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PROJECT FINAL REPORT

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4.1 Final publishable summary report

4.1.1 Executive Summary

Numerous measures and new regulations in civil aviation security have been introduced after terrorist attacks in the last 25 years by member states and the EU. The current EU regulatory framework (EC300/2008, EC1998) aims at effecting coherent and adequate measures, including security checkpoints at airports for passengers and their belongings. There is a growing understanding among regulators and industry that a change in the approach to aviation security checkpoints is required: in the future they should deliver sufficient but more flexible security and ensure a more positive passenger experience. The sector needs a paradigm shift from addressing performance at equipment level to system level, and from separate consideration of security, operation and impact on passengers to a holistic approach from the design phase onwards, supported by system level evaluation methods. XP-DITE has made a major step towards this approach and supports it on different levels.

XP-DITE makes performance in so-called Performance areas (Customer and Ethics, Security and Compliance, and Cost and Operation) at system level quantifiable, measurable and predictable, and has developed the concepts, methods and software tools to support this. A first generation set of tools allows the user to design a checkpoint from a repository of components such as detection equipment, that best meet a user set of requirements, thus enabling balancing different aspects: security, cost, customer service and ethics. To complement prediction of performance by simulation, a suite of evaluation methods was developed to empirically assess performance of whole checkpoints in operation and of subsystems under laboratory conditions. All concepts, methods and tools were trialled in an operational checkpoint and in an innovative checkpoint technology showcase. Key results from the project are:

1. The checkpoint system level concept, a comprehensive set of system performance indicators and metrics, organized in three Performance areas;
2. Supporting concepts, such as an ethical framework to support 'privacy by design', and a framework to make best use of equipment security performance data for prediction of system performance;
3. Methods for modelling of checkpoints and predicting performance in all performance areas, and working software tools with a user interface and databases (ADT) and a simulation engine (SEP);
4. Empirical methods for evaluating whole checkpoint performance, in all three performance areas;
5. Technology development to prototype stage: four detectors providing innovation through their combination of security performance and concept of operations, and biometric tracking that may enable future concepts of operations;
6. Two successful trials and application of all empirical evaluation methods, one in a unique operational combined EU/US pre-clearance checkpoint at Shannon Airport that was partly designed with support of the XP-DITE system level concept and which has been adopted for permanent use at the airport, and one in an innovative technology showcase in The Netherlands;
7. Performance prediction of several checkpoints (real and permitted designs) through simulation; and
8. Recommendations for using project results in other security domains (e.g. mass transportation).

The XP-DITE team has worked closely with stakeholders to gather requirements and increasingly disseminate the results so that the European and international security community can benefit from

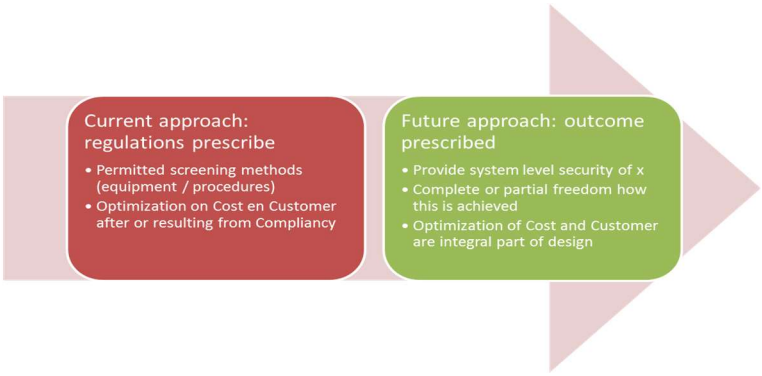
it. Results can be used on the short term (within the current regulatory framework) through case studies on existing checkpoints, designing checkpoints to meet specific business needs (such as pre-clearance checkpoints like the one at Shannon Airport), and predicting implications of regulatory reform. A roadmap guides activities to develop benefits on the longer term under an outcome based regulatory regime.

Based on the assessment of results and objectives, and the possibilities of using XP-DITE results to support aviation security and other checkpoints and modes of transport, it is concluded that XP-DITE has fully met the main goal and delivered expected results, and reached the expected impacts as set out in the call text. As such, it has lived up to its stated ambition and expected results, and delivered important innovations.

4.1.2 Summary description context and objectives

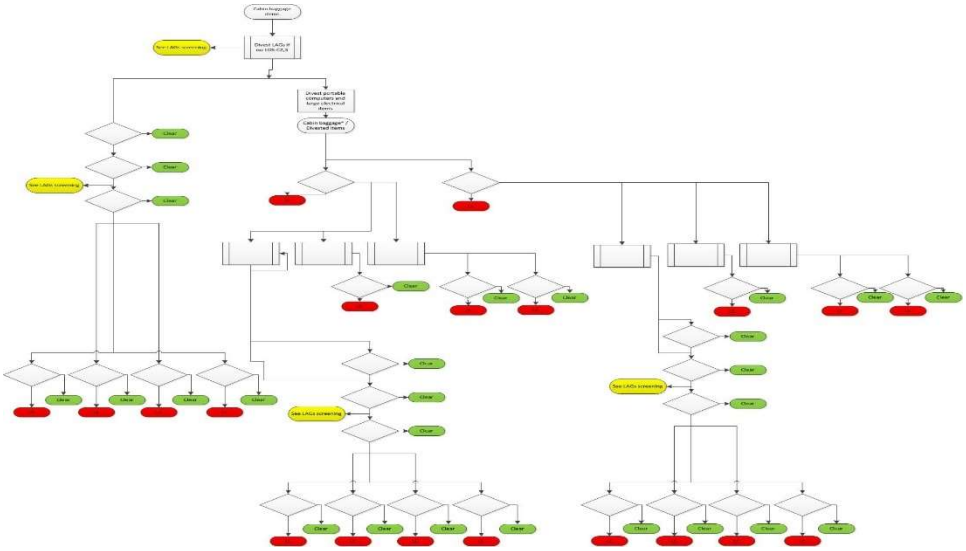
Numerous measures and new regulations in civil aviation security have been introduced after terrorist attacks in the last 25 years, at member states scale and, since 9/11, at EU scale. But can the current system with its ever-increasing detail and complexity of security regulations be sustained much longer? Concerns have been raised that the current regime inhibits technological innovation and the ability to adapt and respond to changes in threat perception.

The current EU regulatory framework (EC300/2008, EC1998) focuses mainly on the types of equipment that are allowed to be used in checkpoints and their individual detection performance. Because test and evaluation methods developed to date only aim at comparing performance against requirements on this 'component' level, it is unclear what overall security performance current checkpoints actually deliver. Neither are there quantitative requirements on security performance of the whole checkpoint system. The sector needs a paradigm shift to address performance at the system level, and from separate consideration of security and operational impact, to a holistic approach from the design phase onwards, adequately supported by system level evaluation methods.



The performance of aviation security checkpoints is strongly regulated by governments. The rules are based on international conventions and are broadly similar around the world. In the EU, these regulations are set out in framework regulation EC300/2008 [3] and implementing regulations. Largely due to the way threats to aviation have materialized and in response security equipment and processes have developed over the years, these regulations are component based – that is, they define the outline of screening processes (primary screening and alarm resolution) in checkpoints (as well as hold baggage screening, cargo screening, etc.), the types of detection equipment that may be used, and in most cases the minimum security performance of them in isolation. For example, people shall be screened by either a walk-through metal detector (WTMD), a security scanner (SSc), or a full hand search. Alarm resolution takes place by directed or full hand search. Minimum detection requirements exist for the WTMD and SSc only. Similar outlines are described for screening of passenger' belongings.

As the terrorist threat has evolved over the years, and as new detection technologies have been developed, regulations have been updated and modified, resulting in a very complex ensemble to implement.



The regulations are developed in great detail, comprehensive and effective in implementing similar structures across Europe, but at the same time increasingly restrictive and make checkpoints rigid and difficult to adapt. The figure illustrates the EU security regulations for cabin-bag screening showing permitted options and processes. Compliance is an important design constraint. It is not allowed to use combinations of detection components which individually do not meet the minimum performance levels (but which do so when used together), to implement alternative screening and alarm resolution processes, and to use estimates of the risk posed by different passengers (obtained for example by analysing passenger information) to reduce the level of screening on some passengers and increase it on others. A more outcome-based approach, which still ensures compliance with security requirements, could lead to:

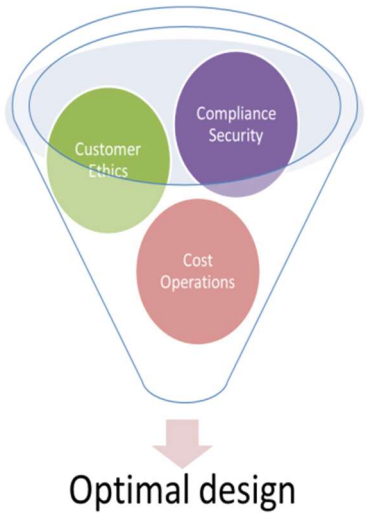
- more focus on performance levels provided by the whole checkpoint ;
- less rigid design framework, compliance of equipment to become less dominant;
- easier integration of risk based elements;
- more room to implement unpredictability in the screening process;
- more room for innovation in detection technology development; and
- more room for design to business needs.

Aims and objectives

The aim of the XP-DITE (Accelerated Checkpoint Design Integration Test and Evaluation) project is to develop and demonstrate a comprehensive, passenger-centred, system-level approach to the design and evaluation of airport security checkpoints, and validate the feasibility. This will allow airports, checkpoint designers and policymakers to incorporate a wide range of requirements and to evaluate checkpoint performance against system-level security, cost, throughput, passenger satisfaction and ethical factors. It will help ensure robust and controllable security performance, whilst providing freedom for airport operators to design checkpoints with innovative technologies and procedures.

The main objective of the project is to support evolution to a system level approach, by developing concept and approach, methods and tools, and by validating and demonstrating them to build trust. Regulators should be informed about the concept and steps in the general direction of introducing

system-level security regulations for checkpoints, and results from the project should facilitate the process. The scientific and technological objectives are derived from it.



A concept of system level performance should be developed, including a structure of (key) performance indicators defined at checkpoint system level, in the performance areas of interest: security, impact on passengers and ethical implications, and operations.

Methods and tools should be developed to allow the design of checkpoints to be supported with the structure of key performance indicators at system level serving as a framework for design requirements, a repository of components, and software tools providing a user interface, guidance in the design process, and optimization/feedback on the basis of predicted performance.

In addition to prediction of performance, empirical methods for evaluation of performance of actual whole checkpoints or subsystems should also be developed, using the same structure of system level performance indicators.

The methods, and tools developed in the project should be demonstrated, and a first validation step should be done within the project.

The design tool should enable the design of checkpoints that display higher security performance compared to current ones (under the current regulatory compliance regime), but also checkpoints that display operational advantages (e.g. higher throughput, lower operating cost) or lead to higher passenger satisfaction, although not necessarily all at the same time.

