atom

Airport detection and Tracking Of dangerous Materials by passive and active sensors arrays

Funded under 7th FWP

SEVENTH FRAMEWORK PROGRAMME

ATOM in short

The goal of ATOM

Improve the security of the airports:

- avoid the introduction of any dangerous object in the terminal area
- without perturbation of normal operations

The approach of ATOM

Multi-sensor monitoring of the entire terminal area

- early detection of suspect items (materials and people)
- tracking of the suspect persons until the alarm finishes
- use of non-intrusive technologies and devices.

The airports involved

- Targu Mures: a medium-size international airport serving the north-central regions of Romania
- Schipol: the airport of Amsterdam, one of the biggest and most innovative hubs in the world.

Strong technology base

The consortium includes:

- 3 big industrial groups, European leaders in civil and military security
- 3 renowned public and private research centers
- 2 airports and 3 SMEs.

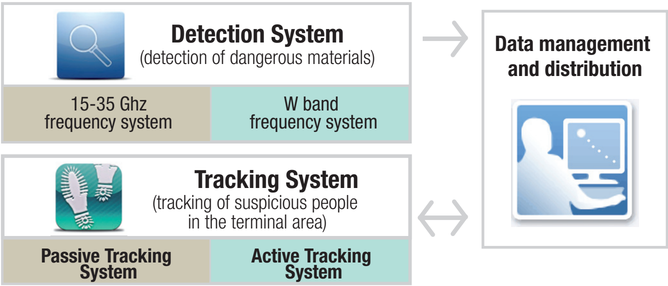
The industrial and research partners own wide competence and experience in the fields of electromagnetism, radar systems, advanced sensors, data fusion and Internet technologies.

The **ATOM** system

SUMMARY

1. System architecture

In the following figure the main blocks of the ATOM system are depicted.



The detection system

The detection system detects possible threats such as weapons and sharp objects, explosives, flammable and toxic substances; it integrates two sub-systems:

- a15-35 GHz radar located in the airport entrance
- a W-band detection radar located in the gate entrance.

The tracking system

The tracking system is activated only when the management block alerts it, that is when the data provided by the detection system suggest the presence of a threat in the terminal area; the tracking block continually updates the track of the suspect person(s) and sends it to the management block until the alarm ends: because the person has been stopped or the threat likelihood has gone below some threshold due to the re-evaluation of the situation.

The communication network

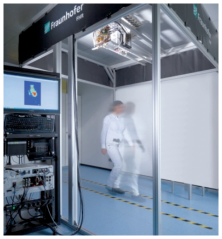
A communication network, based on a mix of cabled and wireless links, supports all exchange of data and control information

- among sensors in the same cluster
- from the detection sub-systems to the management block
- from the management block to the tracking sub-systems (alarm initialization, alarm end) and vice-versa (track updates)
- between the management block and the security operators.

2. Detection – W-Band Sensor Demonstrator

Contribution of Fraunhofer-FHR, leader of Workpackage 3 (Detection of dangerous tools with W-band radar)

This workpackage aimed at setting-up radar sensors able to detect dangerous items worn covertly on the body of passengers. To fulfill the essential ATOM requirement of not disturbing the passenger flow, the radar should be able to scan moving persons. Also, a pre-selection of the passengers is essential for classifying persons as suspicious or not. This procedure would help, for example, in speeding up security checks and reducing waiting queues. Installed at the airport entrances, for instance over moving walkways or escalators, it could identify dangerous weapons, such as explosive belts, large firearms or gas bottles worn concealed under clothes or hidden in the baggage. A quick reaction to avoid further damage would then also be possible.



To demonstrate the feasibility of such a system and evaluate imaging aspects, three different configurations were built: a W-Band multistatic radar rotating horizontally ahead of the person, a W-Band multistatic radar rotating vertically in front of the person and a W-Band monostatic radar with a 2D-plane aperture.
Due to practical reasons, only the configuration rotating ahead of the person (Figure 2.1) will be shown at the final workshop, including the rail system for moving the person.

Figure 2.1 – W-Band Sensor Demonstrator

Demonstrator

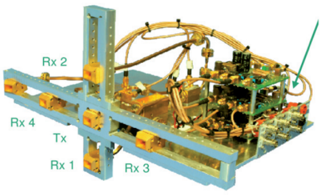


Figure 2.2 – Multistatic W-Band radar

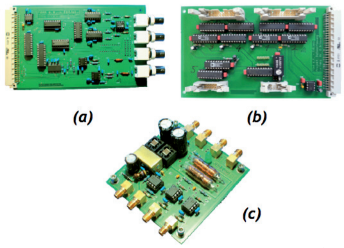


Figure 2.3 – Electronic Devices. (a) FMCW ramp generation, (b) A/D conversion/data acquisition, (c) power supply

To imitate a moving walkway, a rail-system was used.
For practical applications, commercial measurement devices must not be used. That is why all required hardware components are set up separately. It includes the RF transmitter with receivers and antennas (Figure 2.2), the electro-mechanical sensor carrier as well as the necessary electronics (analogue and digital, see also Figure 2.3) for the steer-ing and data acquisition of the W-Band subsystem.
The basic component used in the W-Band radar sensor is a bistatic FMCW radar, operating at a center frequency of 97.5GHz, extended to five receiving channels by additional HF components. The bandwidth of 3GHz grants a range resolution of 5cm and up to 250 measurements per second can be obtained. Table 1 shows the parameters of the multistatic W-Band radar and its electronics.
While the rail is moving smoothly, the above mounted W-Band sensor rotates on a complete

