PROJECT FINAL REPORT

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Project acronym: FASTPASS

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Final publishable summary report

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EXECUTIVE SUMMARY

Security, facilitation, harmonisation: these are the key challenges for border control in the European Union. As passenger flows increase, more and more travellers want to cross the Schengen external borders with maximum convenience and speed, while at the same time border guards should secure the zone against various threats, which can include terrorism, irregular immigration or crime.

Thus, the FastPass project has established and demonstrated a harmonised, modular approach for Automated Border Control (ABC) gates. Uniting the experiences of 27 partners, FastPass took into account the entire ABC value chain – system and component producers, research institutions, governmental authorities and end-users – and proposed a solution fulfilling the specific needs of air, land and sea borders and the needs of a large variety of stakeholders. The modularity of the FastPass solutions allows the exchange of single components of the system and allows to establish a clear comparison between vendors. The harmonised FastPass architecture supports a large variety of processes in border control and different border types. Therefore it empowers the development of the market by reducing buyers' costs and making them more independent towards suppliers.

FastPass is a solution developed in a user-centric way: the whole innovative process was regularly evaluated by two end-user groups: travellers and border guards. For the latter, a new User Interface has been developed, allowing for more intuitive use and a well-arranged overview. As for the traveller, the system helps to reduce stress linked to travelling by fostering a faster throughput (in the range of 500 persons/h) and a simple interaction. The machievements can be summarized as follows:

Next-generation sensor development and novel frameworks, software and algorithms meeting the challenges of on-the-move biometric identification, speed, costs, image quality, reduced intrusiveness and counter spoofing. FastPass took into account all security aspects in the design and development process. Thus it developed modules against the most recent attacks both on identity documents and biometrics, such as detection of counterfeit documents, face or finger spoofing, attacks with mobile devices and piggybacking in ABC gates.

Innovative scenarios developed based on a harmonized architecture and optimized processes (i) to serve demands on air borders, (ii) proposing a solution for border checks at cruise ships and (iii) proposing a solution for travellers remaining in cars at land borders. All these different solutions are based on a common harmonized architecture.

Methodology for a holistic risk and security assessment leading to a list of threats, which were categorized according their type, impact, exploitability and mitigation strategy. More generally, FastPass established methods for security and privacy assessment under a common procedure: security can now be consistently compared among EU Member States, with other countries or among different installations.

FastPass has demonstrated several Automated Border Control innovations at the process, modular and general level at the three European borders in Vienna Airport, Piraeus Port and the Moravita land border crossing point. More than 10.000 travellers and around 200 border guards used the system, which provides a novel analysis and insight into different scenarios and their results from technical, operative, social and legal perspectives. Adapted to various kind of borders and border control processes, FastPass answers the needs of multiple stakeholders. Finally, the project summarized its findings also in a set of recommendations for setting-up, operating and assessing ABC systems.

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PROJECT CONTEXT AND OBJECTIVES

The key challenges for border control in the European Union are security, facilitation, and harmonization. As passenger flows increase, more and more travelers want to cross the Schengen external borders with maximum convenience and speed, while at the same time border guards should secure the zone against various threats, which can include terrorism, irregular immigration or crime.

Systematic ABC solutions are minimizing the conflicting gap between time-consuming border control, handling challenges in quality and quantity on the one hand and shrinking public budgets on the other hand. At the time the call topic was opened, the first member states had started to implement ABC systems. Since then the number of ABC systems in Europe strongly increased and more and more member states were implementing automated systems. Therefore, the harmonization aspect as well as the modularity, security and integration aspect have become increasingly relevant.

The main objectives of the project have been outlined in the beginning of the project as follows:

- Harmonized ABC solution that is able to integrate EES and RTP
- Harmonized ABC usability, based on travellers' feedback and supporting the border guard to focus on potential risks
- ABC solution supporting an innovative border crossing concept with interfaces to existing security and infrastructure processes demonstrated at air-, land- and sea borders
- ABC reference architecture based upon innovative technology within interoperable modules
- European cooperation: A European solution and a European ABC network

After FastPass has been proposed, the first draft of the Smart Border Package was published in 2013 based on the previous suggestions to establish an Entry/Exit System (EES) and a Registered Traveller Programme (RTP). Several years later, the regulatory activities brought up new regulations on PNR and VIS, proposals for a new version of the smart border package and for amendments to the Schengen Borders Code and ETIAS. Also changes of regulations such as the General Data Protection Regulation influences the environment in which ABC systems have to operate. Therefore, the project carefully considered these ongoing developments.

Also during the course of the project, the political landscape was on constant transformation due to crises e.g. in Ukraine and Syria and the following migration developments. This, together with terror attacks in member states, shifted the focus of border control priorities from facilitation - as it was at the beginning of the project - more to security, which is now of particular importance.

Further, over the years, technologies developed, computuational power and camera performance increased and enabled higher accuracy and reliability particularly in overall system performance and biometrics. FastPass has contributed to this development by supporting the massive progression beyond state of the art. This is reported in detail in the following chapters.

Since the preparation of the project, security related events, political decisions and regulatory development have changed aspects that are relevant for the development of ABC systems. However, the main aims of the project were kept, while the detailed objectives were adapted to the current changes: Focus was put on the security and risk assessment work and the developments within the smart borders activities. Additionally the planned demonstrators were enriched in several ways. First they were put into operational settings, second, some of them were even used as pilots with more than 10.000 travellers using them. Third, several different concepts were evaluated, showing that the

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FastPass concept is modular and flexible for a large variety of stakeholder needs and operational settings.

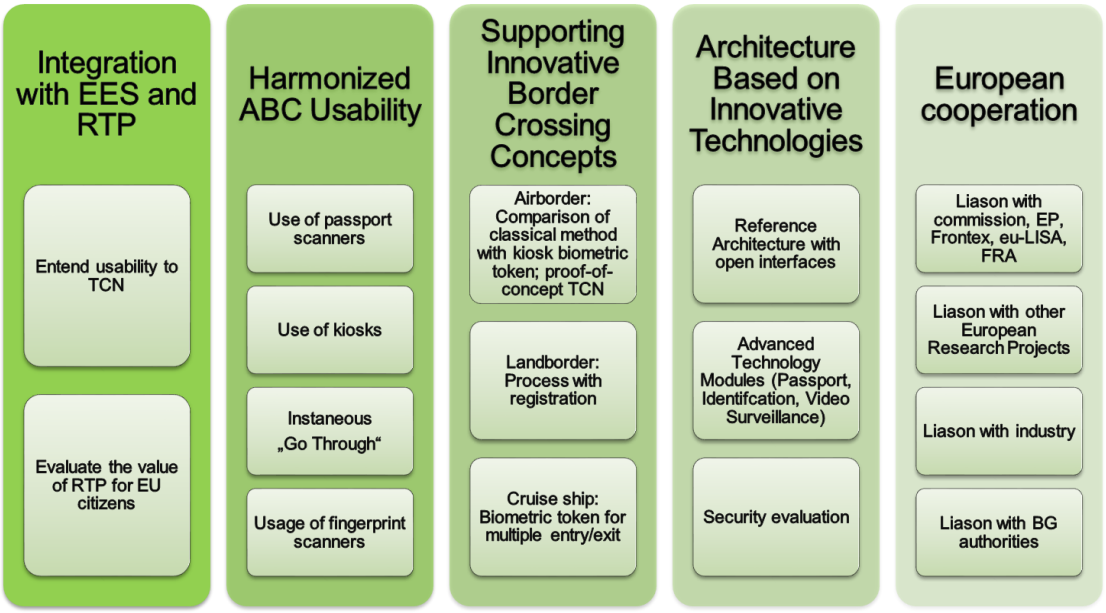

Figure 1: FastPass objectives.

Harmonized ABC solution that is able to integrate EES and RTP

Entry/Exit systems and registered traveller programmes exist in a large variety of implementations. Both could benefit from ABCs in time savings especially in the context of cruise ship or land borders. During the course of the project, the Smart Border initiative with Entry/Exit system and registered traveller programmes was revised twice and future border control was studied and piloted by the EC. It was therefore necessary for the project to observe the regulatory development and to mirror them against FastPass objectives regularly.