A review of threats to airports and aircraft in flight should be incorporated in the results of the project.

A review of checkpoint detection technologies should be carried out, with focus on relevance as dictated by the project overall concept of system level performance.

4.1.3 Main S&T results / Foregrounds

4.1.3.1 System-level security & MO approach

An outcome-focused or system-level security paradigm

The alternative to the current approach which has been in effect for a number of years but increasingly under discussion is to adopt an outcome-focused approach[2], as is being done in other areas of regulation.

In this model, regulation is designed around the required security outcome. How this is achieved is the responsibility of e.g. the airport operator, who must design, implement and operate a checkpoint that achieves a performance level defined in regulations, but is free to do it in any way they choose. Some mechanisms must be in place to assure the regulator that the design will deliver the required performance and that it does so in practice once the checkpoint is in use. The focus shifts from prescriptive regulation and inspections, towards assurance and audit.

Outcome-focused models are central to regulatory reform in many areas, such as the UK Government's Better Regulation initiative. It is also the approach which has been adopted widely in the safety area through Safety Management Systems (SMS) and which is being adopted in the Security Management Systems (SeMS) initiative across all areas of aviation security– driven by IATA and others.

System-level security

In an outcome-focused model, security performance can be defined by measure of the system-level security performance. The principal measure is the overall threat detection probability of the checkpoint. At the simplest level the regulation would be stated as: Overall probability of detection a threat ≥ X, where X is a (security classified) minimum performance level.
In practice however, things are not so simple:

- Detection performance must be averaged over all types of threat – guns, knives, explosives etc.;
- System-level security could be a risk measure; weighted by probability of occurrence and impact;
- Performance can be differentiated for certain specific threat types, or address a very wide spectrum of potential threats;
- …and so on.

Other performance measures may also be relevant, such as requiring a certain level of unpredictability in the screening process.

Obviously, policy makers and regulators must decide what they consider appropriate when this type of regulatory model is introduced.

In XP-DITE, a method was developed to calculate predicted security performance of whole checkpoints at the level of detail of single threat scenarios (such as a sheet explosive worn on the body and well concealed) for a wide range of scenarios. This allows adequate and flexible grouping of threats etc. In the project this grouping and weighting was carried through based on the team's backgrounds and some specific assumptions have been made in order to progress the research and proof-of-principle demonstrations.

[2] The terms outcome-focused and system-level are used interchangeably in this document. System-level security is the central concept in an outcome-focused regulatory model.

The so-called the MO (*modus operandi*) approach has been developed, which allows system-level security performance to be calculated based on a wide range of different criteria that might be chosen by regulators.

MO approach

System-level security is a measure of risk that depends on the likelihood and impact of occurrence of each threat specific scenario, as well as the effectiveness of the checkpoint in detecting the threat. This considers not just the prohibited article, but also how it is concealed and carried through the checkpoint. This is all captured in the XP-DITE MO model.

Each scenario, or *modus operandi* (MO) is categorised by multiple dimensions:

- Prohibited object type – gun, knife, explosive etc.;
- Vector – carried on the person or concealed in a bag;
- Concealment – how the item is concealed in a bag or clothing and what other items are present;
- Etc.

In the XP-DITE model, over 700 such scenarios have been defined, and described in a way that so-called signature information is contained. A component repository has been constructed which contains all data necessary to determine the contribution of detection equipment to overall effectiveness and system-level performance.

The MO framework enables:

- improved prediction of how effective combinations of components are (through the way that performance information is broken down by MOs);
- evaluation of the impact of new and evolving threats on security performance;
- prediction of the effect of human screener variability;
- more meaningful use of test data; and
- advanced false positive modelling by extending the MO concept to non-threats.

While aspects of this approach have been captured in other existing modelling processes, the MO approach represents an accessible framework for directly predicting effectiveness, and is directly applicable to many other security application areas.

4.1.3.2 The XP-DITE checkpoint design approach and tools

The XP-DITE checkpoint design approach is supported by a set of tools and methods: the XP-DITE ACP Design Guide (ADG), ACP Design Tool (ADT) and Shared Evaluation Platform (SEP).

These tools and methods enable modelling of checkpoints and evaluation of performance by calculation in each of three key so-called Performance Areas:

- Security and Compliance;
- Costs and Operations;
- Customer and Ethics.

The ACP Design Guide has been developed to guide a design team in the creation of a checkpoint design, based on a set of well defined (key) performance indicators at system level, subsequent selection by the user who attaches values to them such that they are treated as requirements. The process thus starts from initial stakeholder requirements identification and delivers the checkpoint design with all details to the implementation team. The Design Tool ADT and the Calculation Shared Evaluation Platform (SEP-CALC) together provide the essential support to the Design Team allowing optimization of designs through iterative cycles of design and system level performance prediction.

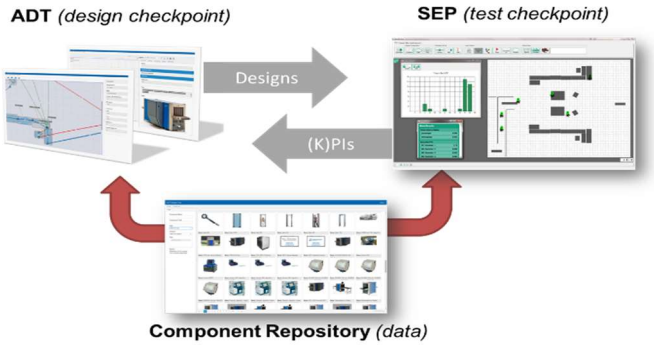
Once the checkpoint is designed and deployed, the final tool offered by the XP-DITE approach is the Empirical Shared Evaluation Platform, which provides a set of methods and experiments to evaluate actual performance of the whole checkpoint through laboratory tests and in operational use.

ACP Design Guide

The Design Guide is a high-level description of the activities that are performed during checkpoint design, together with a listing of documents needed and/or produced during the design and a description of their content. The design process starts with the stakeholder requirements including security, operational, passenger and ethics related requirements, at system-level. The system-level requirements then are translated into a comprehensive checkpoint design that encompasses identification of components and interfaces, lay-out and checkpoint processes.

The XP-DITE Tools

The core of XP-DITE is based around two major tools for designing and evaluating checkpoints. The **Design Tool (ADT)** is used to design the checkpoint from libraries of components, and linking them together to model layout and screening processes, while the **Shared Evaluation Platform (SEP-CALC)** predicts the defined performance indicators by calculation.



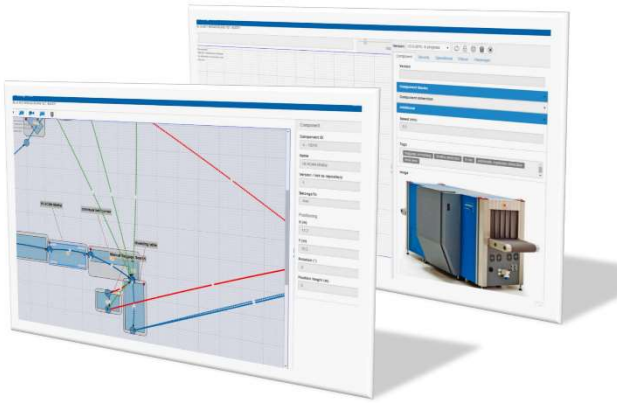
These two tools work together in an interactive way: the Design Tool is used to design a checkpoint based on system-level requirements, the Shared Evaluation Platform evaluates the performance of this checkpoint with respect to the performance indicators. The Design tool can be used to iterate the design of the checkpoint based on the results. At the core of the combined tool is the **component repository**. This is a database which contains all the data on each component needed to make the specific performance calculations. It includes:

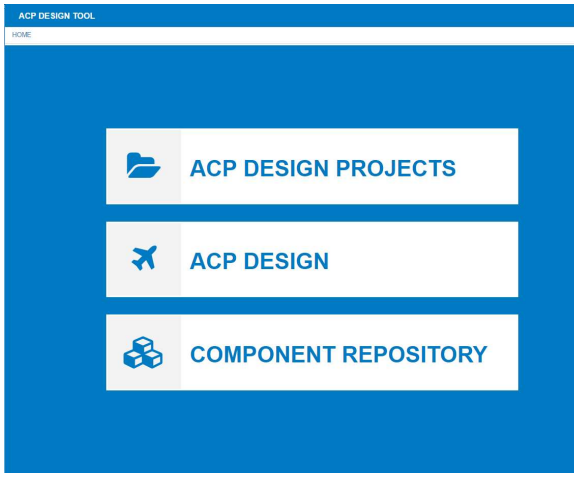
- operational data - non-security-related component attributes (dimensions, throughput, costs, ethical aspects, etc.);
- detection performance data – (security sensitive) detection rates per modus operandi and false alarm rates, per equipment type and configuration. They have been extracted from existing

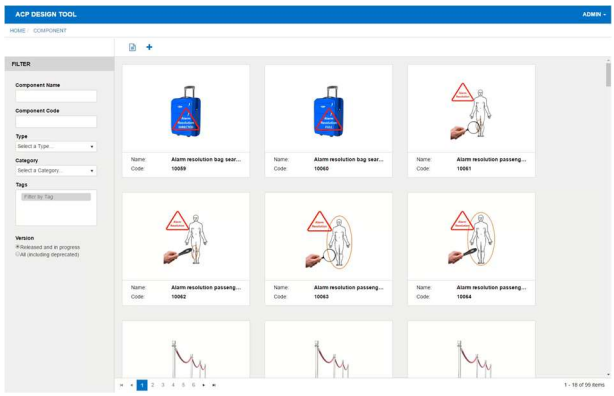
aviation security equipment test data, dedicated XP-DITE tests and subject matter expert estimates.

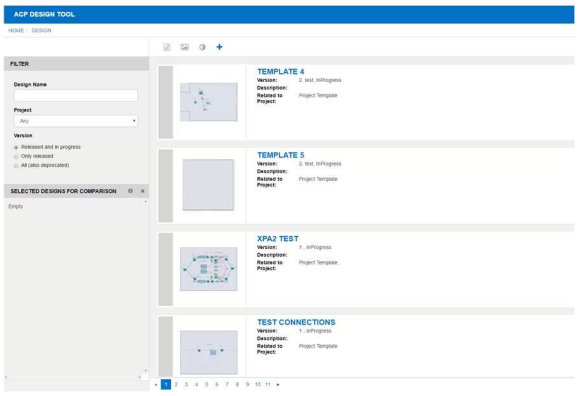
Design Tool (ADT)

The Design Tool (ADT) is a software application capable of supporting creating or choosing a design for a security checkpoint, working from system-level requirements. First, requirements for the Design Tool (ADT) were collected from stakeholders and the XP-DITE team. In an intuitive, straightforward graphical interface, components are dragged and dropped from the repository, and connected to define the logic of alarm and clear paths. Designers can create different variants for each checkpoint and compare performance indicators to identify the optimal solution.