Table 2.1 – Technical data of the multistatic W-Band radar

Parameter	Quantity
centre frequency	97.5 GHz
transmit power	10 dBm
bandwith	3 GHz
range resolution	5 cm
chirp length	4 ms
number of time samples	2000
pulse repetition frequency	250 Hz
intermediate frequency variation	5 kHz/m
sampling rate	500 kHz
quantisation	8 bit
number of transmit / receive channels	1 / 5
polarimetric capability	half polarimetric
channel isolation	> 46 dB
maximum range for coherent reception	10 m

circle and therefore, illuminates and measures the person passing through from all possible transversal aspect angles.
Based on the principle of the synthetic aperture and taking the effects of motion into account, the software tool calculates and displays the radar images, revealing the location of the prohibited item on the body. This software tool is running on a PC with Windows 7 (32-bit) and uses the CPU for all operations.

Experimental Result

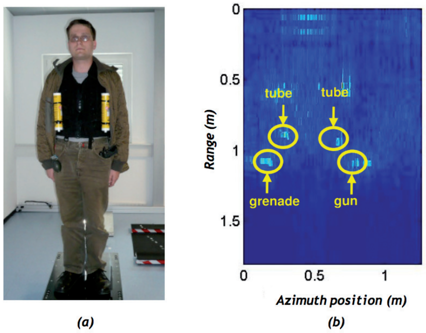


Figure 2.4 – (a) person standing on rail prepared with explosive tube imitations, a grenade and a gun, (b) radar-image of the person with indicated detections

Figure 2.4 (a) shows a prepared person, standing on the rail. The person carries dummy explosive tubes, filled with metal screws and also a grenade and a gun. The reconstructed radar image with indications of the detected threads is shown in Figure 2.4 (b). The back-scattering localizations are corresponding to the tested persons chosen weapon places. The radar images comprise neither anatomic details nor any other ethically questionable aspects. Therefore, this W-Band sensor system is highly suitable for use in public.

3. Tracking – The Active Tracking System

Contribution of Thales-Nederland, leader of Workpackage 4 (People detection and localization using active radar)

The active tracker tracks human individuals within a certain indoor area using active sensors. Each track is triggered upon a designation message coming from the Detection System, or indeed any other external designation message. The sensors are active in the sense that they transmit low-power EM signals and receive the echoes that bounce of objects within the area of interest, such as the designated human individuals. This principle is more commonly known as 'radar'.

System Concept

A simple, possible application of the Active Tracker is visualized in Figure 3.1, where the sensors are mounted on walls. However, the concept allows sensors to be place anywhere, even hanging from ceilings. The main restriction is that there should be overlap in coverage for at least 2 sensors (preferably 3 or more) for the entire area of interest.
The system works by cleverly combining the sensor data in order to find the location of the targeted individual. This is comparable to how GPS works: the signals from multiple satellites need to be combined in order to find the correct position of the GPS receiver. The active tracker thus should be seen as a distributed sensor. However, unlike GPS, the radar principle is used.
A system lay-out of the active tracker is shown in Figure 3.2. The concept allows different areas to be connected using track handovers from one track filter to another.