Furthermore the FastPass system development needed to take into account future regulatory landscape to fully support solutions that take benefit of the automation aspects. To support the ongoing developments, FastPass demonstrated the harmonized concept integrating novel technologies at different pilots on various border types.

It was aimed at broadening the availability of ABCs to Third Country Nationals (TCN). The goal was to demonstrate and confirm this with both visa exempts, and with visa holders with interview questions on a kiosk and fingerprint capture.

The concept of the Registered Traveller Programme changed within the new proposal for Smarter and Stronger Borders into National Facilitation Programs (NFP). ABCs could gain benefits from NFPs in time savings especially in the context of cruise ship or land borders. Additionally, it should be demonstrated that such NFPs also bring benefit when applied to European citizens.

The maximum benefit of the solution can be achieved, when it is easily adoptable to the need of a specific border control organization. Therefore, the solution should be based on a modular IT-architecture. To answer this, the RM-ODP methodology was selected as high-level reference architecture.

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Harmonized ABC usability, based on travellers' feedback and supporting the border guard to focus on potential risks

The usage and success of any ABC system is based on the positive experience of the users – travellers and border guards. This was the motivation to base the whole development process on extensive feedback from these main stakeholders.

One key element for the users' satisfaction and the process smoothness, is the ABC usability. To include this into the development process, stakeholder workshops and interviews with travellers and border guard had to be performed. Based on the stakeholder needs, a comprehensive set of requirements needed to be established and managed throughout the project. Evaluation criteria derived from the stakeholder analysis should be the basis for the overall system evaluation.

An updated concept for usability of ABC gates, acceptance and privacy supported by stakeholder interaction with surveys (e.g., survey for people with disabilities) and newsletters was a key objective. A clearer separation of current and future legal requirements and socio-ethical, political aspects analysing the Smart Borders Initiative and other best case practical implementations could determine gaps and options for further development.

To achieve a harmonized usage, the border guard user interface and the video management system needed be developed and verified with stakeholders to achieve common appearance and usability across different border types and installations.

ABC solution supporting an innovative border crossing concept with interfaces to existing security and infrastructure processes demonstrated at air-, land- and sea borders

Previous border control solution with automated gates were limited to "air-border" like implementations. Solutions for land borders did not exist; for cruise ship also no automated solution was available. In addition, the air border solutions differed considerably and no scientifically grounded comparison was available.

FastPass aimed to develop a border control process that is optimised and harmonized across different border types (air-, land- and sea borders). The developed novel concepts for three types of border crossing should be enriched by training modules and adaptive selection of monitoring techniques. The concepts should include (i) a quick and moveable solution for cruise ships, (ii) a new solution for land borders with passengers remaining in their cars, (iii) a comparison of different ABC concepts for air borders including a novel 2-stage concepts using biometric identification with face as a token.

A main objective was that the solutions are demonstrated at real border crossings, used by real passengers and border guards and evaluated from technology and user perspectives.

ABC reference architecture based upon innovative technology within interoperable modules

One main objective was the design of a modular concept that allows border guard organizations to flexibly manage their borders. This should include the ability to use ABC systems flexible and to be modular, i.e. to enable a reasonable variation and combination in processes and devices/modules.

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Therefore, the reference architecture was aimed to be modular based on the RM-ODP methodology and useable for various ABC topologies. Several ABC modules needed to be advanced in their functionalities and had to comprise safeguards, which increases the overall system.

The developments should include advanced biometric modules, attack and spoofing resistant passport inspection modules, user interface modules and new methods for multi-biometric fusion. Additional modules for adaptation to new documents should be available. Video surveillance modules should be based on an open framework and provide technologies for single person separation for anti-tailgating, left luggage detection supporting the passenger flow, queue management and detection of specific behaviours in front of the gate.

To achieve EU-wide similar security levels for ABC systems, various (IT-related, IEMI-related and user-related) risks needed to be identified. The risks should be quantified with respect to damage potential, exploitability, affected components and threat categories.

One key objective was to define and develop methodologies for security assessment privacy impact assessment, which allows to compare the risk and security levels of several installations within and among member states.

European cooperation: A European solution and a European ABC network

The impact of FastPass technologies and innovations can be increased with the clear objective to foster the European cooperation and the European marketplace. This enables the involved industry to provide European solutions also beyond the continent.

The cooperation with EU institutions (Frontex, eu-LISA, DG-HOME, FRA and others) could provide input in both directions: (i) from the institutions into research by providing insights in political and regulatory developments; (ii) from research to institutions providing fact based scientific inputs for future political and institutional directions.

Through Frontex Workshops (on ABC, on European Research), Frontex and eu-LISA Conferences, European Day of Border Guards and other events, member states must be constantly informed about the progress and outcome of FastPass.

It was aimed at performing the research in cooperation with other research projects such as FIDELITY, FastPass, BEAT, FutureID, MobilePass, Eksistenz, PCAS, PIDaaS, ORIGINS, ABC4EU, INGRESS, HECTOS, BODEGA, OCTAVE, PROTECT and SpeechXRay to avoid parallel developments and to optimize research output. Furthermore by common events, increased awareness of a joint European solution for different ABC related aspects could be raised.

FastPass aimed for further dissemination of research results, papers in recognized journals and academic conferences as well as presentations at ABC related key events.

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MAIN S&T RESULTS/FOREGROUNDS

FastPass has **developed and demonstrated a next generation automated border control gate solution** for different (land-, sea- and air-) border control points across Europe, through a three-pillar approach:

- **user-centric:** design around the needs of travellers and border guards
- **innovative:** research and development on the major technical and conceptual challenges for identification and verification with respect to spoofing, usability and data protection
- **context aware:** demonstration pilots to verify the feasibility and full functionality under various conditions and constraints.

FastPass has **designed a modern border control process,** taking full account of privacy, social, ethical and legal issues. This resulted in **smooth and fast border crossing** for legitimate travellers, **while ensuring a high level of security**. In this way FastPass is contributing to **a modern and efficient management of the EU's external borders**.

FastPass engaged with the two most important users of the ABC solutions during the whole development process to reach the project's objectives: travellers and border guards. These two user groups were be accompanying the technological development from the definition of requirements to the demonstration of ABC at selected border control points.

The interaction between users and the technological development effort was ongoing throughout the entire duration of the project. This increased the effort necessary to develop an ABC gate, however it also ensured that the developed technology is accepted and optimised for the end-user. FastPass's user centric approach ensured that the developed ABC Gate has a high end-user acceptance, while at the same time satisfying the needs and restraints of other stakeholders, and allowing border control authorities to better manage and control passenger flows at the external border crossing points.

The first stage in the development process was to establish precise specifications (technical, legal, social, etc.) for the development of harmonised ABC gates. The design and optimisation of security modules within the second stage include travel document inspection, biometrics, video surveillance and the gate itself. In a third stage the individual security modules were assembled into a complete ABC structure. The development of the entire ABC system went beyond the gate itself. The ABC system interacted with national and EU-infrastructures, such as the Schengen information system, visa information system, blacklist and others. FastPass realized several demonstration gates to be tested and evaluated under laboratory conditions. The whole design, development and test process was performed iteratively and tested systems were deployed in various border control settings in Vienna International Airport, Piraeus Port and Moravita Land Border Crossing Point to demonstrate their effectiveness.

As mentioned earlier this entire process was be accompanied by the end-users, who were involved in developments and testing in all work packages reflecting the user centric approach.

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USER AND STAKEHOLDER INTERACTION

The integration of stakeholder and end-user feedback into FastPass, supporting the continuous dialogue with travelers, border guards, and other stakeholders was of critical importance for the success of the technological development activities.

Stakeholder Support and Guidance of Development Activities

For the stakeholder interaction, a management system has been developed based on a customer relationship management system in order to administrate contacts, interaction items and results in a single central database. It has been used over the complete period to avoid duplicate contact, data loss and to provide central access to results.

At the start of the project FastPass members conducted traveler interviews at two European airports and observed travelers using existing ABC systems. Special efforts were taken to reach travelers with disabilities or reduced mobility and ask them for their requirements and demands on future systems. The results were used to create user specific requirements from the travelers' point of view.