The ADT application consists of three main parts:

- **ACP Design Projects:** create design projects and define requirements at system-level. It allows designers to edit existing projects, create new projects, or delete outdated projects.
- **ACP Design:** accesses the design management and the design repository, which include the following elements:
  - ***Design browser*** which allows to search and filter the design repository.
  - ***Data view*** of designs which presents calculated (key) performance indicators to the user and gives the opportunity to insert empirically assessed data of physical checkpoints.
  - ***Blueprint view*** of designs which allows the creation and editing of ACP designs. Designs can be created from scratch or existing designs can be copied and edited. Components and other elements can easily be included in the design with drag-and-drop functions.

- **Component Repository:** stores all components (detection components, elements, other components) in a database with data needed to make performance calculations of checkpoints on system-level (dimensions, costs, ethical aspects, etc.). The component repository allows searching and filtering for components, the creation of new components and the editing of existing components in several user interfaces. In order to be able to use data describing performance of components, in the area of detection equipment and detection performance a unique Arrangement with ECAC was drafted, which allowed under strict conditions the use of actual test data from the Common Evaluation Process CEP) for selected equipment. This data is considered the most reliable available, although the CEP fits a different purpose, i.e. approval of compliance against criteria, rather than performance testing as such. The data were used as input to the component repository as well as the MO structure.

The ADT Software comes together with a comprehensive user manual, enabling users to work with the ADT-SEP installation as a supporting tool in designing ACPs with system-level requirements and performance in mind.

Shared Evaluation Platform - SEP-CALC

The SEP-CALC is the calculation engine which produces system-level performance information based on checkpoint designs from the Design Tool.

First, requirements were collected from the XP-DITE team and use cases for the SEP were identified and defined according to needs for semi-formal modelling. A basic modelling approach of airport checkpoints that models checkpoints as interconnected components was established. Passenger arrive at a checkpoint with a certain inter-arrival time distribution and move through the checkpoint via randomly preselected paths that are defined by the decisions at the components. At the component itself passenger/trays spend time due to a certain time distribution. Suitable existing computational methods to estimate checkpoint performance on system level were identified and modified or newly developed. These calculation methods are analytical, where applicable, or use a Monte Carlo simulation technique that allows to process the modelling approach iteratively to calculate performance measures numerically.

The methods build the framework for the calculation part of the SEP (SEP-CALC) and thereby allow evaluation of the ACP by means of prediction of performance through mathematical models. An interface to the WP3 XP-DITE design tool (ADT) was developed and implemented. A stand-alone version also provides visualization of the results of a Monte Carlo simulation iteration in real-time 2D or 3D environments.

The SEP-CALC calculates (Key) Performance Indicators ((K)PI) in a number of areas, including:

Security & Compliance:

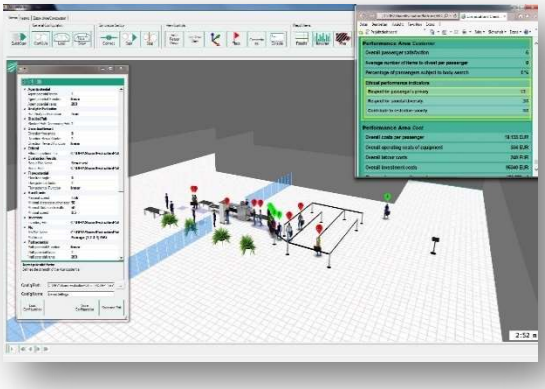
- How well are the individual threat scenarios and user definable groups of threats and scenarios detected?

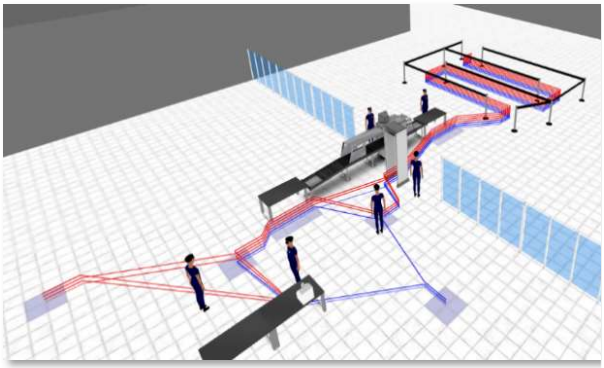
Customer & Ethics:

- How much inconvenience does the passenger experience (degree of divesting, manual searches etc.)?
- Does the design respect passenger privacy?
- Are specific passenger groups discriminated against?

Cost & Operations:

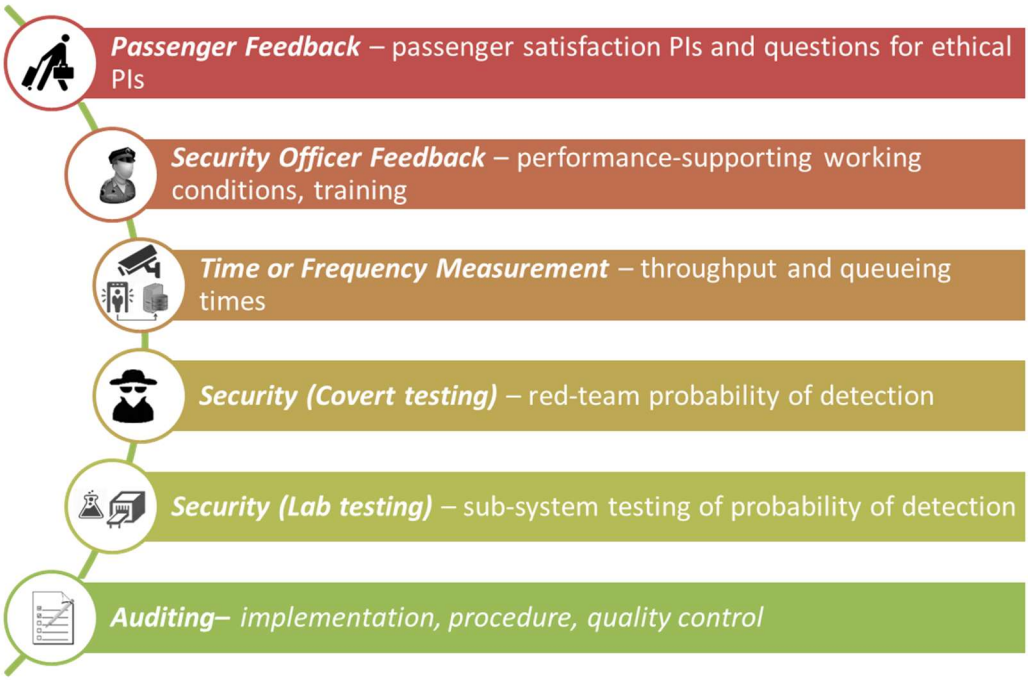
- What is the capacity of the checkpoint at maximum load?
- How quickly do passengers transit through the checkpoint?
- How many staff are needed to operate the checkpoint?
- How much does the checkpoint cost to build and run?





Evaluation of a deployed checkpoint by empirical methods – SEP-EMP

In order to support the evolution to a more system level based approach to checkpoints simulation and calculation is providing predicted performance, however, an approach to actually measure performance of a whole checkpoint while in operation will also be required. To complement the simulation of checkpoints and calculation of Performance Indicators in the Shared Evaluation Platform software tool, XP-DITE has developed an empirical analogue, known as **SEP-EMP**. It is a suite of methods that together can measure all PIs as defined in XP-DITE.



Seven methods were developed and reported together with theoretical background information on external/ecological validity, reliability and precision of data measurements, basic principles of data analysis and statistics, etc. All methods were validated in the proof-of-concept activities in XP-DITE and are ready to use with printable questionnaires, detailed instructions, checklists and protocols, and step-by-step descriptions on how to analyse the data and calculate the respective (K)PIs.

The Performance area *Customer & Ethics* is covered by the **passenger questionnaire**, which can be distributed to passengers and takes about 10 minutes to fill out. The Performance area *Cost & Operation* is covered by **time and frequency measurements**, which includes instructions on how to assess processing times and frequencies of events either with direct or with video observation. Some frequency information can also be assessed when gathering data and **information from detection components** directly. The Performance area *Security & Compliance* includes the method **covert testing** and **lab sub-system testing** to measure detection rates and false alarm rates of operational systems or of (sub-)systems in laboratory environments, respectively. The security **officer questionnaire** covers the human factors of security performance by assessing the performance-supporting working conditions with a questionnaire. The figure presents an example of protocol and checklist (left) and printable questionnaire (right).

Outcome-focused regulation with the central concept of system-level security also requires a change in the way checkpoints are inspected and audited. Under the current regulatory framework this is done by checking for compliance of equipment with specifications and of detailed procedures defined in the regulations. Since in the new approach, airports would define their own standard operating procedures, **quality control method** (QCM) audits would be required first to check that these procedures are correct, complete and clearly described. The QCM audit would then be used to assess how well the airport is complying with its own procedures.

4.1.3.3 XP-DITE trials & evaluation

A large part of the XP-DITE research has focused on establishing, through a variety of experiments, trials and validation exercises, whether the approach and tools developed meet the original goals of the project and to show that the project outputs can be used to help improve the performance and passenger experience of airport security both within Europe and worldwide.

The specific aims for this evaluation process included answering the following questions:

- Does the XP-DITE approach encompass the notion of comprehensive system-level design and evaluation of airport checkpoints?
- Is it possible to define a set of system-level security performance requirements?
- Is it possible to design a checkpoint to meet these security requirements (whilst also meeting operational and customer requirements)?
- Is it possible to evaluate the security (and other) performance of these checkpoints?
- Do the XP-DITE tools support delivery of the XP-DITE approach?

Five different approaches have been used to evaluate the XP-DITE central concept and tools:

- Design and evaluation of test and operational airport checkpoints – including field trials in operational airport environments;
- Evaluation of existing checkpoints and comparison with simulation results;
- Laboratory tests on checkpoint sub-systems;
- Paper system-level design of concept checkpoints; and
- Peer review of methods and calculation techniques.

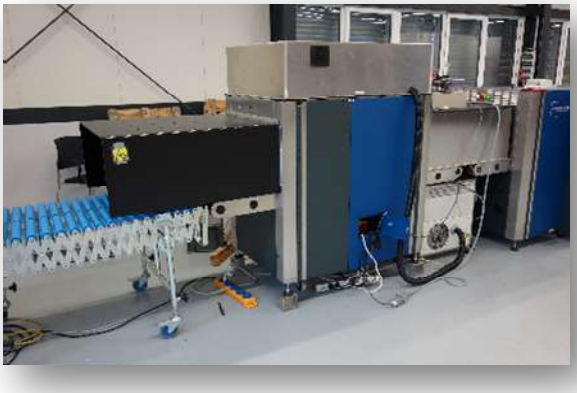
Through a combination of empirical measurements, modelling, expert reviews and design sessions, all aspects of the XP-DITE approach, from requirement setting, through design, modelling, implementation and operational evaluation have been evaluated at various stages in the project.

The trial and evaluation process has demonstrated that the XP-DITE approach and tools are valid and suitable for the design and evaluation of checkpoints at the system level. XP-DITE is an iterative process, and where improvements have been identified through testing and evaluation these have fed back into the design and used to improve the final versions of the tools.