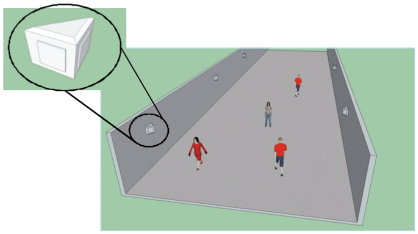


Figure 3.1 – Active Tracker sensors on walls

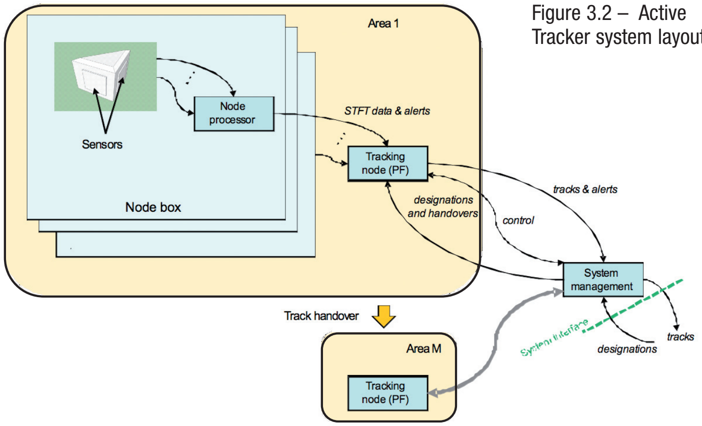


Figure 3.2 – Active Tracker system layout

Testbed Demonstrator

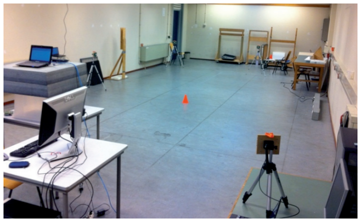


Figure 3.3 – Impression of the demo area

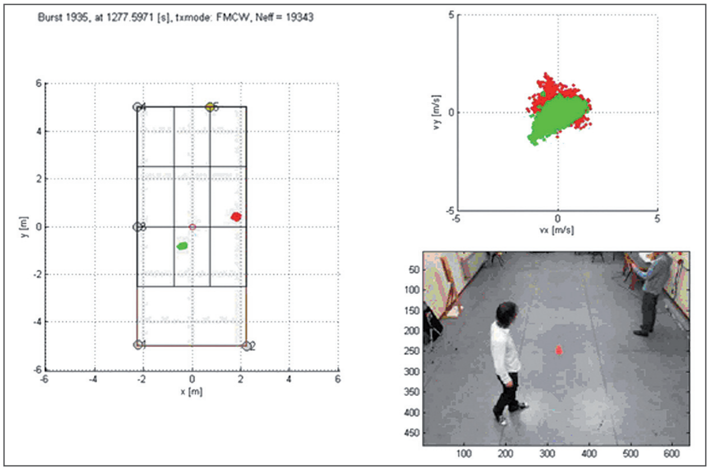


Figure 3.4 – Screenshot during a two people experiment

A photo of the ATOM testbest demonstrator is shown in Figure 3.3. The system consists of 5 small radar sensors capable of CW and FMCW mode that operate around 24 GHz (K-band). A screenshot of the tracking process is shown in Figure 3.4, representing a two people experiment, their positions and velocity are indicated with green and red colors. The system is able to track the targets and keep them apart very well, even when they are in close vicinity with respect to each other.

4. Tracking – Passive Radar for people detection and localization

Contribution of "Sapienza" Università di Roma, DIET Department, leader of Workpackage 5 (Passive radar for people detection and localization)

As of today, the possibility of accessing the Internet has become a primary need for many people, since Internet provides information, fun, education, online socializing, etc. This obviously applies also for people in the airport who are waiting for their flight. Nowadays, it is almost impossible to switch on your mobile device and find less than three or four WiFi networks ready to provide you Internet access in airports' areas. If radio waves would be visible to our eyes, most probably we couldn't see nothing but WiFi electromagnetic propagation waves in any airport's public area.
Now, the main questions are: would it be possible to further exploit all of this electromagnetic energy already available? And, would it be possible for security purposes? We investigated the possibility of answering these questions.
Particularly, the aim of ATOM is to improve the security level in airports' public indoor areas by detecting the presence of prohibited items and, subsequently, tracking people carrying them much before the passengers enter the gate area. The ATOM system should be a non-intrusive but pervasive security system, it should not interfere with normal passengers flow and should operate in covert mode. This means that it should make more difficult for ill-intentioned people to identify where sensors are placed and to cheat controls.
The availability of WiFi electromagnetic waves answers the need for covertly localizing people and the passive radar principle is the way in which this could be achieved, since it is not known that the WiFi signals are used for the people tracking.

System concept

The research activities carried on allowed to develop and field a WiFi-based passive radar prototype (as sketched in Figure 4.1(a) at the DIET Dept. of the University of Rome "La Sapienza". It mainly consists of a four-channel receiving system (base-band (BB) down-conversion stage and digitizer), a transmitter of opportunity and three receiving sensors. The system allows to store the collected signals for off-line processing.

Figure 4.1 – Sketch of the WiFi-based passive radar prototype and system configuration

Once the transmitted WiFi energy bounces off people moving in the airport area, the scattered energy is collected by a network of passive receiving sensors: RX1, RX2 and RX3; see Figure 4.1(b) and Figure 4.1(c) that depict the antennas dislocation. Then, accordingly to the WiFi-based passive radar processing scheme sketched in Figure 4.2, the Doppler effect arising from the typical person movement allows to discriminate between energy scattered by people and energy scattered by stationary obstacles like walls, airport seats, etc. (disturbance removal stage). Moreover, ad hoc designed processing techniques (sidelobes control stage) are necessary to treat the WiFi waveform which wasn't conceived for radar purposes.
When the target is detected over the evaluated range/velocity map, the related measurements (distance from the receiver, Doppler effect and radio echo's angle of arrival) can be taken and used to localize it within the area to be surveyed.

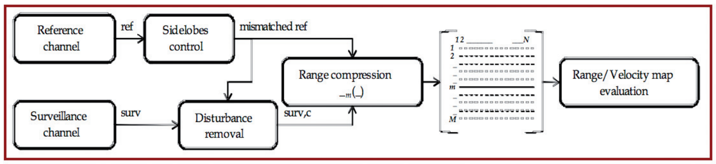


Figure 4.2 – WiFi-based passive radar processing scheme

WiFi-based passive radar prototype and experiments

Figure 4.3 – The indoor set chosen for the passive radar demonstration

Figure 4.3 shows a wide indoor set (an exhibition hall of the "Nuova Fiera di Roma") chosen for the WiFi-based passive radar demonstration since its sizes are well comparable with the wide public airports' areas ones.
Different experiments have been performed to demonstrate the capabilities of the conceived passive sensor. As an example, the experiment depicted in Figure 4.4(a) has been performed with two human targets moving along different paths and making changes of walking direction with different angles. This clearly appears from the ground truth reported in Figure 4.4(c)-(d). In particular, the screenshot shown in Figure 4.4(c) has been taken at about the middle of the acquisition, when the targets approximately start turning on their own right, while the screenshot shown in Figure 4.4(d) has been taken at about the end of the acquisition. Notice that, the turning angle of the 'blue' target is greater than that of the 'red' one.
Figure 4.4(b) reports the obtained sequence of localizations. As it is apparent, the obtained targets' tracks very nicely meet the test's ground reality by remarking the different paths over which the men moved with their different turning angles.