Once the FastPass system became available additional observations and interviews were used to have a continuous improvement of the developed systems. At all three FastPass installations (Piraeus – sea border, Vienna – air border, Moravita – land border), observations and manual measurement have been performed. The results were statistically analyzed.

Interdisciplinary Design of a Concept for Acceptance and Privacy

Evaluation of political acceptance

In order to determine the views of political stakeholders and their engagement in the development of ABC systems, FastPass conducted empirical research via a two-pronged approach. First, semi-structured qualitative interviews were conducted with stakeholders at the EU level, in three EU Member State contexts (Romania, Portugal and Austria), and in two non-EU countries with extensive experience in deploying ABC systems (United States and Hong Kong). These case studies were undertaken in order to examine best practices and lessons learned in developing ABC systems within and outside the EU context. Within the case studies we also examined stakeholder views on the Smart Borders proposal (2013 proposed version), which foresaw the use of ABC systems. Interviews were conducted both with policy makers and government representatives within relevant Ministries, as well as with social and ethical stakeholders advocating and/or involved in the policy development process. In total, 66 interviews were conducted, 48 of which were with EU or Member State stakeholders. A divergence between stakeholders was discovered, primarily based on their view on the use of new forms of technology in border management in general and also based on the estimated costs (monetary and perceived social and ethical implications) of implementing such systems.

In the first phase, the team conducted a Q methodological pilot study on what political views are involved and may impact the deployment and development of ABC systems in Finland. As part of this work an extensive documentary and scientific body of material on ABC was systematically examined and 19 Finnish key political stakeholders were approached. In the second phase, the Q methodological instrument was further developed to examine the views of political stakeholders in

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four Member States: Finland, Romania, Spain, and the United Kingdom. These cases at the EU's external borders were selected as they vary in terms of institutionalization of ABC systems, border challenges, Schengen membership, and position vis-à-vis the Smart Borders initiative. Altogether 44 political stakeholders representing 18 parties took part in our Q methodological experiments: 20 Members of Parliament, 3 Members of the European Parliament, 1 Senator, 12 policy experts for parties, and 8 high-level political experts. They were asked to rank-order a sample of carefully selected statements on ABC systems drawn from our documentary and scientific material, according to their own view, which is assumed to be operational in their decision-making and/or advisory role.

Our findings include a clustering of their views into three groups: privacy and fundamental rights View; ABC-positive security and integration View; and the immigration critical Eurosceptic View. In the third phase, we compared the vested interests of all Member States vis-à-vis the Commission's revised Smart Borders proposal of 2016 by first examining their publicly available submissions, resolutions and position papers. Significant differences were found in the national consultation and decision-making processes; in how much information the MS share on their emerging views (seven MS did not release a single document or communicate any position); and some divisions on the views on automation of border control as such, the costs, data use issues and operational principles. Finally, it was found that no MS currently communicates any clear preference for EU-level legislation on automation of land borders with existing technologies.

Border Guard Interaction

Semi-structured qualitative interviews were conducted with border guards (operational level) and border management representatives in the context of the research on political stakeholders, for their views and role in the development process of ABC systems within a broader border management perspective. The views of border guards and managers in Austria, Portugal, Romania and Hong Kong were collected. This empirical research aided in the analysis of socio-ethical and political viewpoints of ABC systems, as well as in identifying best practices and lessons learned for future development and implementation of systems.

Analysis of Legal Aspects

The FastPass objectives were also driven by regulatory activities. Therefore, a main part of research was performed, by analyzing all important legal aspects of the developed processes and technologies:

- The legal requirements concerning the operation of technologies for (automated) border control (ABC), which stem from the EU Schengen acquis. This included following up on the different EU legislative proposals which could affect in the future the operation of ABCs by imposing new requirements and checks. These proposals were the first Smart Borders Package Proposal, the new EES proposal, the ETIAS proposal and the proposed amendments to the SIS II, to the Schengen Borders Code and the Visa Code. The analysis sought to follow up on the possible future border control processes as well as to propose improvements to the proposals in view of better compliance with the existing EU data protection, privacy and free movement framework.
- The EU privacy and data protection framework as it applies to ABC technologies. The analysis took into account both Directive 95/46/EC and its successor the GDPR, Articles 7 and 8 CFREU, and Article 8 ECHR. The purpose was to create the legal requirements for the FastPass scenarios and ABC technologies in general, to critically examine the existing technologies for border control and legislative proposals and existing legislation on border

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control. Such an analysis was useful as in 2009 privacy and data protection became fundamental rights and thus examining the compliance of existing laws and practices with these rights became necessary.

- Together with the partners from the FastPass end-user authorities, the legal documentation for the validation demonstrations was prepared by analyzing the legal requirements on the border control and data protection requirements for each demonstration/FastPass scenario, drafting the consent forms for the participants and the data exchange agreements between the FastPass partners, as well as preparing the notifications to the local data protection authorities where necessary.

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ANALYSIS AND REQUIREMENT

Analysis and requirements finalised the systematic approach for analysing the stakeholder needs and defining requirements. The knowledge created provided a solid basis for defining detailed requirements for the FastPass system and processes so that the project meets the demand for harmonisation, operational efficiency and border security as well as altogether meet the important expectations from various stakeholders. The work has:

- provided new understanding of the current systems and operational approaches and environments as well as legal concerns and standards
- acted as an initiator and producer of the background knowledge for task forces on land border, air border and sea border scenarios
- revealed the differences between the different border types and developed further understanding of the traveller profiles, operational environments, and surrounding development
- analysed stakeholder needs and refined them into FastPass system requirements, and developed a comprehensive set of system requirements.
- drafted legal requirements stemming from the Schengen *acquis* and fundamental rights framework
- created the project taxonomy.

Stakeholder needs

Key stakeholder needs and requirements work analysed regulatory regime, current experiences of practical solutions, processes, efficiency and harmonisation needs of the future of ABC. Privacy, acceptance and political needs have been considered as well as development for all aspects. It introduced a systematic approach for analysing the stakeholder needs and defining requirements. The engagement with the border authorities in Europe at the strategic, tactical, operative and technical levels has ensured a comprehensive view on the development targets, needs and the potential for innovation.

The operational environments that border authorities meet at air, land and sea borders are essentially very different, and the primary issues and concerns related to them differ greatly from each other. Also, border crossing points situated along the same borderline of a single state may face completely different traffic profiles (‘mass of traffic’). The output illustrated the general and more specific features of the infrastructure and environment present at different border crossing points at European external borders. It took an operational perspective to different border types and to enrich the understanding of the varying contexts and local circumstances that breed into different end-user needs. The results are based on a thorough analysis of research interviews, observations, border crossing point visits. Also, literature reviews and secondary research material and additional sources were used to support the findings. Key stakeholder needs hierarchy consists of the following four levels: 1) border security, 2) speed and smoothness of border crossings, 3) efficiency and cost-effectiveness of border checks, 4) usability of ABCs. These levels are dominated by interdependency. Thus, changes in one of them affect the others.

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Analysis of current and future scenarios

The FastPass project focused on what the future might hold for Automated Border Control. The session targeted at creating scenarios on how border control can reconcile future requirements. As a result the following shared themes emerged:

Introduction of dynamic borders **Emphasis on pre-departure clearance of passengers and free-flowing border crossing:**
Deepening information exchange between different actors **Emphasis on interface development to different databases and information systems:**
Development of next generation tools for the identification of persons **Emphasis on further use of wireless technology:**
Wider application of technology in border control **Emphasis on decreasing human intervention and human interaction in first line checks:**

Based on the 2 workshops three textual narrative scenarios have been produced for envisioning future use of ABC systems. These 'vignettes' present a future vision of how the system could behave, or how the users might interact with the system.

Requirements and evaluation /success criteria

The user needs were further analysed and refined into technical requirements. With three major iteration rounds complemented with numerous smaller stakeholder and partner iterations the original requirements have a structure, content and descriptions responding to the FastPass development needs.