Two distinctively different proof-of-concept trials were defined that allowed the team to reach these conclusions. The general design process developed in WP3 was applied twice, starting with gathering of stakeholders' requirements. The trial at Scarabee aimed primarily at integration of innovative detection equipment developed in the project and the project came up with most of the requirements. For the trial at Shannon Airport, Ireland, the main requirements were from the project itself, namely to allow the validation exercises, and from Shannon Airport. Shannon Airport was highly interested in merging their EU bound passengers checkpoint and the US bound checkpoint in the pre-clearance operation into a single screening operation.

New technology demonstrator trial

The first XP-DITE trial focused on integration of the innovative detection and tracking technologies developed in XP-DITE combined with existing equipment familiar to current checkpoints. It was installed at the Scarabee integration facility in Hoofddorp, the Netherlands.



The use of innovative technologies are of interest in the XP-DITE system-level approach because, while they are not necessarily compliant with current regulations when used stand-alone, they may fill a gap (e.g. in concept of operation) and contribute to security which can be validated and predicted through the system-level checkpoint design process. This concept aimed to demonstrate how non-compliant technologies could be combined in an integrated checkpoint.

The integration work assured that the whole system performed as necessary for the trial. Specific integration challenges included the overall system integration and installation of prototype equipment, biometrics based identification and tracking of passengers in the checkpoint area. Equipment from different sources and manufacturers (Cascade Technologies, FOI, Smiths, Morpho (now Safran I&S), L3 and Ceia) was included. A central alarm management system was installed, which

consists of electronic and software interfaces between several sub-systems and checks was designed for managing and controlling the results (alarms/clear) at the overall system-level. The passenger screening subsystem was subsequently integrated at the TNO laboratory and the baggage screening subsystem at Fraunhofer ICT laboratory.

Innovative technology used

The passengers' bags and belongings are screened separately by a chain of innovative equipment developed within XP-DITE: first the trays with bags are scanned by a Smiths Detection X-Ray scanner based on a non-CT (Computed Tomography) platform with automated solid and liquid explosives detection algorithms, while the operator analyses the images for guns and other forbidden objects. After the X-ray system, bags are additionally screened inline by two trace detection devices developed in XP-DITE by FOI (particulate surface trace contamination) and Cascade Technologies (vapour trace concentration).

If an alarm is generated by one or more of the components of the baggage screening lane, the bag is submitted to hand search for alarm resolution. The security officer can use detailed X-ray images on a remote viewing station (linked to the Smiths Detection equipment) to look for the forbidden objects. People are screened by either a commercially available security scanner or a walk-through metal detector, one of which is selected through a random process, thereby introducing a certain degree of unpredictability for the passenger.

Safran Identity & Security has developed a contactless 'on-the-fly' fingerprint scanner – the MorphoWave – which was used for enrolment at the checkpoint entrance and to identify and track passengers throughout the checkpoint, such that the appropriate alarm resolution was applied after linking the passengers to the primary screening method. The biometric fingerprint information was combined with RFID tag data from the bag trays to ensure the connection of bags and divested items with the right passengers. This is one of the first checkpoint implementations where the passenger and their belongings are directly linked throughout the screening process.

Evaluation

At Hoofddorp the checkpoint was evaluated principally for its operational efficiency, looking at performance indicators like divesting time and total screening time. Alongside this, the security officers were challenged with a series of covert tests with realistic threat items to confirm that they could correctly intercept potential threats throughout the trial. Interviews and questionnaires with the security team were used to measure satisfaction with working conditions and sufficiency of training. Following the deployment at Hoofddorp, the checkpoint passenger screening subsystem and the belongings screening subsystem were transferred to security test laboratories (Fraunhofer ICT in Germany and TNO in The Netherlands) to evaluate its detection capability directly using real explosives threats.

Operational trial – Shannon Airport

The second trial was implemented in a regular airport security operation at Shannon Airport, a partner in XP-DITE.

Shannon has a US preclearance capability which allows US-bound passengers to complete immigration and customs formalities, as well as security screening for US domestic flights, before they travel.

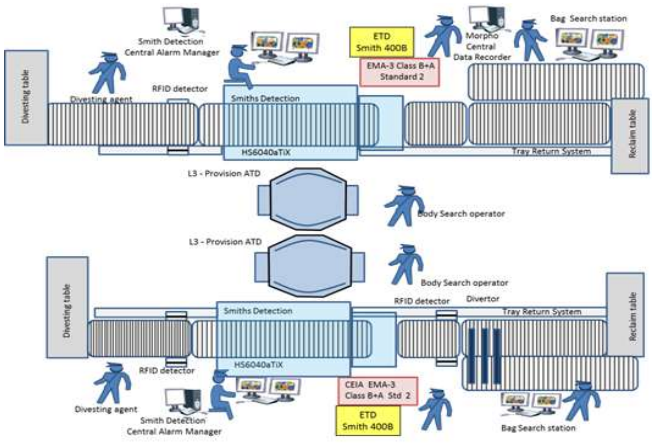
This was originally provided by means of an additional TSA-compliant checkpoint in combination with US immigration processes. Passengers outbound for US are first checked in the EU compliant checkpoint and then screened again in the TSA checkpoint. All US-bound passengers had to queue up twice and be screened twice before their flight.

The XP-DITE team cooperated with the national and US regulator to realise a trial where the two separate checkpoints were integrated into a single security checkpoint. This provided an improved customer experience with a "**one stop security**" experience for US bound passengers and was the first of its kind in the World.

This trial served several important purposes for XP-DITE:

- Putting the system-level performance concept to work: – in this case merging different requirements into a single operation;
- Predicting overall system performance; and
- Applying system-level evaluation methods in a live operational setting.

The checkpoint design included new multi-view X-ray scanners from Smiths Detection; newly installed security scanners replacing the walk-through metal detectors previously in use; and, specially designed screening processes in order to be accepted to fulfil both the EU and US regime.



The checkpoint was designed, implemented and integrated by the XP-DITE team together with the management and staff of Shannon Airport.

The trial ran at Shannon Airport from early September 2016 for an initial ten-week period as part of the project.

Evaluation

The proof-of-concept checkpoint was evaluated against a range of performance indicators in the performance areas Security & Compliance, Cost & Operations, and Customer & Ethics (including passenger satisfaction), using the XP-DITE Empirical Shared Evaluation Platform. After the airport trials, parallel tests of subsystems took place at security testing laboratories at TNO in the Netherlands and

Fraunhofer ICT in Germany to evaluate security performance in more depth in a controlled environment (as with the Hoofddorp checkpoint).

The ten-week trial was successful, with both US and Irish regulators auditing and assuring that security standards were not being compromised. Given the success of the trial, Shannon Airport decided to keep the merged checkpoint in operation, reducing queuing time and improving customer experience for many travellers every month, as well as releasing valuable space for other activities. This is an important early example of the exploitation of the XP-DITE results.

4.1.3.4 Validation of approach, methods and tools

The system level approach, the methods (MO-approach, ethical framework) and tools (ADT, SEP-CALC and SEP-EMP) were all subjected to a first validation step by means of a structured approach of gathering data from the two trials and comparing them to each other and with peers.

To this effect a so-called a high-level validation strategy was developed within the project to ensure that there is a common understanding of the set of principles and practises which are to be used to structure and organise the validation activities. It sets the validation objectives based on the project objectives and the stakeholders' expectations, the validation activities necessary to achieve these, and a global validation exercise plan. The detailed description of the validation exercises was done by the teams that carried out the validation exercises. They addressed:

- application of tools, which implied application of underlying developed methods;
- prediction of performance of selected checkpoint designs available to the project, Performance indicators in all three Performance Areas;
- assessment of performance through application of empirical and experimental methods; and
- comparison of results (where the same PIs were addressed) from the different sources mentioned above with information shared by professionals in the field.

The main observations, conclusions and feedback extracted from the validation activities were analysed and reported and summarized in terms of validation statements and recommendations. They were shared with the developers of the ADT and SEP to support the development of the final versions.

4.1.3.5 The XP-DITE Ethical Framework

One of the major goals of XP-DITE is to allow checkpoint designers to consider ethics related questions from the outset by enabling the designers to select and specify ethics requirements and to help them meet these requirements in their designs.

Design guidelines – ethical checkpoint design

XP-DITE has developed a comprehensive ethical framework with design guidelines and evaluation techniques to enable users to:

- Identify and analyse relevant ethical and societal factors;
- Define ethical and societal performance system-level requirements; and
- Define and apply a system-level methodology for evaluating ethical performance.

Since airport preferences, passenger demographics, security demands, cost restrictions and other factors differ from checkpoint to checkpoint, the trade-off between ethical, legal and societal aspects (ELSAs) and other requirements will be different for every checkpoint.

It is important to allow designers flexibility to specify different desired performance goals with respect to certain ethical risks of checkpoint screening, while, at the same time, always ensuring a minimum level of protection and giving them a clear feedback on how their designs perform with respect to ELSAs, e.g. how intrusive a specific design is into the passengers' privacy.

The framework describes recommendations and guidelines for taking ethical, legal and societal considerations into account during system design by formulating minimal and desired performance requirements. The design approach is supported by the Airport checkpoint Design Tool ADT and enables a passenger centred "ethics by design approach" for airport checkpoints. These guidelines form part of the "design guide" that outlines XP-DITE's comprehensive, passenger-centred approach to checkpoint design. The guidelines can also be used separately by checkpoint designers to work with ELSA-related requirements as part of their own established design processes.

Evaluation – checkpoint ethical performance

In the same way that performance is assessed at a system level for security and operational requirements, checkpoint performance is also assessed with respect to ELSAs.
Building on a typology of ethical and societal risks of checkpoint screening, a methodological framework was developed that enables the evaluation of ethical and societal requirements of checkpoint screening within the XP-DITE Shared Evaluation Platform.

This was developed to allow not only the assessment of implemented operational checkpoints, but also – with the exception of passenger perception related aspects – theoretical checkpoint 'paper' designs.

Main focus for ethical evaluation	Requirement Category	Key Performance Indicator	On-paper Evaluation	Empirical Evaluation
Intrusiveness of screening procedures	Respect for passengers' privacy	Overall respect for privacy	×	
Fair distribution of impact and non-discrimination	Respect for societal diversity	Overall respect for societal diversity	×	
Societal restrictiveness and civil liberties protection	Respect for societal openness	Overall respect for openness of society	×	
Passenger perception of security screening	Societal acceptance and trust	Perceived respect for privacy		×
		Perceived respect for societal diversity		×
		Perceived respect for openness of society		×

The framework evaluates a checkpoint against six ethical key performance indicators covering a wide range of ethical and societal risks measured along a four point ordinal assessment scale. Based on the specific components and procedures used in a given checkpoint design, the framework allows a comparative, qualitative assessment of the system-level performance.