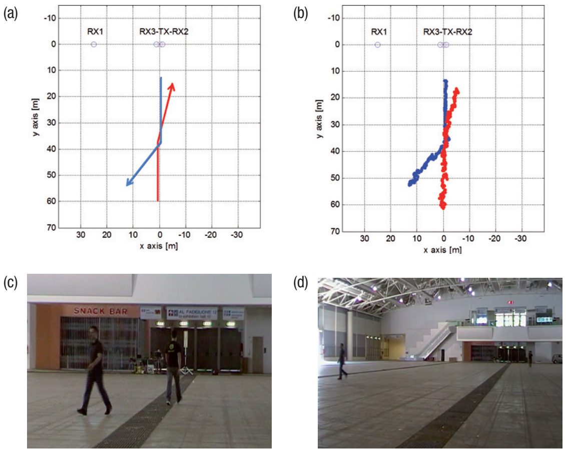


Figure 4.4 – Experiment with two targets moving along different paths

A second experiment is described in Figure 4.5. In this case, the targets sham a suspect behaviour by approaching each other and passing a bag between them (see Figure 4.5(a)-(b). Figure 4.5(c) shows the output of the ATOM passive tracker designed at Fraunhofer FKIE within Workpackage 7. As it is apparent, not only both the targets are correctly detected and localized, but also their suspect behaviour could be taken by the obtained tracks. In fact, Figure 4.5(c) clearly shows that the targets' tracks become very close each other when they reach approximately the same location.

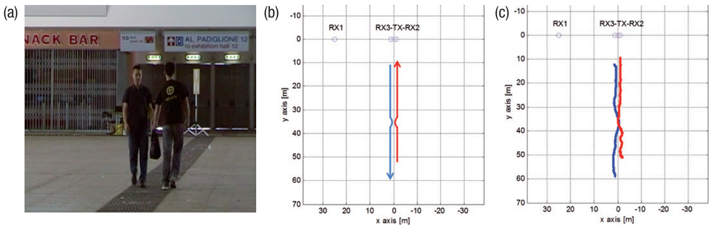


Figure 4.5 – Experiment with two targets shaming a suspect behavior

The neat experimental results obtained within Workpackages 5 and 7, show that indeed the approach of detecting, localizing and tracking human targets in indoor environments by means of a passive radar sensor is promising. Thus, it could usefully feed the possibility of improving the security level within public indoor areas of airports as foreseen by the ATOM project philosophy.

5. Tracking and Data Fusion – Summary of Passive Radar Tracking with WiFi

Contribution of Fraunhofer-FKIE, responsible of Task 7.1 in Workpackage 7 (Data fusion and management of information from advanced integrated security system)

Passive radars exploit illuminators of opportunity (radio, TV, WiFi transmitters) to detect moving targets. At the receiver the direct signal as well as delayed echoes from targets are collected. Signal processing at the receiver delivers measurements of the time delay of the reflected vs. direct signal path, which gives the bistatic range, and the direction of arrival and Doppler shift of the reflected signal.

Advantages and Challenges

With the transmitted waveforms not designed for radar, passive radar systems deliver typically less precise measurements than active radars. This is compensated by using multiple illuminator-receiver pairs. This requires a strategy for tracking and fusing the multiple sensor data. Multistatic radar operation significantly improves the total probability of detection and target state estimation. However, the measurement errors depend in a complicated way on the Tx/Rx geometry as indicated in Figure 5.1. Multistatic tracking of multiple targets is a key component of all passive radars if realistic scenarios are taken into account. This topic has been studied at Fraunhofer FKIE in various projects. The task WP 7.1 conducted by FKIE in ATOM was to develop such a strategy for WiFi passive radars.

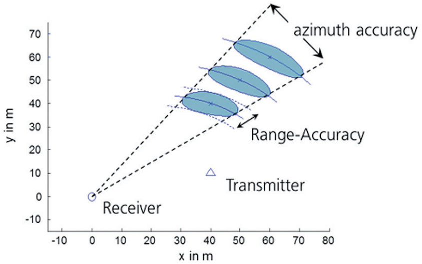


Figure 5.1 – Shape of bistatic measurement uncertainties in geometric coordinates

Tracking Method

The tracking task is composed of the subtasks of target association and state estimation. The association task maps new (multiple) measurements to multiple existing tracks or ignores them as false alarms. The problem is illustrated in Figure 5.2. Obviously, the association task depends critically on the magnitude of the measurement uncertainty. The problem is solved by the Multi-Hypotheses Tracking concept (MHT), a proven concept which is robust for difficult association scenarios.