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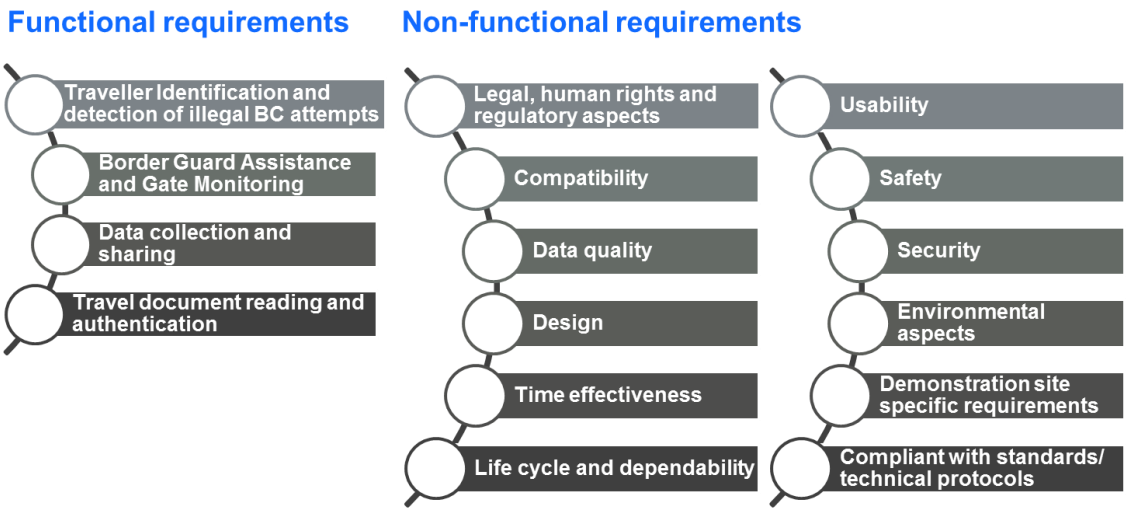

Figure 2: System requirements structure

Included in the analysis are functional requirements such as identification and detection of illegal crossings, border guard assistance and gate monitoring, data collection and sharing, and travel document reading and authentication. Non-functional requirements listed include: system compatibility with applicable standards and technical protocols; systems shall conduct verification using high quality data; design; environmental aspects; compliance with legal and human rights or other regulatory aspects; lifecycle; safety; security; time effectiveness; and usability.

Analysis of Usability

The FastPass concepts drive towards making self-service a self-evident choice for passengers crossing the borders at European border crossing points. The requirements related to usability and positive user experience were described. Passengers can be roughly divided into business and leisure travellers according to purpose of travel. Further the passengers' age, education and nationality affects significantly their knowledge and ability to use technology and to their attitudes towards new technology. Also different physical and mental disabilities may affect the passengers' ability to use self-service border checks. A significant factor in user behaviour is the "amount of experience" to ABC systems. Requirements to ensure the efficiency of border guard's tools and work processes are also presented. The requirements have been divided into five categories (Figure 3).

Figure 3: Categories of usability requirements from border guard's point of view.

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Specification of Evaluation/Success Criteria

With respect to evaluation and success criteria the final criteria catalogue was reported. The work provided an initial specification for the establishment of measurable evaluation and success criteria which ensured that the project produced an acceptable product in the eyes of end-users (potential customers, end-users and travellers). It discussed the relations of evaluation and success criteria to the project's harmonization and efficiency objectives and provided a background to support critical decision-making in the project's lifetime. The work was correlated with stakeholder needs and evaluation efforts: measurement values were specified in detail in parallel with early phases of system design.

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TRAVEL DOCUMENT OBSERVATION

The objective of FastPass was to enhance current state-of-the-art document authentication systems which can be used in an eGate to automatically verify if a travel document is genuine and extract all necessary data that is used by other processes in the border control process (for example the face image for face recognition algorithms to perform biometric matching). One aspect of the development was the interchangeability of components to be open for different vendors. Another aspect was the evaluation of the security, quality and speed of automated document inspection process which can potentially compromise the whole border control process. This was achieved through the following steps:

- assessment of the inspection process (security, quality)
- integration of standardized document inspection hardware components and well-defined software interfaces
- development of guidelines from document inspection perspective concerning the implementation of a FastPass gate in certain scenarios
- sustainable operation of document authentication without the need for third parties managing the inspection process and providing the document databases.

Automated Inspection of Optical and Electronical Security Features

Within FastPass analysis of external threats related to high power electric magnetic signals intervening with inspection hardware operation was performed and recomendations on counter-measures were provided. This included joint work with the EU projects HIPOW.

A strudy on durability of security documents was conducted with emphasis on stablity of selected visbile, IR and UV security features. Factors such as wear and tear, abrasion, graffiti, or mechanical crumpling strongly influence the overall document's condition and may have severe impact on the image quality perceived by document readers. This study allowed to determine critical and less critical security features for reliable performance of document readers in ABC systems and take these factors into consideration during creation of templates with the document verification module.

Another study was conducted on avaialble document reading technology with 9 document readers and 6 vendors. Tests were performed with a set of 41 genuine documents from 10 different countries. These tests showed very different performance of these devices and huge deviation from parameters declared by vendors. Those deviations relate to optical resolution, colour calibration, lens distortions, illumination spectra especially for UV-A. As a result it could be recommended to establish certification procedures for hardware compliance to certain requirements, not only for software compliance to international standards.
There were no substantial development in verification of electronic chip data. This part is standardized and strict complience of software performance with these standards is a must. Authentication software must support all electronic check protocols, including:

- access control protocols (BAC, PACE, EAC)
- authentication protocols (PA, TA, CA, etc.)

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Document Verification Module (DVM)

DVM was developed and presented as a complete state-of-the-art solution for description of security features of any travel document or other secure documents and creation of templates for further use with document readers in order to perform automatic checks by ABC systems.

DVM structured all existing documents by country-document-sample scheme. Functionality to create, store and manage templates was clearly described and documented. This modules enable the border guard authority to manage level of security, change thresholds and set rules of countries and documents depending on situation at a border.

Background Adaptor

Background Adaptor Component was developed in order to meet the real world demands of an automated border control system. This modules connect the ABC system with different background systems for individual background checks. The operational implementation of the Background Adaptor, using the Microsoft .NET Framework, has been realized.

In order to provide a method for the system integrators to test the FastPass prototypes without a live connection to background systems, mockup-components have been developed.

The integration within the FastPass system has been realized with the BackgroundAdaptor implementation for the Austrian EKIS system (national databases, SIS v2, Interpol). This component was successfully tested within the Vienna Airborder Scenario prototype, where it served in a fully operational environment.

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TRAVELLER IDENTIFICATION AND MONITORING

FastPass concentrated on evaluation and optimisation of technologies for the identification and monitoring of the traveller based on biometric (face, fingerprint and iris recognition) and video surveillance technologies. The work on traveller identification and monitoring can be divided into five main tasks. Through these tasks, technology innovations in both biometric video surveillance fields have been achieved by all the technical partners, via academic research and industrial development.

Evaluation of applicable technologies and sensors

Review, analysis and evaluation on state-of-the-art technologies and investigation on novel potential sensing technologies for both biometric identification and video surveillance that are suitable for the purpose of automated border control were performed. The literature of the state-of-the-art for both biometrics and surveillance technologies was elaborated in detail. Intensive evaluation based on experiments and SWOT analysis has been carried out. Limitations and challenges have been identified for the current technologies. This helped the whole FastPass project establish a good knowledge base on the technical side and informed FastPass with a clear and deep understanding on both advances and limitations of current relevant technologies in the context of border control. The evaluation of both biometrics and video surveillance technologies and functionalities shows the shortcomings of current products for future eGates.

Development of advanced biometric identification

FastPass has developed the next-generation biometric identification approaches and video surveillance components for ABC. Solutions for traveller identification using face, iris, and fingerprint as biometric characteristics, as well as fusion concepts and video surveillance (monitoring) technology have been developed.

Identification and monitoring guidelines were developed, which provided an updated review synchronised with the latest scenario descriptions outlining the Border Guard and Traveller's experience for each of the employed Border Types, and highlighted exceptions, how to deal with them, and how they are reflected (processed) in different modules. Exhaustive insight was achieved in conducted research activities (i.e. with quantifiable results, listing research questions addressed, means to answer the questions using experiments, sample data) related to the different individual biometric characteristics in the project: fingerprint, face and iris recognition.

