found in many security and environment related areas.
Multistatic algorithm Multi-aspect observation for improved classification and recognition	The ARGUS 3D partners expect the developed multistatic algorithm for air target detection, tracking and classification to enable further research pinpointed towards the issues and conclusions of WP7 activities as well as implementing the proposed approaches on actual systems using real radar measurements.

4.3 REPORT ON SOCIETAL IMPLICATIONS

SECTION B. Ethics

1. Did your project undergo an Ethics Review (and/or Screening)?	No
If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final reports?	
2. Please indicate whether your project involved any of the following issues :	
RESEARCH ON HUMANS	
Did the project involve children?	No
Did the project involve patients?	No
Did the project involve persons not able to consent?	No
Did the project involve adult healthy volunteers?	No
Did the project involve Human genetic material?	No
Did the project involve Human biological samples?	No
Did the project involve Human data collection?	No
RESEARCH ON HUMAN EMBRYO/FOETUS	
Did the project involve Human Embryos?	No
Did the project involve Human Foetal Tissue /Cells?	No
Did the project involve Human Embryonic Stem Cells (hESCs)?	No
Did the project on human Embryonic Stem Cells involve cells in culture?	No
Did the project on human Embryonic Stem Cells involve the derivation Of cells from Embryos?	No
PRIVACY	
Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	No
Did the project involve tracking the location or observation of people?	No
RESEARCH ON ANIMALS	
Did the project involve research on animals?	No
Were those animals transgenic small laboratory animals?	No

Were those animals transgenic farm animals?	No
Were those animals cloned farm animals?	No
Were those animals non-human primates?	No
RESEARCH INVOLVING DEVELOPING COUNTRIES	
Did the project involve the use of local resources (genetic, animal, plant etc)?	No
Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	No
DUAL USE	
Research having direct military use	No
Research having potential for terrorist abuse	No

SECTION C. WORKFORCE STATISTICS

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	3	11
Work package leaders	2	13
Experienced researchers (i.e. PhD holders)	3	29
PhD student	1	0
Other	17	30
4How many additional researchers (in companies and universities) were recruited specifically for this project?		9
Of which, indicate the number of men		8

SECTION D. GENDER ASPECTS

5. Did you carry out specific Gender Equality Actions under the project ?	No
6. Which of the following actions did you carry out and how effective were they?	
Design and implement an equal opportunity policy	Not Applicable
Set targets to achieve a gender balance in the workforce	Not Applicable
Organise conferences and workshops on gender	Not Applicable
Actions to improve work-life balance	Not Applicable

Other:	
7. Was there a gender dimension associated with the research content - I.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?	No
If yes, please specify:	

SECTION E. SYNERGIES WITH SCIENCE EDUCATION

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?	No
If yes, please specify:	
9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?	No

SECTION F. INTERDISCIPLINARITY

10. Which disciplines (see list below) are involved in your project?	
Main discipline:	2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)
Associated discipline:	2.3 Other engineering sciences (such as aeronautical and space)

SECTION G. ENGAGING WITH CIVIL SOCIETY AND POLICY MAKERS

11a. Did your project engage with societal actors beyond the research community? (if 'No', go to Question 14)	yes
11b. If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?	no
11c. In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	no
12. Did you engage with government / public bodies or policy makers (including international organisations)	As part of the validation activity ARGUS 3D has engaged with stakeholders representing

	potential users beyond the consortium Stakeholders involved in the user validation included international organizations such as: Eurocontrol, European Defense Agency (EDA), military organizations (AFCEA), Navigation Service Providers (NATS), government departments (UK Trasport Ministry) and regulatory agencies (UKCAA)
13a. Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?	Only at a very preliminary discussion level.

SECTION H. USE AND DISSEMINATION

14. How many Articles were published/accepted for publication in peer-reviewed journals? (give number in each row).	8
To how many of these is open access provided?:	3 (still going through reviews)
How many of these are published in open access journals?:	3 (still going through reviews)
How many of these are published in open repositories?:	0
To how many of these is open access not provided?	5
Please check all applicable reasons for not providing open access: (indicate YES or NO in each row)	
publisher's licensing agreement would not permit publishing in a repository:	YES
no suitable repository available:	NO
no suitable open access journal available:	NO
no funds available to publish in an open access journal:	NO
lack of time and resources:	NO
lack of information on open access:	NO
If other - please specify:	NO
15. How many new patent applications('priority filings') have been made? ("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant). (give number).	No patents are foreseen
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in	

each row).	
Trademark:	0
Registered design	0
Other	0
17. How many spin-off companies were created / are planned as a direct result of the project?	0
Indicate the approximate number of additional jobs in these companies:	0
18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project	None of the above / not relevant to the project
19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (FTE = one person working fulltime for a year) jobs:	not relevant to the project

SECTION I. MEDIA AND COMMUNICATION TO THE GENERAL PUBLIC

20. As part of the project, were any of the beneficiaries professionals in communication or media relations? (indicate YES or NO)	NO [but, ECONET contracted (as own personnel) a media specialist from June2012 to October 2012]
21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public? (indicate YES or NO)	no
22. Which of the following have been used to communicate information about your project to the general public, or have resulted from your project? (indicate YES or NO in each row)	
Press Release:	yes
Media briefing:	no
TV coverage / report	No
Radio coverage / report:	No
Brochures /posters / flyers:	yes
DVD /Film /Multimedia:	No
Coverage in specialist press:	Yes

Coverage in general (non-specialist) press:	Yes
Coverage in national press:	Yes
Coverage in international press:	Yes
Website for the general public / internet:	Yes
Event targeting general public (festival, conference, exhibition, science café):	Yes

23. In which languages are the information products for the general public produced? (indicate YES or NO in each row)	
Language of the coordinator:	Yes (press release and presentations at events with national scope were translated to each partner's national language)
Other language(s):	Yes (press release and presentations at events with national scope were translated to each partner's national language)
English:	Yes (all information products have been produced in English)