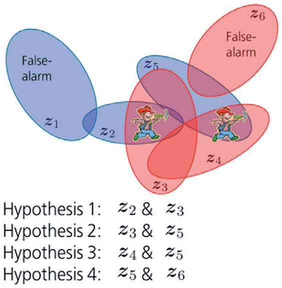


Figure 5.2 – Multiple hypotheses of measurement to target associations

Development of MHT Strategy for ATOM

For the ATOM scenarios the features of MHT have been tailored to a passive radar system based on WiFi transmitters for person tracking. As underlying tracking filter the Unscented Kalman Filter (UKF) was selected, which turned out to be very convenient and which can handle even strong nonlinearities. Furthermore, specific solutions of the following problems have been introduced:

- Development and insertion of *a target motion model* for walking persons.
- Inclusion of *a-priori knowledge* like the admissible area of target movement and the geometric distribution of detection probabilities of the system.
- Incorporation of the *case of occlusion*. Knowledge of walls and corners are used to model occlusion phenomena. This is incorporated in the MHT framework as a-priori knowledge. If in the case of occlusion no measurement is available, this is an expected event and this is a form of negative information as described below.
- Inclusion of the concept of *negative information*. This is general concept developed at FKIE. If a person has stopped, this event implies several possible interpretations for the tracker (target in the zero Doppler notch, target has stopped, target is occluded, target miss). All these interpretations are evaluated with their likelihood and are updated as hypotheses.
- Making decisions on multiple hypotheses. The different association hypotheses together with their likelihood are recursively updated over time. Based on all collected information an automatic decision procedure (track continuation, track splitting or pruning) is running in parallel. This methodology incorporates also handling resolution conflicts in multi-target situations.
- Association problem of two persons coming across. This is a special and highly important case for the objectives of ATOM. It involves the problem of multiple unresolved, ambiguous targets. For this special two target case the algorithms have been fine tuned to achieve track continuity while preserving the track identities.

Analysis of performance

Finally the performance of passive radar tracking has been assessed by simulation and real data for typical scenarios provided by DIET and SESM. As the emphasis of the project is tracking of dangerous persons, the objective is preserving track continuity and identity as much as possible. A detailed analysis of robustness of the MHT strategy in cases of multi-target conflicts of multiple non-resolved targets is given. A result of a critical case is shown in Figure 5.3 with two persons walking together and then separating. Although there is an inevitable resolution conflict, the track identity (blue/red) is maintained.

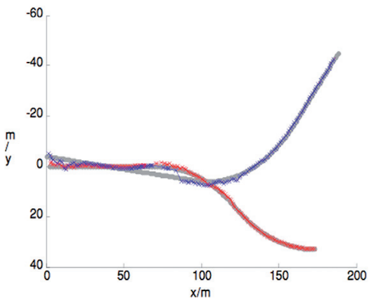


Figure 5.3 – Tracking result of 2 persons with simulated data

6. Detection – Ultra-wideband SAR Imaging

Contribution of the Technical University of Delft, leader of Workpackage 6 (Advanced signal processing for the precise localization and extraction of features of dangerous objects)

Workpackage 6 aimed to the development of advanced signal processing methods for the precise localization and extraction of features of the dangerous objects.

System concept

The underlying idea is that an ultra-wideband microwave sensor is capable to provide 3-D images of persons who might carry concealed dangerous objects. Detection and identification of such objects can be done based on their reconstructed shapes or other features from a 3-D radar image. The whole workpackage consisted of three blocks of activities: i) 3-D imaging of a static human body; ii) Object shape reconstruction in high resolution images; iii) Detection of small objects in vicinity of a human body.

The initial experiments

The research has been based on an extended set of 3-D images obtained via experiments. To acquire the images, TUD has built a laboratory imaging radar system based on UWB Vivaldi antennas, which exhibit a 2.5 – 33 GHz operational bandwidth at -20 dB power level, and a vector network analyzer. A series of precise multistatic and synthetic aperture array measurements of dangerous objects in free space and on a mannequin has been carried out in the frequency range of 1 - 41 GHz.

To produce high-resolution 3-D images of a human body, two different UWB imaging algorithms have been derived – in space-time domain, based on Kirchhoff migration, and in frequency-wavenumber domain respectively. The first one allows for an arbitrary multistatic antennas' configuration while the second requires a regular configuration in order to apply FFT in the focusing procedure. The algorithms have been tested and analyzed on the acquired SAR data. Both of them can reconstruct with high quality the 3-D shape of a dangerous object (a gun) in free space and in the vicinity of a human body (mannequin) when the object is perpendicular to the antenna electrical boresight, which means 0 aspect angle. In case of large aspect angles, like 45°, the shape cannot be reconstructed properly but the object still can be detected. Comparison of the algorithms shows that the frequency-wavenumber algorithm performs much faster by focusing a realistic data volume in a few tens of seconds on an avarage computer. This research contributed to journal papers: please look for papers authored by X. Zhuge and A. Yarovoy in the "Publications" section of the ATOM website.