Counter spoofing methods were developed to enable fast, reliable and secure identification at the border, which provided a robust and secure system against different types of presentation attacks e.g. face images/videos shown on a paper, textiles, handheld devices (e.g. smart phones and tablet PCs), and even 3D masks. A 3D camera technology is developed and deployed in the FastPass gate system. In addition, NIR illumination is employed and the reflection of the skin, which is different to artificial material, is also employed.

For fingerprint, a learning-based counter-spoofing approach based on bagging classifiers was developed. It was achieving excellent recognition accuracy results, which were published in a high-

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impact journal. Further research in the intersection of fusion and counter-spoofing has been undertaken successfully and published.

Next-generation fingerprint identification developments delivered an innovative fingerprint sensor system focussing on usability and ergonomically aspects, since user interaction is a very critical factor in performance. The main objective of the fingerprint product for FastPass was to extend the single finger reader to multiple fingers without compromises in usability if simultaneous four-finger capture is attempted. This was accomplished with a 2-finger reader.

Moreover, several sensor-related improvements towards intuitive and accurate equipment were achieved, together with algorithmic/systemic investigations related to 2-finger versus 4-finger recognition, impact of weather conditions, contactless vs. touch sensors, and investigations related to suitability for different border types.

Next-generation face identification developments delivered an innovative face bridge technology for e-gates and kiosks, which has achieved non-stopping at-a-distance face recognition using an innovative mirror-based technology – Adomo (Advanced Optical Modulation Technology) that enables the camera field of view to be deflected by a high speed moving small mirror so that the camera view can change to different positions within milliseconds and track the face in high resolution independent of height and position.

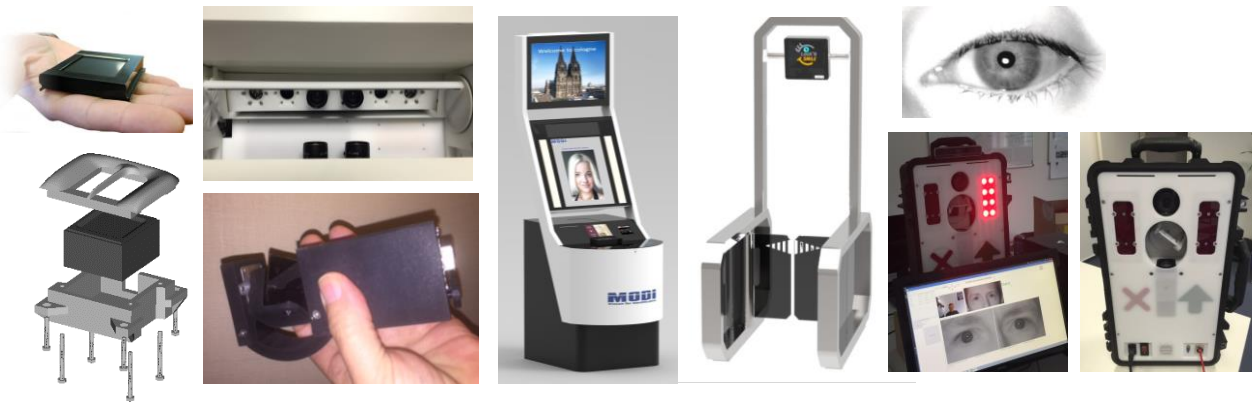

Figure 4: a) Fingerprint finger placement module b) Face recognition system for both kiosk and eGate based on Adomo mirror technology; c) Portable long-distance iris recognition system

Research innovations have also been undertaken beyond these tasks. A periocular recognition algorithm combining 3D and 2D features was developed, targeted the foreseen 3D technology research in this project, which should complement face recognition to increase recognition accuracy when face image quality is low (e.g. partial occlusion, head pose, etc.). A portable iris sensor suite was developed which captures iris at-a-distance and the price is relative much cheaper than traditional iris sensor systems for ABC. Several iris recognition aspects augmenting the state-of-the-art in visible range vs. near-infrared recognition approaches (a cross-spectral sensor developed for this task), segmentation fusion, and sclera segmentation were reported. The first competition on cross-spectrum iris and periocular recognition was organized in association with the top biometric conference BTAS 2016 to promote this research topic and generated a large benchmark dataset for algorithm evaluation. The main purpose is to benchmark the problem of cross-spectrum biometric recognition, increase the usability of ocular recognition, especially in ABC systems, and investigate

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the possible benefits of cross-spectrum matching at-a-distance and on-the-move. This competition is being continued for a second edition with IJCB 2017. These research outcomes have all been reported in top biometric conferences.

Biometric optimised engine

Advanced biometric fusion engine for identification employing advanced data fusion methods was developed. The main objective of the biometric data fusion methodology is to provide a modular approach for combining data retrieved from the biometric sensor (fingerprint, face, and iris) and from the passport. A Neural Network-based biometric fusion, Sum-rule modality-based biometric fusion, Bagging of Classifiers and Spoofing-Aware Fusion and latest results on fusion of face and fingerprint as well as multispectral Fusion have been delivered. These approaches were evaluated with regards to chimeric publicly available datasets offering repeatability of results. The biometric data fusion methodology should be able to handle different kinds of variations in biometric system configurations (e.g. only face, only fingerprint, fingerprint-face, etc.), thus leading towards harmonized solution which will be deployed in different ABC environments.

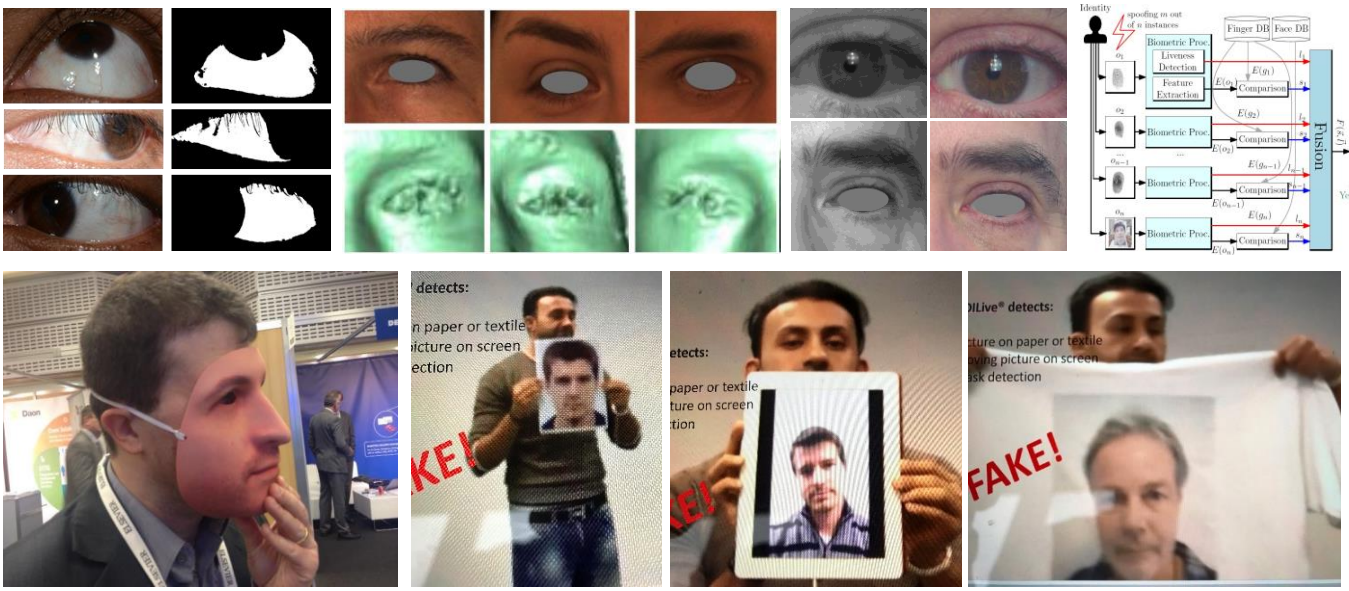

Figure 5: FastPass scientific research for biometrics (sclera segmentation, periocular recognition, cross-spectrum ocular recognition competition, spoofing-resistant multimodal biometric fusion framework) and counter-spoofing module for face recognition system

Development of advanced video surveillance

A novel and modular Video Surveillance Framework connecting CCTV cameras and advanced intelligent video analytic modules for automatic event detection has been developed and showcased during FastPass demonstrations.