For each of the key performance indicators that allow an on-paper evaluation, a framework for measurement of compliance was constructed to assess the different "paths" passengers may take through a specific checkpoint, depending on alarm resolution processes, opt-out possibilities, and other design choices. The empirical evaluation is based on passenger questionnaires that have been developed in such a way as to integrate with already existing infrastructure for measuring customer satisfaction surveys.

The evaluation framework was successfully used at both XP-DITE trial checkpoints. This is believed to be the first time that ethical factors have been systematically assessed on the system-level at an operational airport checkpoint.

4.1.3.6 XP-DITE Technology Development

Innovation activities in XP-DITE included the maturation of selected technologies under development by European security suppliers and SMEs. The technologies were selected as checkpoint components that are not compliant as such under the current regulatory framework but which could be used to test the XP-DITE approach. Five such developments produced prototypes ready to be used in the project, of which four were eventually demonstrated in the proof-of-principle technology demonstrator checkpoint at Scarabee.

The prediction of whole checkpoint performance in XP-DITE is done through the design and evaluation tool (ADT and SEP-CALC combined). In the so-called component repository in the ADT each detection equipment is listed with its attributes, as necessary to be used in calculation. An important subset of attributes describes detection performance, defined in the MO-approach developed in the project.

The detection equipment prototypes obviously were never tested before in any reliable testing system. Moreover, even generally accepted testing methods did not exists to evaluate their performance. Dedicated evaluation methods were developed for each, which are comparable in the level of detail to ECAC's so-called Common Testing Methodologies (CTMs).

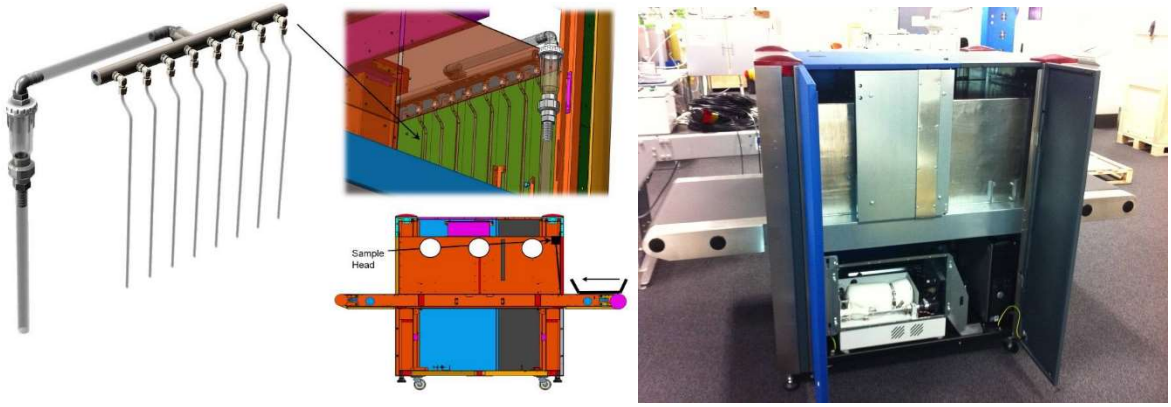
Subsequently, the security performance of each prototype detection equipment developed in WP2 was properly assessed in dedicated laboratories according to these dedicated test methodologies. The evaluation activities extended to 'data collection' intended to collect results before application of the dedicated test method supporting technical development, and testing following the developed test method (sometimes re-testing several versions). The results were reported to developers and used to populate the component repository, and also formed the basis for the decision to use the technology in the proof-of-concept trial at Scarabee.

Vapor sensing for explosives detection (Cascade Technologies)

The Quantum Cascade Laser (QCL)-based vapour detector aims at the screening of both passenger cabin bags and divested items. It has been developed, designed and tested in Cascade facility and its concept is inspired from the Cascade walkthrough passenger screening portal and was based on their proprietary Quantum Cascade Laser technology. This technology is able to detect vapor traces emanating from high vapour-pressure explosives and -precursors (including homemade explosives HME) that leak from the bags they are concealed in. The existing detector technology was adapted to fit inside an X-ray cabinet and screen bags for vapour at inline right after the X-ray stage.

The development in XP-DITE is integrated in Smiths HS6040i X-ray frame. The Cascade proprietary sampling technique has been modified to operate in conventional Cabin Baggage Screening (CBS) cabinets by using a sampling bar drawing in the air surrounding the cabin bags/items passing on the conveyor belt. The sampling bar is linked to a multi-pass optical cell in order to maximise sensitivity, and backed up by a high flow pump driving sampled air from the bar to the optical cell.

The system operates under Cascade gas sensor software and it is based on its generic GS3 platform of detection algorithms. The software continuously analyses the gas stream drawn from around the cabin bags to the measurement cell. When a vapour trace of a target compound is detected, determined by a spike in concentration reading, a detection alarm is issued. The system has the capability to provide a digital signal to an alarm management system (if there is one), which includes detection and concentration data. The protocol used for this communication is based on a TCP/IP Ethernet link. Much work was done on optimization of the sampling head system.



Cascade has assisted with the installation and integration of the QCL sensor with the other detection systems for the trial at Scarabee and at the ICT laboratory.

Stand-off surface trace detection (FOI)

The Swedish Defence Research Agency, **FOI**, developed an automatic explosives particulate traces detector based on Raman spectroscopy. This enables non-contact remote detection of surface contamination of explosives particles on the exterior of carry-on bags, by continuous line scanning. As with the vapour detection system this can be integrated into an X-ray machine so offering inline screening of items passing through the x-ray machine without delaying the process, and eliminating the need to sampling by swab sampling.

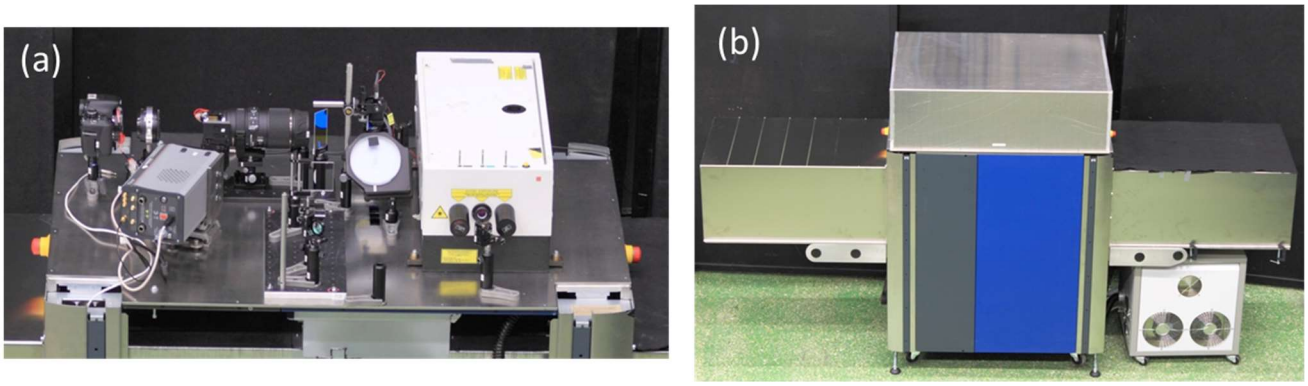
The development objective was to develop a prototype based on line scanning Raman laser spectroscopy and to adapt it for detection of explosives particles on carry-on luggage and other divested items.

The Raman detector has been installed on top of an empty X-ray cabinet with an operating conveyor belt with a fixed speed of 0.2 m/s. An autofocus setup accommodates the different heights of bags entering into the cabinet ensuring that the surface is always focused on the camera. A database of reference spectra have been established, currently consisting of spectra from 5-10 substances. The database can easily be expanded to cover a wider range of threats.

All items are screened for particulate contamination on the outside, and the system provides automated alarming without the need for a human operator. The Raman detector was integrated into the same volume together with the vapour detector developed by Cascade Technologies. This

combined system was further integrated with the aTix X-Ray explosives bulk and liquid detector during system-level tests and trials.

In order to ensure eye safety, the optical components are covered by a hood and the entrance and exit are equipped with extension tunnels with several curtains. Thus, the laser beam (λ= 532 nm) cannot exit from the cabinet volume.



The signal processing was improved in stages and is fast enough for real-time analysis. It consists of 3 steps: matching of individual spectra with reference spectra, filtering and integration to attribute a total score for individual shots, and statistical analysis and thresholding to give an alarm or clear including qualitative substance information. It can communicate to a central alarm management system via TCP/IP Ethernet link.

The detection limit is in the µg or even sub µg for several threat substances in controlled environments, but the fluorescence from typical bag materials reduces the detection performance. Research is necessary to improve this further e.g. by using different wavelengths. The high selectivity of the Raman technology gives very low false alarm rates.

Automated liquid and solid explosives detection (Smiths Detection)

Development of new threat detection algorithms for the aTix platform X-ray systems was carried out by Smiths Detection. It enables automatic screening of bags for liquids and solid explosives, without the need to divest LAGs. Compared to so-called Type C LEDS this increases throughput and reduces hassle; it also potentially enables multi-view systems to provide similar levels of liquid explosives detection performance as those of much more costly systems based on computed tomography.

Most work was done on software developments for an existing four-view projection scanner, the 6040 aTiX machine. For automatic detection of liquid, bulk and sheet explosives, algorithms have been designed for standard and complex bags. Detection has been implemented partly in a two level approach. In a first step image areas are classified and subsequent scenario specific algorithm or parameter settings are used for the evaluation of these areas. Explicitly a classifier for liquid containers and another one for laptops have been elaborated. The classification should allow to create scenario specific tools. Tests with stored images led to convincing results: no wrong classification of areas and a nearly perfect hit rate was obtained. Based on these results, the development of special algorithms adapted to the evaluation of these scenarios made sense.

For solids, improved detection in complex areas and behind strong absorbing objects was obtained. Bulk explosives were localised more precisely than with previous software version in these cases. Due

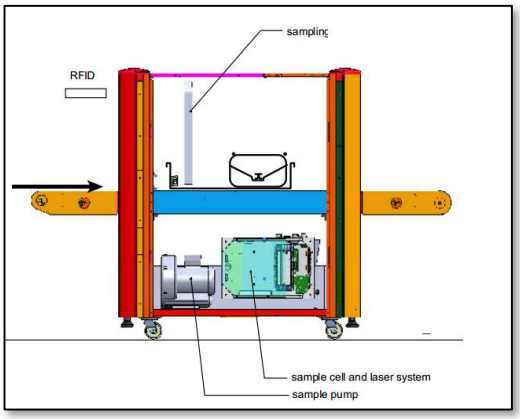
to better marking of the whole bulk object false alarm rates could be reduced by ~25% at same probability of detection (Pd) level. A first version of a sheet detection software has been created for standard and for complex areas i.e. areas covered by electronics (laptops). Detection could be improved for these scenarios as well. However, it did not reach a level which is sufficient for use in the field. More work is needed in this area to reach acceptable Pd in combination with low probability of false alarms (Pfa).