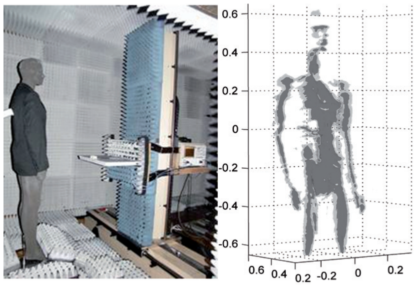


Figure 6.1 – Optical and radar images of a mannequin with gun and knife

New experiments based on advanced methods

To detect small objects in the vicinity of a human body and to reconstruct their shapes, three new approaches have been developed: the depolarization detection method, the SIFT detection/identification method, and the spectrum-based neural network detection method. All three methods have been tuned to work with high-resolution 3-D radar images obtained experimentally. The ability of these methods to detect and classify objects has been experimentally investigated.

The first method was designed for a dual-polarization radar system, effectively combining images with different polarizations to detect irregular points on the microwave images, which has a success rate as high as 83%, and a 35% false alarm rate.

The second method uses SIFT algorithm, which was originally developed for optical images, to categorize each irregular image segment into one of the objects stored in a library. The SIFT detection/identification method gave a 43% false alarm rate and a 36% success rate for the 5 test case scenarios.

Finally, the spectrum-based neural network detection method, which calculates the spatial Fourier spectrum for each image segment, extracts some features from the spectrum and inputs them into a neural network to achieve object classification. This method has been shown to work under certain conditions pretty well.

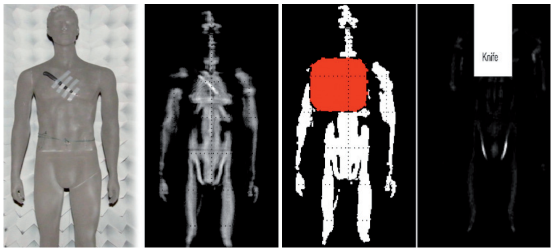


Figure 6.2 – Optical images of a mannequin; objects detection with neural network and SIFT methods.

In Figure 6.2, from left to right: optical image of a mannequin with a knife, radar image, knife detection with the neural network method, knife detection with the SIFT method.

Important future tasks for practical implementation of the developed methods will be the combination of these methods, and the elaborative tuning of the parameters for microwave images, to achieve more accurate detection and identification with lower false alarm rates and miss rates in realistic scenarios.

7. Communication – The ATOM Communication Network

Contribution of Hellenic Aerospace Industry, leader of Workpackage 8 (Interconnection of the security control system with proprietary or a general purpose LAN)

Airports are very sensitive targets for a multiplicity of crime actions. The continuously increasing concentration of passengers, along with the technological evolution and changing forms of malicious acts, highlight the necessity of optimizing the security standards.

The challenge

In this framework, the ATOM project focused on the design of an innovative Security System, consisting of Detection and Tracking Sensors based on emerging technologies. The objective was to enhance the security level and to expand the controlled space to include almost the entirety of an airport's area. The ATOM Network seeks to interconnect the different subsystems and all involved parties in the overall scenario: the sensing technologies, the personnel charged with maintaining the airport secure and all additional equipment and staff, in the intermediate nodes of the information flow (e.g. computers that collect and process data coming from sensors). The design of such a network was made to provide a complete, as possible, architectural solution that will not interfere with an already crowded airport whose operations go on at high rhythm.

Technical approach

The workplan of Network Design started with setting the framework and identifying the Requirements. These concern the communication needs of the interconnected parties, the constraints and networking requirements of the target environment (the airport), at least the most important among generic and application specific ones. Special emphasis was given to network security, as a factor that makes the difference between a robust system and a non-viable one. In parallel, state of the art technologies in the Local Area Network domain were studied and theoretically adapted to our scenario cases. The technical specifications of the Protocol Standards were analyzed. Network Topologies were examined, candidate design models were identified and a parameterization effort was done. Followed a comparison between families of standards for secure data transmission and an attempt to visualize the results of the network feasibility study.

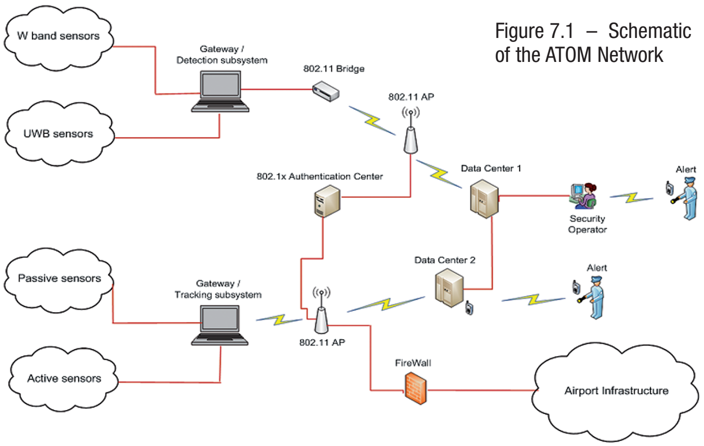


Figure 7.1 – Schematic of the ATOM Network

The ATOM Network

Mathematical computing tools were used to test and validate the communication network's functions. Network Performance was evaluated against different airport sizes, different communication technologies and different parameters modelling the information produced by the ATOM subsystems. The simulation techniques assisted the team in recognizing the "weak" points and in identifying where the proposed architecture could need some optimization. Unique conclusions and solutions do not exist, least of all when the airports considered as possible hosts of the ATOM system and network vary so much in size and exhibit peculiarities relevant for feasibility.