Connected Vision – comprehensive distributed videos surveillance Software Development Kit (SDK) for rapid computer vision application development. The SDK achieves a modular and micro-service architecture, and allows collection of data from multiple hardware sources.

Based on a newly built trinocular 3D camera system the following systems have been developed:

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Person separation – top view 3D-system deployed in the gate, to automatically detect illegal passing through the gate, such as piggybacking and tailgating.

Left luggage detection – top view 3D-system deployed in the gate, to automatically detect left luggage inside the gate by combining 3D and 2D information. This ensures no luggage left behind inside the gate.

Queue analysis – deployed perspectively to cover a large area (up to 15m). The system automatically analysis complex, dense and meander-shaped queues to automatically estimate queuing time.

Abnormal behaviour detection – based on the individual person tracking from the queue analysis and a novel activity zone learning algorithm has been developed to automatically analyse and detect abnormal behaviours of the travellers in front of the gate/kiosk area. The purpose is to increase border control security.

Dynamic queue optimisation – based on the queue analysis the system automatically optimise the passenger flow and manage the waiting queues, which would be beneficial to travellers, security staff and control staff.

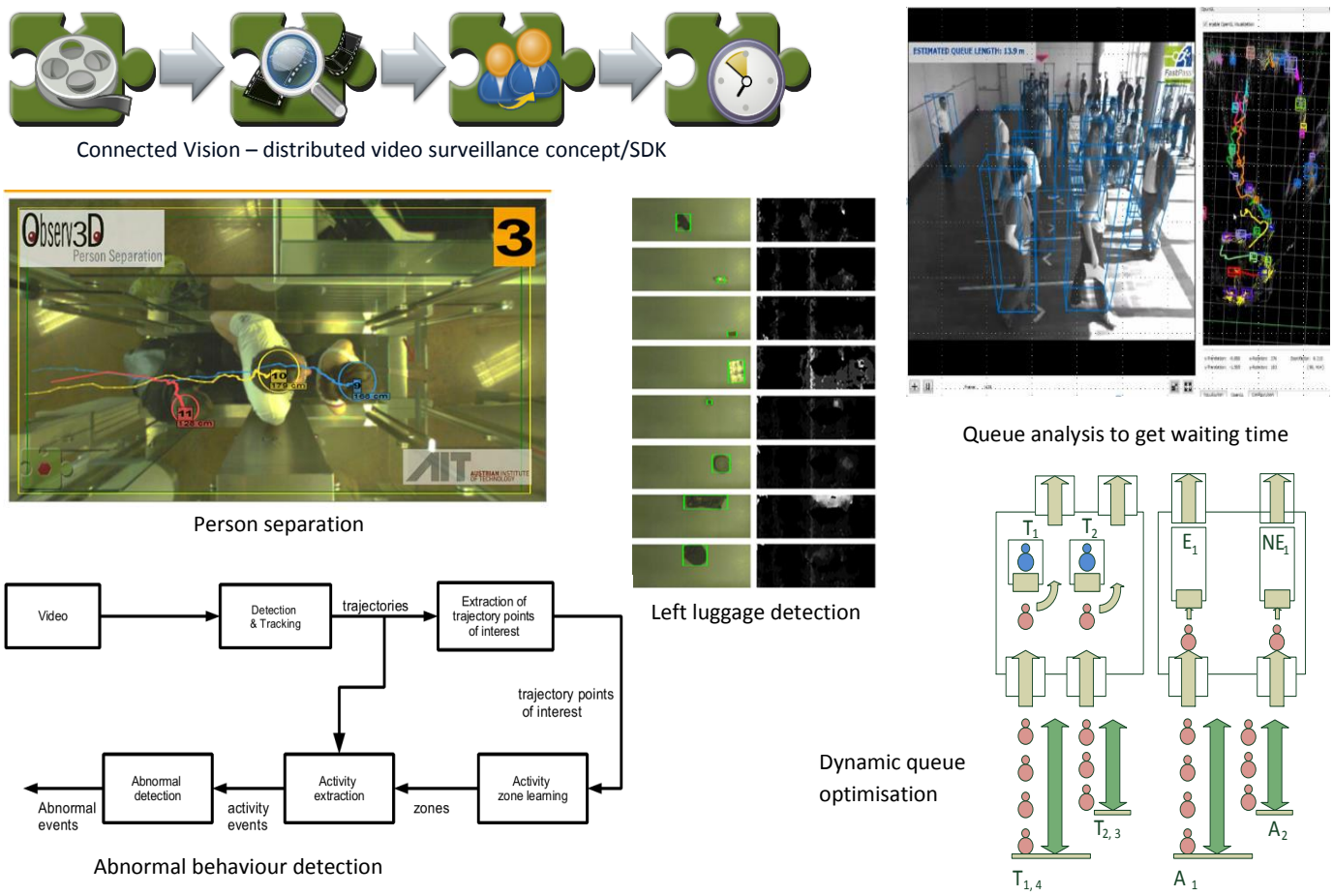

Figure 6: FastPass video surveillance modules

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ABC event detection and alarming

A software framework was developed that can effectively make a decision on letting a person go through the gate by combining the output from biometric identification module, video analytics module, travel document reading module, and even the background information. The output for each module is based on a parallel of events detection, which may result in raising the potential risk of a particular passenger. The alarming module is a crucial component in the eGate system for border crossing security.

An efficient alarming framework was developed based on abnormal event detection and robust rule-based fusion logic. The framework can be easily updated and adapted to different border crossing scenarios. In the current setup, the alarming module takes input from biometric identification modules, video surveillance modules, a travel document verification module and a background adapter to detect security events. However, further input sources can be plugged in and the event list can be updated accordingly. The high-level rule-based fusion logic can be easily tuned based on the source data type and the border scenario. The self-contained alarming API can be easily adopted in another framework, while additional components can be simply plugged in to provide more information.

At last, a detailed evaluation of the biometric and video surveillance modules based on data collected for FastPass and synthetic data generated based on FastPass scenarios were achieved, which closes the feedback cycle to optimise developed concepts.

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BORDER GUARD ASSISTANCE AND GATE USABILITY MODULES

The main purpose of gate usability modules is the integration of several software and hardware components into one test system at the different scenarios in Vienna, Moravita and Piraeus. This means gate mechanics and hardware housing for all technological components such as document reader and cameras as well as user interface for border guards. User interface integrates together and graphically presents all the information coming from other parts of the system such as alarms, video feeds and automated analysis results.

Translucent and illuminated eGate for Air border needs

The air border eGate design contains a significant amount of glass to make it open, friendly and attractive for passengers (Figure 6). In addition, a new concept of a friendly and attractive gate illumination was developed and tested with the Airborder and the Seaborder gates. The result is a comprehensible indication of the status of the gate. Additionally new semi translucent materials were used for these gates. All electrical wires and cabling is designed to connect to the gate from the ceiling above. This design provides significantly easier and more flexible positioning of the gates in the border area. When moved, the gate does not leave any holes or marks into the floor.

Figure 7: eGate design variations for air border implemented at Vienna airport.

In order to ensure the eGate can meet the ABC market needs now and the future, it used a modular, flexible design with building block architecture, supporting several component vendors and other co-operation partners globally.

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Intelligent Gate for Land border adapts to car dimensions

With the drive unit for the land border gate it was developed a new range of products. This unit drives a fixed terminal vertically and horizontally towards passengers sitting in a car, to positions where installed devices can easily and comfortable be operated. Figure 7 illustrates the concept of the gate with two ABC terminals, entry and exit barriers and traffic lights. An intelligent sensor technology prevents the terminal from touching the surface of the car and from injuring the users. With the drive units being fixed to the ceiling the land border gate needs as less space as possible regarding the width of the passage. The drive units can be arranged in a way that up to four passengers sitting in a car can be checked simultaneously.

Figure 8 illustrates the implemented gate at Moravita border crossing point. Figure 9 shows a detailed view on the ABC terminal unit that integrates passenger information screen, face capture camera, passport reader and intercom phone.

Figure 8: Land border tunnel gate for vehicles and passengers supports 1-4 ABC terminals.