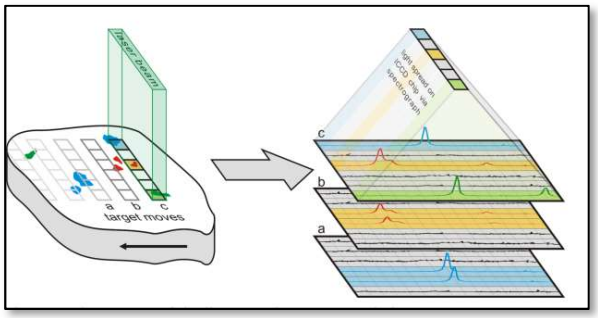
For liquids in bags the situation is similar to sheet detection. Areas which have been classified as containing liquids have been further analysed. An algorithm identifying a few optimised positions to perform a reconstruction of a slice-based on the four available views has been created. An algebraic reconstruction for fixed positions in the bag has been developed and optimised in view of liquid parameters in the bottle, which are used for classification of the liquid. A reconstruction based on single energy absorption and an effective atomic number (Zeff) sensitive version has been implemented. First stable software versions of these reconstructions were implemented and classification parameters for suspicious liquids were elaborated. The prototype was not initially developed to pass compliance testing, and whether it can be tuned to that purpose needs to be further evaluated.

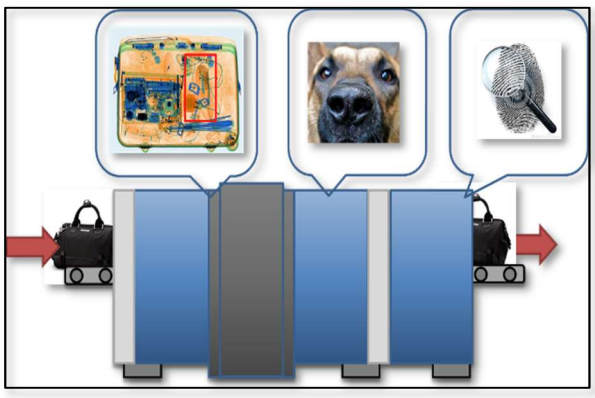
Detection of other prohibited articles than explosives (guns, knives) is done by a human screener. In order to support him, a complex image algebraic reconstruction for the whole bag has been designed based on four available views only. The information gathered in the four views is fused into the 3D voxel array. The position of bulk objects can be determined by use of the reconstructed pixel volume. This provides useful information to the operator when evaluating the projection images of the bag. He may use one projection image in combination with the 3D voxel array for evaluation of the bag. The algebraic reconstruction method being used is a very processing power consuming algorithm. Therefore, the implementation was optimized in view of runtime and a processing time in the order of 10 seconds has been obtained for previous generation Graphic Processing Units (GPU). It is estimated that with next generation GPUs reconstruction of the complete bag can be performed in almost real time.

Combined bulk & trace explosives detection for cabin baggage

The three systems introduced above (Cascade Technologies, FOI, Smiths Detection) were integrated into a combined cabinet and deployed in the proof-of-principle trial.







System-level integration and biometric tracking (Safran)

A development was proposed by **Safran** to integrate the alarm management of multiple detection components in the checkpoint, thus enabling more elaborate checkpoint system concepts compared to those based on AND/OR logic and binary detectors, as well as transferring information between components (e.g. specific alarm location) and linking passenger information via biometrics to bag information tracked via RFID. This system, once developed, could play an integral role in enabling any system-level processes, including risk based differentiation of screening. This idea was supported by refinement a contactless fingerprint system which captures fingerprints from four fingers with a single quick wave of the hand. It can be used to track passengers through a checkpoint, allowing a link to be established between passengers, baggage and detection equipment output.

The choice for biometric tracking for recognition of the passenger at different key points in the checkpoint, compared to video tracking technology, was made because several of those systems available on the market lack both accuracy and automatic real time operation capability. Three types were assessed for fit for purpose. Different acquisition campaigns occurred during the project so that the face, iris and fingerprints biometrics could be compared. For each biometrics, one acquisition device was implemented for the enrolment, another one for an 'on the fly' acquisition (a short stop of 2 seconds max or no stop at all).

The results showed that fingerprints provide acceptable results and accuracy (0.5% FRR for 1% FAR in 1 second time), even if the fingerprints recording can be discomforting for the passenger to some degree.

Iris turned out not to be a good option for the "airport use case" because of the difficulty to obtain irises in the airport environment (put a luggage on a belt then go through a portal, such as a metal detector or a body scanner). In the future Iris at Distance technology maturity may overcome this problem.

For face recognition Near Infra-Red (NIR) acquisition helps improving the face accuracy compared to visible light, but the results remain less good than the one obtained with fingerprint. Face tracking and identification needs more research to be considered an operational option.

Hence, it was concluded that on-the-fly fingerprint acquisition is the preferred technology for passenger recognition inside the ACP within XP-DITE.

A contactless fingerprint acquisition prototype already existed when the XP-DITE project began. However, this device had some ergonomics issues. For example, the acquisition window - the physical gap in the fingerprint device through which the passenger moves his hand - was considered as too short by the user for passing the hand easily. Reducing the size of the device helped the user feel the acquisition window to be bigger. And efforts have also been made on further improving the accuracy of the device. The results are used in the Morpho Wave product which has been launched and is now marketed as a commercial product by Morpho (now SIS), another early example of exploitation of the project results.

Millimetre-wave screening (Alfa Imaging)

A prototype passive millimetre-wave people screening system was developed by the former Alfa Imaging to allow passengers to be screened without having to stop and pose in the detection system.

The passive stand-off mm-wave full-body scanner developed in the project by Alfa Imaging was based on an existing imager (ALFA2). This imager was redesigned, increasing the aperture and improving the automatic threat detection (ATD) software. For example, the primary mirror size was increased to 840 mm in order to improve the sensitivity and the spatial resolution (2 cm at 3.5 meters). Processing speed was improved in order to work at video rate (8 frames/s).

The graphical user interface was enhanced to include a technical user mode and the generic silhouette was changed to make the front and back views more obvious. Initial performance tests were carried out at Alfa Imaging premises with in-house available threat simulants and a real threat (gun). In addition, the recordings from the data collection campaign was thoroughly analysed to optimize the balance between false negatives and false positives. Hence, the automatic threat detection (ATD) software was upgraded in several steps in order to optimize the detection, resulting in a final version of the signal processing algorithms in May 2015.

Alfa Imaging left the project in October 2015.

Emerging Technologies

New and emerging technologies are a vital element in the development of innovative security checkpoints. XP-DITE carried out an assessment of existing, emerging and new technologies to identify the capabilities likely to become available to designers in the coming years.

In each area of the checkpoint, the main technology opportunities were explored, based on what regulators, operators and passengers are looking for - to meet the demands of improved security, reduced running cost and better passenger experience. The survey highlighted the following areas and main opportunities:

Person inspection: technology improvements to security scanners such as improved image quality, better automated algorithms or material classification techniques; walk-through or walk-by screening to eliminate the imposing “booth”-style portal process.

Cabin baggage screening: computed tomography and perhaps multi-view X-ray to deliver improved performance areas by eliminating divesting, increasing throughput and introducing automatic detection of explosives; new X-ray techniques, such as multi-energy detectors and X-ray diffraction to reach better detection performance, with reduced false positives.

Explosives trace detection: short-term incremental improvements to ion mobility spectrometry to deliver improved reliability and detection performance; longer-term introduction of mass spectrometry with its better sensitivity and better specificity: non-contact sampling to reduce need for swabbing and passenger cooperation.

Logistics: parallel divestment to speed up passenger unpacking coupled with well-designed conveyor belts to maximise the use of space and passenger flow; automatic tray-return systems to free up staff for the more security-critical tasks. Improved checkpoint aesthetics and better passenger interaction using innovative technology platforms (smartphone apps, wearables, augmented reality).

Identification and tracking: technologies to enable passengers to be tracked between different inspection components so that results from these can be correlated and processes tailored to the individual; remote biometric techniques such as face or iris recognition at a distance.

Systems and operations management: centralised image processing, instead of operators at each X-ray machine; use of algorithms to carry out mundane tasks and humans where their intelligence and insight adds most value; longer term use of “Big Data” techniques to improve operations. Modular checkpoint architectures, interoperability, open data formats and data fusion techniques, all to support moves towards risk-based screening and the XP-DITE system-level security concept.

4.1.4 Impact, main dissemination items, exploitation of results

4.1.4.1 Potential Impact

XP-DITE could have a major impact on aviation security, helping protect citizens from terrorism, whilst respecting privacy and safeguarding fundamental rights, at the same time supporting the aviation industry and the convenience of the travelling public. The XP-DITE approach would allow airports, checkpoint designers and regulators to incorporate a wide range of requirements and evaluate checkpoint performance against system-level security, cost, throughput, passenger satisfaction and ethical factors. XP-DITE therefore reaches a higher level of integration, not only technical, but also regarding processes and organisations. Benefits from a change to an outcome-focused, system-level regulatory paradigm, supported by the XP-DITE approach and tools, are foreseen for a range of industry stakeholders:

- Airport operators and checkpoint designers
  - Optimise checkpoints to individual business needs – throughput, cost, customer service
  - Enable use of innovative procedures and technologies
  - Flexibility in checkpoint design to cope with change
  - Checkpoint design and evaluation tools - on paper and in the field
  - Provide evidence to regulators of security level achieved
- Regulators
  - Gain control over real system-level instead of equipment-level security performance, including risk-based elements
  - Enable checkpoints that can be more easily adapted to new threats
  - Explore system-level approaches to security performance evaluation
  - Carry out 'what-if' experiments on potential new regulations and impact of new technologies
- Equipment Manufacturers
  - Facilitate innovation and introduction of new technologies
- Passengers
  - Fewer delays & improved convenience whilst ensuring they are kept safe
  - Screening procedures designed with customer service & ethics in mind

Whilst the XP-DITE long-term vision is that security regulation and policy will evolve towards an outcome-based, system-level and risk-based paradigm, the approach and tools can be used today within the current regulatory framework:

- Regulators can use the tools to perform "what-if" scenarios to calculate the impact of potential changes in regulations, for example to respond to new and evolving threats. In this way regulators will get more comfortable with the system-level and outcome-focused approach of XP-DITE.
- Airport operators can use the tools to design customer friendly, efficient checkpoints, optimised to the needs of their business. The scale of airport operations is such that significant benefits can be gained from optimising checkpoints in response to changing technology, regulations, traffic, customer expectations etc..

XP-DITE has already supported Shannon airport in **combining its separate EU and US preclearance checkpoints** into a single security checkpoint operation for passengers travelling to the USA. This checkpoint, the first of its kind in the world, has resulted in eliminating the need for passengers to

queue up twice for two separate security processes, and significantly reduced the space needed for checkpoint operations within the terminal. Since new checkpoint is currently still in use and inspected on a regular basis by the Irish government and TSA, it can be concluded that the XP-DITE system-level approach can deliver benefits for airports and passengers, within the regulation. The same approach could be applied at other current or future preclearance airports in Europe and around the world, delivering benefits to both operators and passengers.