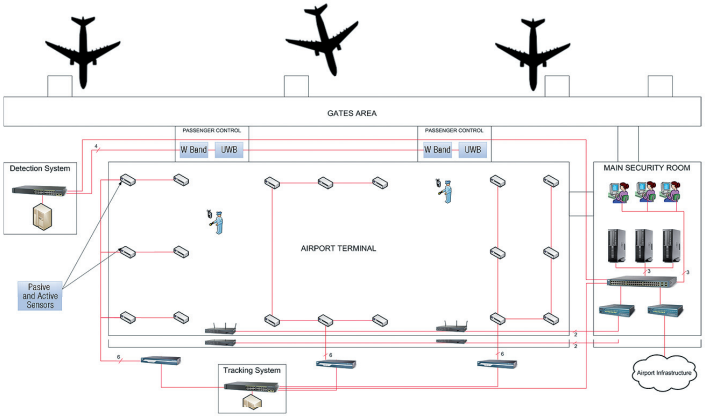


Figure 7.2 – Example of the ATOM Network deployment

Results and roadmap

The suggested ATOM Network architectural solution was framed highlighting

- components, devices and equipment
- architectural scheme, hierarchy and protocols
- implementation considerations, deployment and scalability
- re-configuration capabilities.

The design effort devoted to the Communication Network, spanning from theoretical requirement specifications to dealing with application-related practical issues, prepared the way to future research and produced guidelines for validating the applicability in specific cases, towards the overall objective of enhancing of the airport security levels.

8. Data Management and Data Fusion – ATOM overall system

Contribution of SESM, leader of Workpackage 7 (Data fusion and management of information from advanced integrated security system)

Data Management and Data Presentation

The data management function can be considered the final block of the overall ATOM system. It represents the interface between the new innovative system and the security operator. The ideal data presentation block should be able to give the maximum information available by the ATOM system to the security staff, in the simplest possible way, in order to be clear and effective at the same time. The data presentation block gives to the operator the situation awareness of the monitored area. Based on the available data, the security operator can decide upon the action to be taken if a suspected item is detected by the sensors.The ATOM system foresees two kinds of detection sensors and two kinds of tracking sensors. A dangerous material can be detected from one of the sensors, both sensors, or none of sensors.

The ATOM management system is able to provide to the security agent three different kinds of alarm level: a green alarm (no alarm), a yellow alarm (medium alarm) and a red

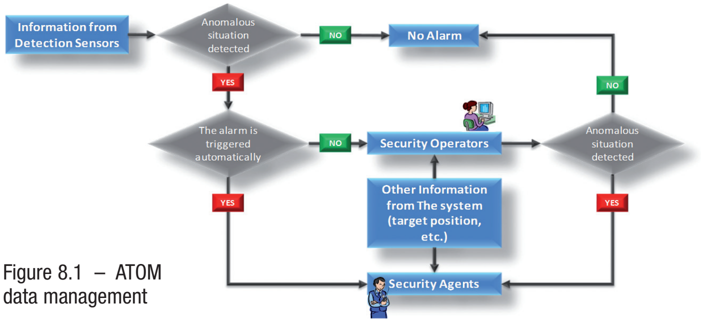


Figure 8.1 – ATOM data management

alarm (maximum alarm). The security agents are located in the airport terminal and they are equipped with a mobile device. By using these devices they are able to receive all the information about the airport situation. In particular, when an alarm is triggered, this device shows them (or one of them) different information, i.e. the overall alarm level, the kind of threat and the threat position in the terminal. The security agents are employed to verify and physically stop the threat, when an alarm is triggered.

On the other hand, the Security operators have another important role inside the ATOM security system. Conversely to the Security agents, they are located in a control room. They control all the information coming from the detection sensors and in case the system is not able to provide automatically an overall alarm level (for example if the detection sensors provide different information about the observed target) they take a manual decision about the situation at hand. In case the security operators detect an anomalous situation, the alarm is triggered and the information is sent to the Security agent, which decides to stop the threat.

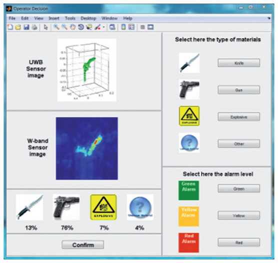
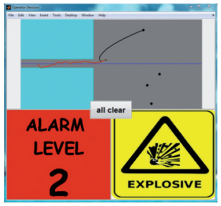


Figure 8.2 (a) – Example of data presentation to the security operator

Figure 8.2 (b) – Example of data presentation to the security agent



Data Fusion

In the ATOM system the data fusion is another important issue. In the last years more types of sensors became available and the problem of data fusion becomes more relevant. The need to fuse the data coming from different sources can be an advantage to extract more useful information than a single type of sensor. In fact multi-sensor data fusion seeks to combine information from multiple sensors and sources to achieve inferences that are not feasible from a single sensor or source. The fusion of information from sensors with different physical characteristics enhances the understanding of our surroundings and provides the basis for planning, decision-making, and control of autonomous and intelligent machines. In the ATOM project, the management of the different sub-systems and the sharing of data from the different devices represent one of the added values of the project. The data from the different sensors will be conveyed in a unique data management block that will provide an opportune data fusion, taking into account:

- outputs from the ATOM sensors;
- dislocation (or placement or deployment) of the sensors in the airport area;
- accuracies of the different sensors;
- data rate and data refresh of the different sensors.