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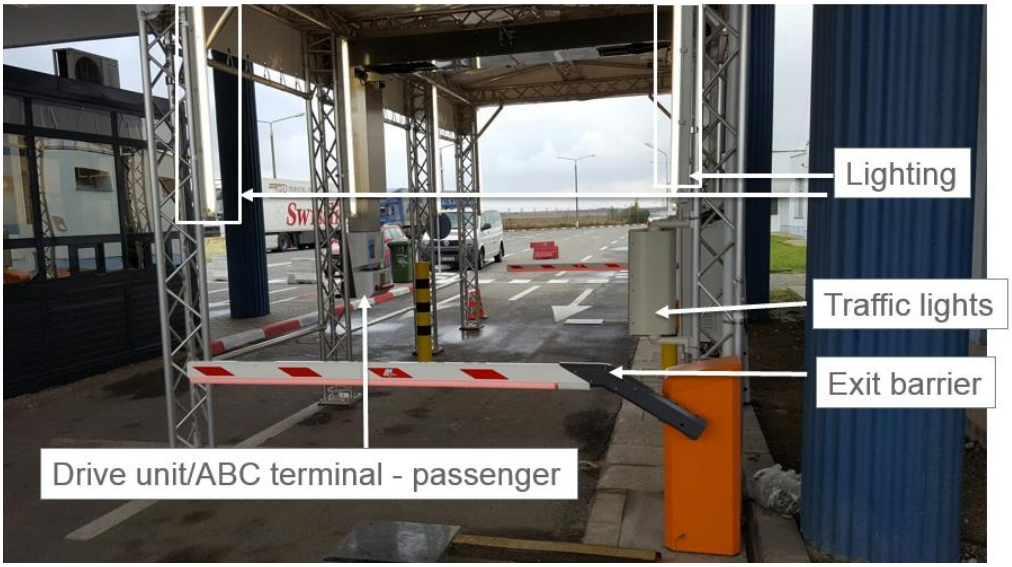

Figure 9: Installation of the land border gate tunnel in Moravita.

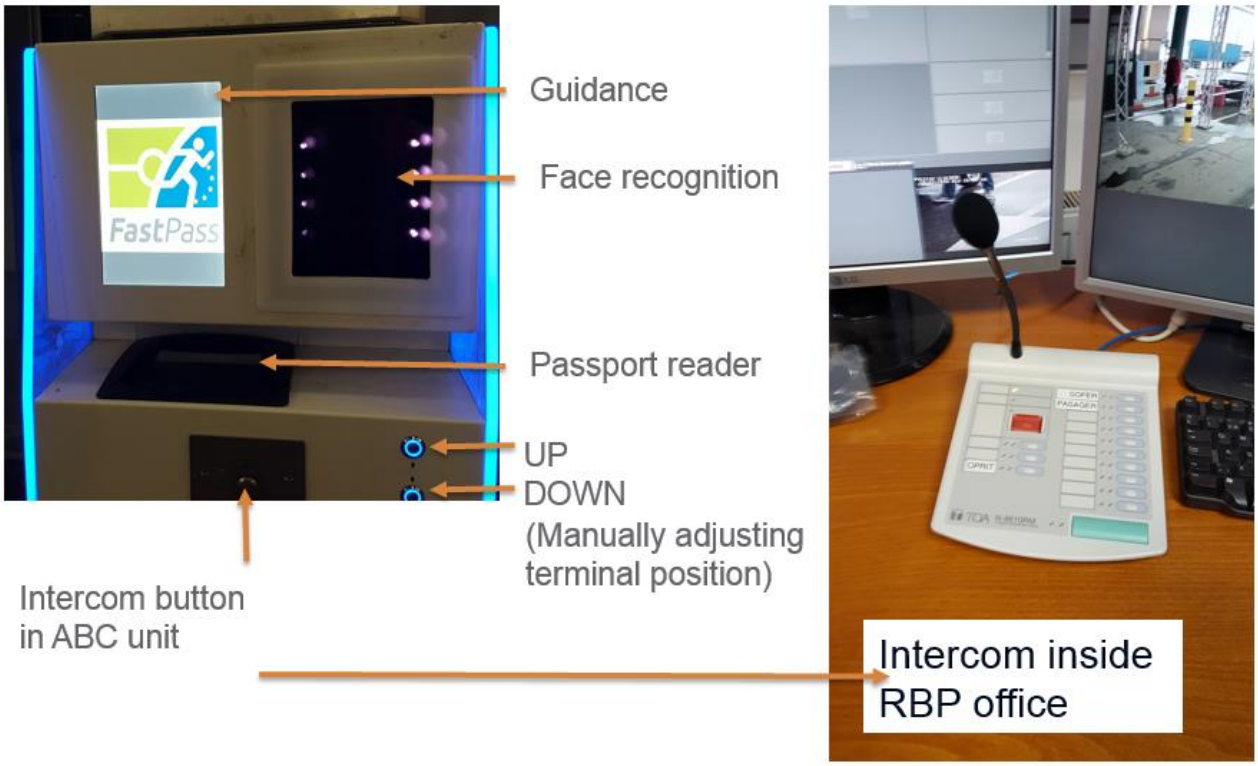

Figure 10: Details of the land border gate: ABC terminal (left) and intercom (right).

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Portable and lightweight Gate for high throughput at Sea border

With the Seaborder gate it was developed and tested an automatic border control gate for pedestrians which can be easily uninstalled and folded, so that it can be moved to various locations in harbours also through small and low doors.

Figure 11 illustrates the concept of the gate and how it can be folded for transportation. The gate is very lightweight and it can be moved by one person with a low-floor fork-lift (red, in the middle of Figure 11). The single door gate makes the border check process very fast.

Figure 11: Sea border gate

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PROCESSES AND BORDER MANAGEMENT

FastPass took the challenge to harmonise and optimise processes for different border crossing types - air, sea and land - where no automated process has been used before. The purpose of the process harmonisation and optimization is to ensure that passengers have similar experiences at different border crossings. This will speed up the processes significantly and will give passengers a secure and comfortable feeling, while also enhancing the acceptability of the ABC gates. Another reason of harmonisation and optimisation is to ensure process's efficiency and proper management of all resources (e.g. people and technology). Processes for travellers and border guards have been designed in accordance to the guidelines from Schengen Border Code and Frontex publications relating to ABC implementation and TCNs processing. The results of harmonisation indicate that all process aspects (= different stages and elements of border crossing process), regardless of their differences, allow to achieve a common goal in the efficient way. As it occurs, the results of harmonisation and optimisation of automated border control processes show that the total harmonisation (unification) is not possible due to the specific conditions of different borders border. On the other hand, even though the processes and technologies differ it is possible to develop solutions where the most important criterion, the traveller perspective, is adequately harmonised and the processes look similar among all border crossing points from travellers' perspective. Harmonised processes offer the travellers the possibility to familiarise themselves with border crossing procedures and act in a similar way at any crossing point.

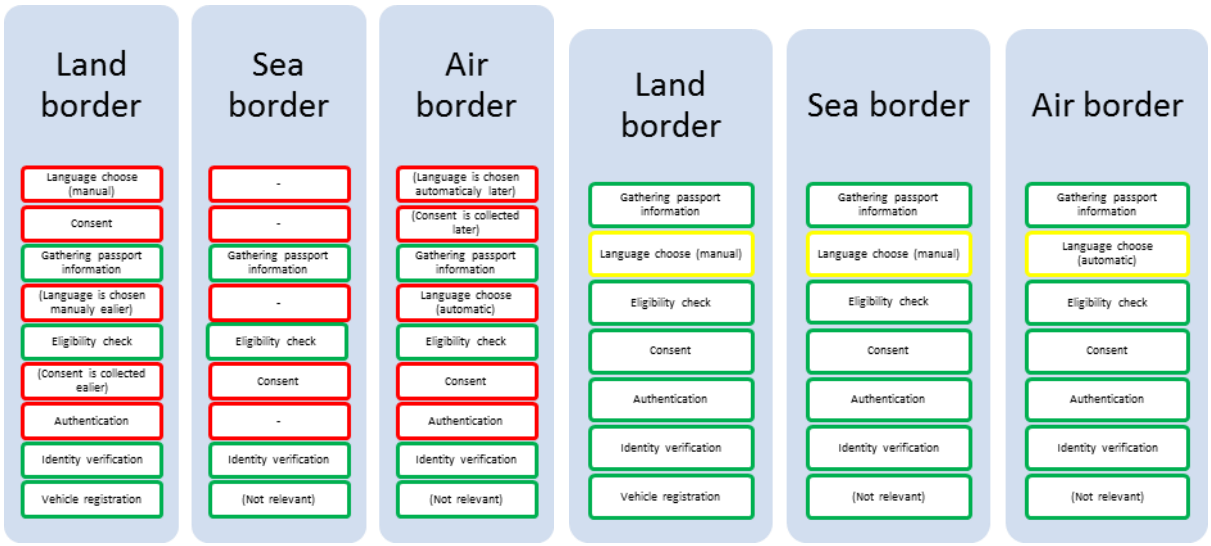

Figure 12: Enrolment process before (left) and after (right) harmonisation

Harmonised processes also offer the border authorities the possibility to develop solutions to different border checkpoint, facilitate standardisation of equipment, processes and working practices, and consequently reduce life cycle costs. For optimised outcome, ABC lines need to be constantly monitored by border guards responsible for the process flow supervision and traveller assistance.