The innovative detection and biometric identification technologies developed on the project and already launched as products can be exploited in products for aviation security, other security applications and in other areas ranging from environmental sensing to entry control systems.

While the principal focus of XP-DITE is on the aviation security passenger checkpoint, the concepts and tools developed could be used in other aviation and non-aviation applications:

Aviation hold baggage and cargo screening can use the XP-DITE tools for security and operational modelling; much of the existing MO and repository data can be re-used.

Secure locations – the XP-DITE tools can also be used to optimise checkpoints in critical infrastructure and other secure facilities; with a new set of MOs to match the different threat.

International Rail – is an application with checkpoints and passenger volumes similar to aviation. Again, the XP-DITE tools could be used with suitable changes to the repository data.

Commuter and Metro Rail - Solutions for security screening are sought, since little currently exists for these applications due to the very high peak volumes of passengers. Applying the XP-DITE principles to the challenge of high throughput screening would be beneficial.

Open public spaces - Despite being a very challenging area, the XP-DITE approach has a number of attributes which could be extended to offer benefit in this area. This is a topic which would certainly require further research effort.

For the last four non-aviation cases, the use of XP-DITE would not be held back by the existence of a rigid set of prescriptive component-based regulations. Outcome-focused, risk-based checkpoints using the XP-DITE approach could be deployed operationally, without the need for regulatory reform.

The MO model provides a practical basis for calculating security performance in many areas, particularly given the ability to weight threats according to likelihood and impact. Many applications cannot adopt the aviation "*screen equally for everything*" model due to operational constraints.

XP-DITE provides a flexible framework to *evaluate technology in a virtual sandbox* without necessarily resorting to highly visible and expensive operational trials. Models can be used to challenge and

validate assumptions made by new technology providers, and also to provide feedback on changes that can benefit their operational usefulness.

4.1.4.2 Dissemination

The project has worked closely with the aviation security stakeholder community (government, airline/airport industry and security equipment and system suppliers) throughout the project. A dialogue has been maintained both to help guide and shape the work of the project and to disseminate the vision and results of the project as they have emerged. The principal dissemination activities during the project have been:

- Development of a dissemination plan analysing and defining the project's communication and dissemination strategy to all the various stakeholders and the general public.
- Annual stakeholder meetings with EU & Member State government regulators, airport operators, airlines, equipment and systems suppliers – both directly and through industry organisations such as ECAC, IATA, ACI, EOS.
- One-to-one interactions with key stakeholders – meetings and presentations throughout the project. These have included EU, Member State and other national regulators such as the TSA, industry representatives, airport operators and manufacturers.
- Scientific publications including PhD theses.
- Presentations at industry conferences and published papers – over 30 conference presentations and posters at a wide range of events in Europe and USA.
- XP-DITE proof-of-concept demonstrations, especially the Shannon Airport combined EU-TSA pre-clearance checkpoint trial and associated stakeholder interactions and wider publicity.
- Trade press articles, press activities and the XP-DITE website for public dissemination
- XP-DITE project Final Event and the associated 26-page project booklet and project video, which have subsequently been distributed via the partners, on the project website and on YouTube.

In addition, studies were carried out and white papers written on dissemination and exploitation related topics.

A study explored the feasibility of a **Permanent Field Lab** to support the exploitation of XP-DITE results. The investigation extends the existing test laboratories in multiple ways: system level approach, more performance areas than just security, impact on the normal operation at airports, multiple stakeholders, iterative learning and improvement. The aim of the study was to propose a feasible version of a permanent field lab, formed from a small group consisting of a regulator, an airport, an integrator, and a test laboratory. Assuming a group can be identified it should be feasible to set up a field lab within a limited timeframe (1 to 5 years), including arranging investment capital.

A workshop and study, explored the **applicability of the XP-DITE approach and results to other checkpoints and other modes of transport,** especially mass transportation, such as long distance and commuter/metro rail. The findings from the workshop were used to refine the initial list of into a shortlist of five areas where potential applications were identified and explored:

- Aviation hold baggage and cargo screening
- Secure locations
- International Rail
- Commuter and Metro Rail
- Open public spaces

A white paper on **IP and Confidentiality** explored and analysed the complex set of intellectual property and confidentiality of information that applies in XP-DITE. A number of issues that have arisen on the project were identified. These are not only important within the project, they also have an additional significance since very similar issues are likely to arise in the aviation security community (regulators, airport operators, manufacturers and system designers/developers) as it embraces the concept of outcome-focused, system-level regulation and airport checkpoint design.

The project website contains summaries of all the deliverables, the XP-DITE booklet and video describing the project and links to the project partners as contact points for stakeholders interested in access to the results. The website will be maintained for at least 5 years after the project.

4.1.4.3 Exploitation Plans

Moving to outcome-focused regulation will be a major paradigm shift for the aviation sector. XP-DITE is a step in this process and starts the process of giving both regulators and industry confidence that it can be achieved.

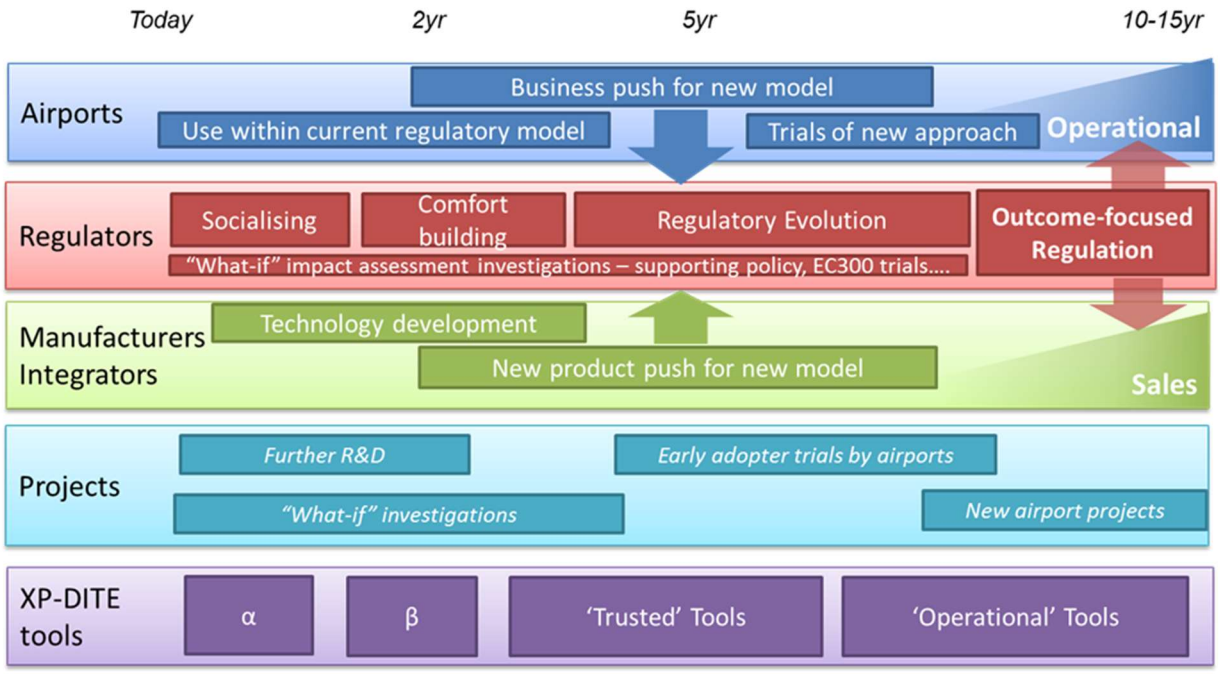
The XP-DITE results will be exploited in a number of different ways:

- A long-term initiative leading towards the implementation of a new outcome-focused aviation security regime.
- Shorter-term exploitation activities within aviation security using elements of the XP-DITE system-level approach, tools and the innovative technologies developed as part of the project.
- Exploitation activities using the XP-DITE approach, tools and innovative technologies in other areas of security.
- Exploitation outside of the security sector, such as the vapour and trace sensing technologies in environmental and safety applications and biometric identification in various areas.

Outcome-focused aviation security roadmap

XP-DITE has developed a roadmap for the implementation of an outcome-focused aviation security regime with a 10-15-year horizon, showing where further R&D is required, and how and when industry and regulators would need to implement the results of XP-DITE to help make this vision come true.

The roadmap, shown in the figure below, shows how a wide range of different actors are required to move the XP-DITE vision and approach forward towards adoption. It shows how the tools and methods could be used on smaller-scale nearer-term initiatives – adding value in their own right, as well as helping build confidence, support and momentum towards the change to outcome-focused regulation.



The XP-DITE system-level security approach, based on MOs, and the tools developed to design and evaluate checkpoints, both before and after they are built, are a first prototype of what needs to become a reliable and trusted toolset that will be used to design checkpoints and demonstrate their compliance. The XP-DITE tools would need updates based on the what-if impact assessments and new research results, resulting in 'trusted' tools for airport and regulators

A robust, verified and validated set of checkpoint evaluation tools is a critical enabler to stimulate the debate on regulation and to give regulators the confidence they need to move to an outcome-focused regulatory model. Once in place, airports would use the tools to design and implement checkpoints that are optimised to the business needs of the airport – large or small; domestic, international or transfer; low cost or high service; and so on.

Furthermore, the XP-DITE approach can be extended naturally to accommodate risk-based and other forms of differentiated screening – whether these use passenger intelligence, behavioural monitoring or different lanes for different passenger types. When the approach is accepted, it can be extended quite straightforwardly to other airport checkpoints and screening processes (vehicles, personnel, checked baggage, cargo, etc.).

Although the realisation of the XP-DITE vision is by no means within the total control of the project partners, initial steps (below) are being taken to begin the implementation of the roadmap which, it is hoped will eventually lead to regulatory change, the opening up of markets for the XP-DITE approach and tools and significant benefits for the aviation industry and the travelling public.

The partners will continue to work with other organisations who have complementary initiatives that support and will help promote the holistic 'security by design' XP-DITE approach, such the IATA/ACI Smart Security programme and Security Management Systems (SeMS) supported by IATA and several Member State civil aviation authorities.

Further research

Further European research would be beneficial in several areas to extend and support the development and exploitation of the XP-DITE work. These include:

- Research into risk-based screening, especially the incorporation of risk-based information (on a time, location or individual passenger basis) into the XP-DITE approach.
- Further research into the fundamentals of outcome-focused, system-level security such as incorporating measures of unpredictability and deterrence, further work on the MO approach and dependencies between detection components.
- Research into the extension of the XP-DITE concept to other security challenges, such as improving the security of soft targets and crowded places, and border security.

Ideas for a possible future Horizon 2020 topic in extending the XP-DITE approach to risk-based screening have been prepared and submitted to the European Commission through DG HOME.