The output of the data management block consists of an innovative range of data including all the available information on dangerous or potentially dangerous tools.
In The ATOM context two kinds of approaches have been analyzed: the single sensors tracking followed by track fusion and the only-doppler localization analysis. The first is a methodology quite simple from the computational point of view. It can give good results, especially in presence of different kinds of sensors. This approach foresees that each sensor has its own information processor that provides the track of the target. The latter method aims to verify how to increase a radar system performance by exploiting also the Doppler frequency of a received signal in the estimation of a target position.

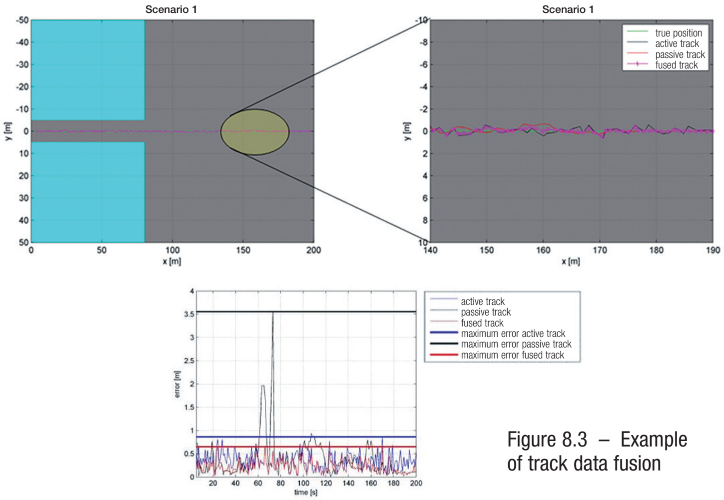


Figure 8.3 – Example of track data fusion

A synopsis of tasks and technologies

TASK/SUB SYSTEM		LOCATION	TECHNOLOGY	BAND
Detection	UWB microwave radar	airport entrance	Ultra-wideband SAR imaging radar, using Vivaldi antennas; provides 3-D pictures.	15-35 GHz
	W band radar	gate entrance	W-band radars on rotating platform for moving passengers inspection.	96-99 GHz
Tracking	Passive sensors	corridors and transit rooms	Network of WiFi-based passive radars; handles DSSS and OFDM modulation; uses Doppler-rate targets discrimination.	Wi-Fi channels 1-13
	Active sensors	corridors and transit rooms	Network of simple, low-cost, broad-beamed, active RF sensors; tracking is based on a model of human locomotion (GAIT)	24 GHz

Essential technical glossary

Radar

A radar is a system which uses radio waves to detect and possibly identify objects in the line of sight; usually it tries to determine their range, altitude, direction and speed. Every radar has a receiver antenna that captures and measures the electromagnetic energy bounced by the target objects; as a rule to higher levels of energy correspond a higher precision in the evaluation of the target parameters, the range in particular.

Sensors

A sensor is a device that measures or detects a real-world condition, such as motion, heat or light, and converts the condition into an analog or digital representation. An example of sensor is the receiver antenna of a radar.

Multi-sensor systems

ATOM is a multi-sensor system both because it integrates several radars of different kinds and because some of them include many receiver antennas. A "data fusion" process is performed at various levels, among data collected by similar and different sub-systems.

Data fusion

Data fusion is the combining of data from disparate sources such that the resulting information is in some sense better than would be possible if these sources were used individually. The ATOM system applies different kinds of "data fusion"; at the sensor level, for example, the use of multiple sensors of the same type can allow a more precise estimation of the "range", the distance of a target from the receiving antenna; at the system level it is possible to combine guesses made by individual subsystem to decide whether an alert should be raised.

Active and passive radar

The radars used in most applications, for example in ATC (air traffic control), are "active" ones, in that the targets bounce the radiation emitted by a transmitting antenna belonging to the same radar system. ATOM uses also passive radars, the role of the transmitting antenna is taken by "sources of opportunity", for example by wireless access points (WAPs) already present in the area of interest; the available sources usually emit much less energy than an ad hoc transmitting antenna, and the associated parameters cannot be controlled; to compensate for that, especially for the imprecise range provided by the individual sensors (mainly due to low energy levels), a well-designed multi-sensor network is necessary.

THE ATOM **Project**

Project acromyn: ATOM
Contract number: 234014
Instrument: Collaborative Project
Call: FP7-AAT-2007-RTD-1
Funding: 3.2 M-Euro
Starting date: 2009-07-01
Ending date: 2012-30-06
Duration: 36 months
Website: atom-project.eu

THE ATOM **Consortium**

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Airport detection and Tracking Of dangerous Materials by passive and active sensors arrays

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Fraunhofer FKIE FHR
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Ayco
LINK Informatica Ricerca & Sviluppo
Transylvania Tirgu-Mures Airport
Schiphol Group

Design: Giovanni Toffoli and Mariarosaria Manco, LINK srl - Roma
Art Director: Maria del Rosario Cuervo
Printed by: Grafica Giorgetti - June 2012

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