

## Progress Report 3: 1<sup>st</sup> September 2010 – 31<sup>st</sup> October 2011



The Surveillance of Unattended Baggage and the Identification and Tracking of the Owner, (SUBITO), project was a research & development project funded by the European Commission Framework 7 programme. It was classified as an European Union capability project and was designed to research and further develop novel

technology for automated, real-time detection of unattended baggage and the fast identification of the individual responsible (the 'Owner'), their subsequent path and current location. The project was guided by end-user driven requirements to ensure that security personnel receive the technologies they need in order to deliver improved threat security.

The project culminated in a demonstration of semi-automated, human-in-the-loop data processing operating with existing closed circuit television technology and demonstrating:

- Fast detection of baggage that has been abandoned,
- Fast identification of the individual who left the baggage, and
- Fast determination of their location or path they followed.

The key project objectives for SUBITO were:

- To understand the threat scenarios involving unattended goods from a user perspective, identify alarm and non-alarm conditions related to these and the decision logic applied by human operators in taking proactive or reactive actions.
- To determine the key measures of performance which a fielded system should attain and produce test plans which demonstrate the function and performance expected of the SUBITO system in real applications.
- To undertake a Privacy Impact Assessment process as part of the system design, including consideration of general theoretical and practical aspects of the social, legal and ethical issues of surveillance.
- To analyse the benefits to system function and performance to be gained by the use of improved camera technology, additional sensors or distributed processing schemes.
- To support the operator with a set of tools to detect abandoned baggage, identify and track the person who left the baggage and provide corresponding warnings or alarms.
- To develop algorithms that provide the capability to robustly detect, segment, track and classify moving objects within the monitored scene.
- To develop threat analysis algorithms for classifying potentially critical situations, given positional and classification data about the objects and people within the sensed environment.
- To demonstrate an integrated system operating against realistic scenarios in a typical end user facility.

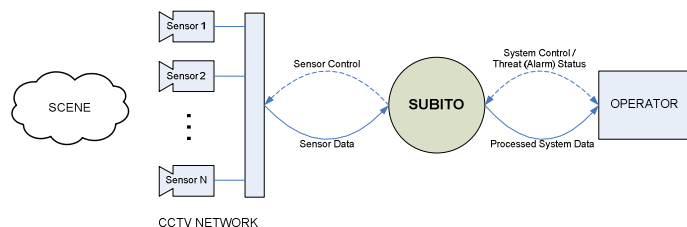
The project reached a successful conclusion in October 2011 with all key project objectives achieved and exhibited to End Users at the Final Project Demonstration and Workshop.

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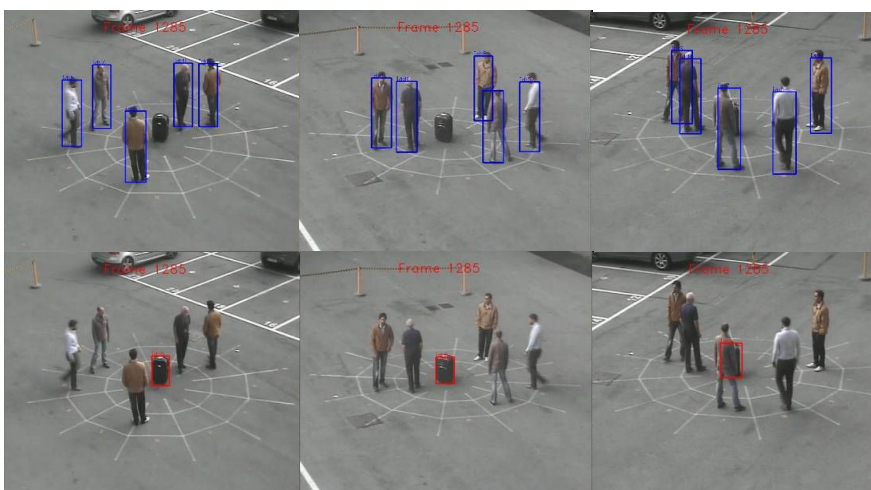
The key requirements for the SUBITO system were derived from a series of discussions held with end-users, and from recommendations resulting from previous work in this area. Through these discussions a view on the decision logic applied by system operators to the problem of unattended baggage has been generated. This decision logic and the defined requirements were recorded in the Systems Requirement Document.

Building on the defined requirements, the system architecture design was completed and the Systems Architecture Document produced which described the main system components, functions and data flows. This document also contained details of supporting modelling activities carried out to verify the major design decisions and ensure that the system architecture complied with the system requirements. A theoretical Privacy Impact assessment was performed on the developed architecture and recommendations made as to how privacy issues be addressed in future work in this area. The wider social and legal aspects of the technology were also considered in a supporting study.



An analysis of the system requirements was performed to develop a test methodology that would allow system function and performance to be tested and demonstrated in a cost effective manner. Testing incorporated a range of scenarios designed to display realistic interaction and behaviour in a systematic and controllable way. A baseline test and demonstration plan was produced describing the test scenarios and the testing methodology.

The development of the system architecture was supported by a series of additional studies which analysed the benefits to system function and performance to be gained by the use of improved camera technology, additional sensors or distributed processing schemes. The outputs from these studies influenced the generic system architecture design to ensure that these technologies could be implemented in to future systems while maintaining a scalable architecture.



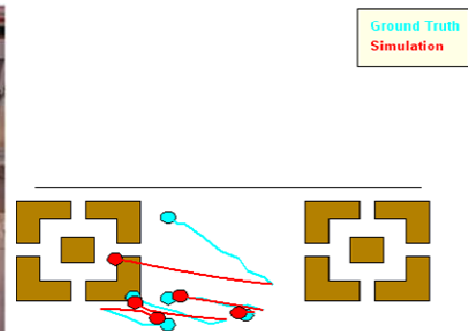
The implementation of the system architecture into a demonstration system required both image analysis and threat assessment algorithms to be developed. The key goal of the image analysis algorithms was to develop the capability to robustly detect, segment, track and classify moving objects within the scene.