Current and planned exploitation activities

Several partners including TNO, Iconal, and CASRA, plan to exploit the core XP-DITE approach and tools, as well as the general expertise gained during the project, with government security agencies, airport operators and others. They, and other partners, are in active discussions with national government stakeholders (The Netherlands, United Kingdom, Switzerland, Ireland, Germany, Sweden) responsible for security in aviation, other transport modes, critical infrastructure, events and crowded places. Dialogue is also underway with the EU – DG HOME and DG MOVE and with aviation industry organisations such as IATA, ACI and ECAC.

These partners will seek to carry out studies and investigations for their national Governments and other customers where possible, where the XP-DITE tools and approach are used to design and evaluate new checkpoints and modifications to existing checkpoints, the so called 'what if' investigations that are a key element of the XP-DITE exploitation roadmap. They will also seek to carry out similar investigations with and for the EU aviation security regulator, DG MOVE.

As well as building awareness, confidence and support for the XP-DITE system-level approach, this work will also provide shorter-term benefits such as evidence-based support for regulation changes which may be needed in response to new threats and to make best use of new technology capabilities.

Other partners, such as FOI, Fraunhofer, Freiburg and IDT will exploit different aspects of the project, specific tools and methods such as the ADT and SEP, the MO-approach for security evaluation, the ethical evaluation tools and so on. Smiths, SIS (Morpho) and Cascade are already or will all use the results of their innovative technology work in the security sector and in other fields.

The airport operators and integrators in the project (Shannon Airport, Schiphol Airport, Scarabee) will exploit the results of the project through implementation of improved checkpoints. The merged EU/US preclearance checkpoint initially built as a proof-of-concept demonstrator, but which has been adopted for permanent use at Shannon is a clear example of exploitation that has already occurred and which will provide ongoing benefits. Other airports have expressed an interest in following a similar model.

Articles are being planned for scientific journals and the trade press to promote the XP-DITE concepts and approach, both in aviation security and in other sectors. The XP-DITE booklet, prepared at the end

of the project, serves as a source of text and visual material to support these kind of exploitation activities.

Several of the XP-DITE partners have collaborated with others on a proposal into the H2020 research call on risk-based border security, using some of the XP-DITE concepts and results.

Partner plans

Specific exploitation plans of each partner are summarised below:

The XP-DITE tools enables **Amsterdam Airport Schiphol** to design the optimal process to reach the objectives of the security department: compliance, customer centred and cost reductions. The project helps provide Schiphol with a security process that is customer friendly and that respects the privacy of the passenger

Shannon Airport's principal objective was to achieve a merged EU/TSA pre-clearance checkpoint, both to reduce costs, free up valuable space in the airport terminal and to improve customer service – all whilst not compromising on security. This exploitation has all been achieved within the timeframe of the project itself, since the decision was taken to keep the merged checkpoint developed for the XP-DITE trial and evaluation in operation after the end of the trial. The merged checkpoint will provide a continuing benefit to the airport in terms of both cost efficiencies and customer service.

There are a number of other airports in Europe and around the world that also provide US pre-clearance and the program is continually expanding with the addition of new airports. The positive results achieved at Shannon through use of the XP-DITE approach is expected to encourage these other airports to adopt similar merged checkpoint operations, with similar benefits to the industry and the traveling public. Shannon Airport is active in encouraging other airport operators to visit and study what they have done on XP-DITE.

TNO participates in many (inter)national bodies including the Technical Task Force of ECAC and is involved in most security and border control activities for the Dutch national government and has the strategic ambition to extend its expertise and broaden its leading European RTO position in aviation security and security of mass transport. In particular the XP-DITE system level concept, the MO approach regarding system level security, and the use of the Design Tool and the SEP will enable TNO to cooperate with national and international regulators and operators as well as with industrial partners, as described above.

TNO has already initiated the concept of a permanent field lab (an actual or virtual laboratory) involving government and airport partners where checkpoint equipment and concepts can be evaluated according to the XP-DITE approach. This concept will be progressed as an exploitation activity.

For **Smiths Detection**, being a leading designer and manufacturer of airport checkpoints and detection equipment XP-DITE will have an important impact in bringing future systems to market faster and more efficiently. Smiths Detection plans to further develop and use the techniques for 3D analysis of multi-view X-ray images developed during the project in its aTix range of x-ray systems.

Exploitation of results for **Safran** (Morpho) include:

- Touchless Fingerprint scanner has already been launched as a product under the name Morpho Wave. This is being marketed for use in a variety of applications.
- XP-DITE contributed to the development of an Alarm Management System prototype that allows the supervision of multiple equipment
- eGate products: Safran will continue working on other biometrics scanners such as iris and/or face based on the 'on-the-fly' concept developed in XP-DITE on iris and/or face

In **Fraunhofer EMI**, the performance evaluation of security systems and safety critical systems is a rapidly growing field. The methods developed for the SEP within XP-DITE, will enable this field to develop even further. Strategically, XP-DITE will also enable Fraunhofer EMI to further strengthen its position in aviation security research.

Fraunhofer EMI is interested in the further development or tailoring of the SEP software tool in order to bring it to market and attract new customers. Furthermore, Fraunhofer EMI intends to transfer or extend the SEP software tool to other fields of application in the security area. Fraunhofer EMI is interested in applying the XP-DITE concept to other security checkpoint types in future research programs. A License model is under planning for the SEP software tool. Further research and development will be necessary to produce a market-ready version of the SEP software tool (e.g. improvement of usability) and to transfer it to other checkpoint types.

Fraunhofer ICT's business unit for security, specifically "testing, trialling of detection systems", works on the development of standardised test setups for the field of trace detection as well as the development of new chemical and electric sensors, a fast growing field. The test methods developed in XP-DITE in particular will enable ICT to develop similar structures that could be offer to manufacturers of detection system to help them to improve their products for future needs. The XP-DITE approach and concepts will be used in other projects with national regulators and other customers.

FOI expects to use the knowledge of the aviation security and checkpoints gained on XP-DITE to be able to develop their technologies to meet today's security requirements as well as be prepared for future challenges. The XP-DITE approach and concepts may be used in dialogue with national regulators.

FOI also expects to progress its work on laser spectroscopic detection of explosives, building on the stand-off Raman spectroscopy technology developments in XP-DITE.

Homeland security forms a core strand of **Cascade**'s business activities, with a particular focus on aviation security. The results of its work in XP-DITE will add to and leverage Cascade's ongoing activities in explosives vapour detection, as well as in other vapour sensing applications.

The sensing technology developed for the QCL-based baggage scanner, an instrument for the detection of trace levels of vapours emitted by explosives or precursors of explosives, baggage screening at airports security checkpoints, is being and will continue to be exploited in different security and non-security related projects. More specifically, it can be used in leak detection system for a range of markets from food packaging to pharmaceuticals, in which the objective is to detect the emission of unwanted gases rather than measuring their exact concentration. This type of sensor could also be

used in future security related application such as cargo aviation or mail screening for instance. The detection method and software developed in XP-DITE can also be used in Cascade's leak detection systems. The experience gained in analyser testing and sample preparation has led to knowledge being gained regarding the specific properties of gases, and can also be used in other security applications.

Iconal Technology is already benefitting from the knowledge, insights and expertise it has gained in the design of innovative security systems and will continue to apply these to work in aviation security, airport security and in other checkpoint and crowded places screening applications. Iconal plans to exploit the XP-DITE design and evaluation tools and methods developed in the project in its work for national and European government authorities as described above A series of meetings has been planned with the UK Department for Transport and is already underway. Iconal will also benefit from the contacts built up during the project with other project partners and stakeholders from across the EU.

Iconal also plans to exploit the results of the study on Emerging Checkpoint Technologies, which resulted in a substantial survey and analysis of new and emerging detection and other enabling technologies, in its work for government customers in the UK, Europe and USA.

As well as aviation security, Iconal is exploiting the results of XP-DITE in other applications identified in the XP-DITE study on other checkpoints and other modes of transport, with projects just starting in the area of security of large events and crowded places in response to recent attacks.

As a consulting practice, **ID Partners** is regularly hired by government agencies and industry firms addressing aviation security issues. Based on its work in XP-DITE, it intends to:

- Increase activities with government agencies and industry in aviation security areas
- Help government clients select equipment based on regulations and standardisation advances
- Cooperate with industry to include new systems and pioneering technologies

In particular ID Partners is interested in coupling the MO approach to passenger profiles, and the concept of system level security, for the purpose of Risk Based Security.

Scarabee, as a security integrator and innovative company, benefits from the knowledge and experience gained working together with high level partners in aviation security on the innovative topics of system level design of checkpoints which can be used in future projects and collaborations

CASRA/APSS are particularly interested in the project and its outcomes mainly because of the research possibilities. The project should enhance APSS's expertise in checkpoint design and therefore facilitate generating research ideas. Furthermore, the collaboration with versatile groups of organizations and experts is something APSS is always seeking to stay at the pulse in this rapidly changing field. CASRA/APSS plans to further develop and exploit the XP-DITE design and evaluation tools and methods developed in the project in its research and projects for customers in the aviation security sector as described at the beginning of this section. Exploitation is foreseen both directly by CASRA/APSS and indirectly through licencing to other project partners and to third parties.

The knowledge of the aviation security area combined with the ethical evaluation methods and tools developed on XP-DITE will be used by the **University of Freiburg** as the basis for further research and applications in the field of security ethics. The Ethical Framework (a validated framework for

comparative evaluation of ethical, legal and societal risks of passenger screening at airports) can be used as part of consulting activities for airport checkpoint designers and other decision makers. While the approach is documented in detail and will be published as open access, it requires a considerable know-how to apply it correctly to new situations.

Freiburg foresees this as part of a wider consulting approach in cooperation with some XP-DITE partners. Furthermore, the ethical framework could be adapted to other screening contexts as part of further EU or national research projects. Work on this has already begun and we hope to thereby deliver the necessary tools to strengthen the consideration of ethical, legal and societal aspects in security provision contexts.

4.1.5 Website and relevant contact details

Website

www.xp-dite.eu

Contact details

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Partners

TNO – Netherlands Organisation for Applied Scientific Research
(Coordinator)
The Netherlands

Alfa Imaging
Spain
Alfa Imaging has been a partner until October 2015

Cascade Technologies
United Kingdom

Center for Adaptive Security Research and Applications (CASRA)
Switzerland
CASRA is a partner since July 2014

FOI – Swedish Defence Research Agency
Sweden

Iconal Technology
United Kingdom

ID Partners
France

Fraunhofer Gesellschaft
Germany

ISDEFE – Ingeniera de Sistemas para la Defensa de Espana
Spain
Isdefe has been a partner until February 2014

The Manchester Airport Group
United Kingdom
Manchester Airport Group has been a partner until April 2014

Morpho
France

Amsterdam Airport Schiphol
The Netherlands

Shannon Airport Authority Ltd
Ireland
Shannon Airport is a partner since April 2015

Smiths Detection
Germany

University of Freiburg
Germany

Video

https://www.youtube.com/watch?v=fHdN1351xw0

4.2 Use and dissemination of foreground

This section is available in the EU portal

4.3 Report on societal implications

This section is available in the EU portal