Robust detection and segmentation of individuals and unattended baggage was achieved using a number of component algorithms, utilising adaptive processes to automatically adapt to the current scene, and provide resilience against changes in the image, e.g. lighting levels. Improvements to the algorithms

allowed these detection processes to run between 15 and 30 fps depending on scene content. Tracking of individual was initially achieved utilising simple Kalman filter models and Munkres associations. This baseline was then enhanced to utilise homographic constraints and *a priori* hypotheses to produce an estimate of the 3D bounding box surrounding the moving individuals. Implementation of extra spatial reasoning and accumulation maps improved performance by filtering out artefacts generated in fusing the data from the multiple views. Further performance improvement was produced by introducing a Multiple Hypothesis Tracker to better manage small occlusions and ambiguities.

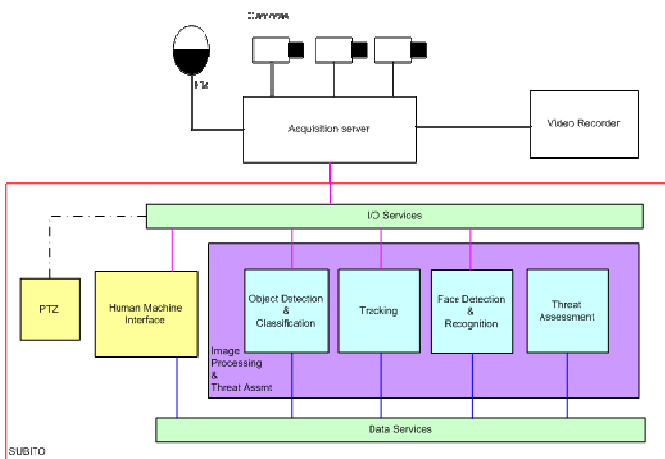
The SUBITO project also considered the issue of Object classification using Facial recognition and object description by use of PTZ cameras.

The Threat Assessment algorithms were developed to classify potentially critical situations, given positional and classification data about the objects and people within the sensed environment. The developed algorithms advanced state-of-the-art in three principle ways.



Firstly a method for inferring social relationships between the people in a scene was developed that outperformed existing methods. Secondly a method for inferring where individuals are heading within a scene has been developed; and finally a method for detecting abnormal pedestrian movements was developed which compared predicted and actual paths given knowledge of local goals and points of entry and exit.

The experimental results achieved demonstrated that the inclusion of reasoning about the intentions of individuals within a scene and the interactions between these individuals leads to greatly improved performance over the state of the art in abandoned baggage detection. The performance of the developed SUBITO system was shown to exceed that achieved in the previous ISCAPS study which defined the performance target baseline.



The project culminated in a final demonstration of an integrated system operating against pre recorded scenarios, as defined during the system requirements phase, designed to show capability against the top level objectives mentioned above.

In parallel a technical workshop was held which allowed discussion of the project results and future prospects in several areas of the implemented technology solutions, in addition to gathering the views from various potential End Users on the potential

capabilities of the SUBITO system in their own organizations.

In general the feedback from the End Users for the SUBITO Demonstration system was positive, indicating that the principle capabilities of the system are in line with End Users expectations for current and future systems. When asked if there were any other capabilities that would be useful in a future system, the main replies were the integration of other sensors (thermal cameras, microphones etc.) – as studied in a supporting workpackage – and the inclusion of further cognitive functions in to the threat assessment. Finally when asked how well the demonstrated system met the End User requirements the response was again generally very positive scoring 70%.

Further work would be required to better meet the End Users requirements, but this would be achieved by inclusion into the demonstrated system of the more advanced areas of the system architecture, i.e. other sensors, and advanced algorithm design. Both of these areas have already been studied during the project and recommendations for their inclusion made in the relevant project deliverables.

The output from the SUBITO project is expected to significantly improve the capability beyond the state of the art, robustly detecting an unattended bag and identifying and tracking its owner. This will offer security improvements that can be adopted by industry, integrating new surveillance software into existing and future closed circuit television, thereby benefiting the security of all European citizens.

SUBITO is also expected to generate technologies in the areas of closed circuit television image segmentation and analysis, facial recognition across multiple cameras, behavioural analysis and people tracking in crowded scenes. While primarily addressing civil security and surveillance, this work has a wider reaching application into world wide counter-terrorism and the military.

The emphasis of SUBITO is to develop and demonstrate the incremental improvements that can be achieved by adding layers of increasing sophistication to already existing technology and infrastructure, This approach recognises that a high level of investment in new technologies has been made in this area and yet the systems still fall considerably short of meeting the end users requirements. The output from the SUBITO project are designed to produce a robust yet scaleable solution that can be built around an end users previous investment offering improved security at reduced cost.

A competitive assessment was also carried out comparing SUBITO functionality to similar product offerings in the current market place. It was found that the SUBITO system capabilities exceeds those of most deployed systems (products) and uniquely exploits the “concept of ownership” principle that is fundamental to effective threat management and resolution.

For further information see the project website: [www.subito-project.eu](http://www.subito-project.eu), or contact the project coordinator:

Mike McPartlin

Project Manager  
SELEX Galileo Ltd.

Tel: +44 (0) 131 343 8926

Fax: +44 (0) 131 343 8110

E-mail: [mike.mcpartlin@selexgalileo.com](mailto:mike.mcpartlin@selexgalileo.com)



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