In the FastPass demonstration scenarios with a registered traveller programme (RTP) an enrolment process is required. After the enrolment the traveller may proceed to the e-gate process or may also take a manual control. It must be notified that if consents from travellers are required, these phases must be included in the processes. An e-Gate process harmonisation recommendation at different

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border type installations has been also presented. In the process harmonisation also the land border process has been taken into account with additional steps of vehicle related document check phases. In FastPass these processes were included in the enrolment phase.

An additional aspect to the harmonisation of processes may be presented from the airport where border check processes are in the heart of the airport process in general within a multi-stakeholder environment. In this environment, the results of the modelling and process development work show the importance of distinguishing the processes of different stakeholders from each other and to developing the border checks in cooperation with other stakeholders. At the airports in general, the passenger processes differ according to the passengers' origins, nationality and country of the departure or the destination. From the process harmonisation point of view, the difficulty of the transfer passengers often lies in the fact that the various processes at the airport are different for the passengers depending on their route before the arrival (e.g. country of departure) and their destination. Processes for the travellers whose destination is inside Schengen or EU are different from the processes for travellers with destination outside EU. Furthermore, states that are non-Schengen but EU or Schengen but not EU have their own processes. The customs authority is also very integrated to the airport process.

Yet another process-related challenges could be observed in the sea border environment. A typical airport style ABC system is not an option in the sea border cruise ship context, especially given that several thousand passengers need to embark or disembark within a small period of time and often within a tiny infrastructure. Such a configuration would have led to lengthy queues unless large numbers of ABC gates were installed. Moreover, big cruise ships, especially those arriving from non-EU or non-Schengen, require different handling in terms of border control due to the mixture of passengers. The proportion of non-EU passengers on such cruise ships is typically less than 10%. The demonstrator setup on an ABC-system is completely new and was deployed because such installation is not in use at any other big cruise ship ports in Europe. The process flow for cruise ships was improved by installing two Kiosks: one on the ship and one in the border control hall. This allowed the necessary passport scanning and biometric template capture (in this case face) to be carried out at a kiosk in the terminal building or on board and not at the ABC gates. This resulted in an immediate time saving at the eGate of several seconds per passenger, as the time taken to scan the passport machine-readable zone (MRZ) and to open the RFID device was avoided.

Land borders demand a specific approach, in contrast to other border types; cross border traffic involves passengers travelling by different types of vehicles including cars, trucks, vans or buses. This means that border control usually takes place with passengers remaining in the vehicle during variable weather or lighting conditions. Such conditions have a great influence on the border crossing processes. The FastPass solution for land border is a sort of Registered Traveller Programme (RTP). That means passengers could voluntarily register once (having been informed about the use of their personal data) by providing their biometric, biographic and passport data. What is different in the FastPass solution is that after passengers have crossed the border their data is not deleted but stored, so that next time they wish to use the FastPass eGate they need not to register again, which minimises the amount of time needed for border control at latter border crossings.

A thorough training of the end-users (at the working system) and user manuals were prepared. Based on this tailor-made trainings for border guards (BG) and e-Gate assistants were held.

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SYSTEM DESIGN

The objectives of the system design and its security were derived from the requirements of various stakeholders. This includes particularly the major objectives regarding system design, risk analysis and system security and availability.

Modular architecture of an automated border control system

The main purpose to develop a harmonized and holistic system architecture was to have system in place that supports ABC gates for different border types (air, land, sea) and provides generic interfaces in order to facilitate and harmonize the integration of software and hardware components. As such, the architecture supports different possible e-Gate solutions for example with and without kiosks. The same software can also be used for manually operated border stations. This enables harmonization of systems in the country independent of the control process used at the checkpoint or the control point type.

The FastPass architecture is designed in a way that it maximizes security and privacy. Due to the different border types, implementation scenarios and possible parallel operation of eGates and manual controls the architecture was designed in way to offer maximized modularity and flexibility. Consequently, some of its components are optional and can be removed from the configuration in order to support different types of concepts for an automated border control process. This is not only applicable for software components but also for different external hardware parts such as passport readers or biometric sensors.

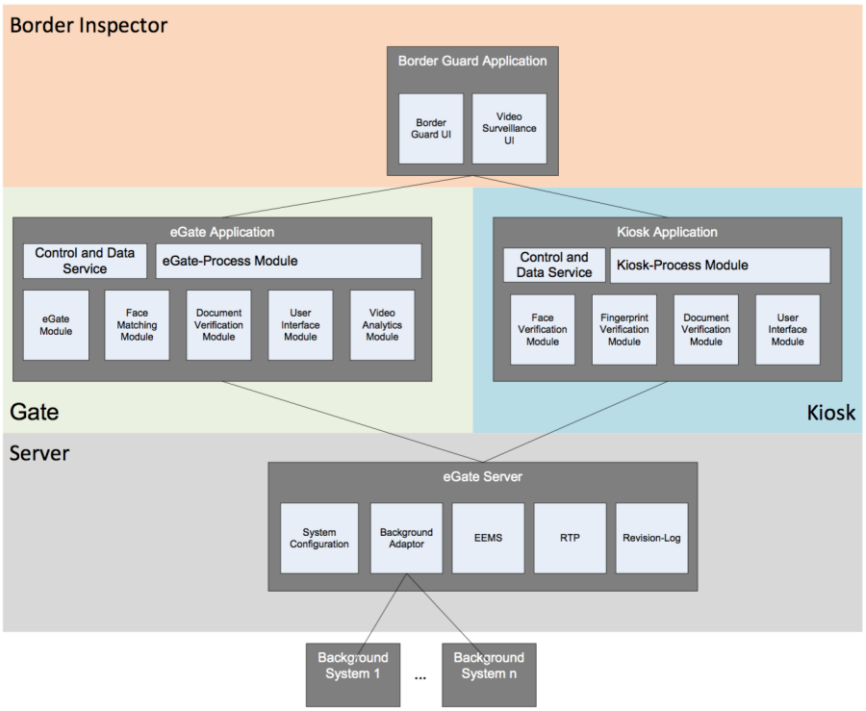

Figure 13: System architecture

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Addressing security right from the beginning

As security is of highest importance with respect to border controls a systematic and holistic security evaluation framework comprising of a risk analysis as well as system security evaluation has been developed. This risk analysis methodology was developed and applied at a very early stage of the project in order to address security risks to the system at the earliest stage possible.

The risk analysis methodology follows mainly existing standardizations regarding risk management (ISO 31000:2009 and Microsoft STRIDE/DREAD model). It was important to have basic principles and generic guidelines available as within FastPass not only IT related risks where addressed but also user related risks and potential risks arising from intended electromagnetic interference (IEMI).

The risk analysis methodology covers the identification of risks based on both IT-related and user-related threats. The threat identification has been carried out based on a high level e-Gate process and the classification of the damage potential and the exploitability was verified with responsible stakeholders. The results were provided to system integrators in order to address security relevant issues at an early stage of development. As a final result, the risk analysis provides the basis for the system security and availability.

The developed security and availability concept addresses security measures for relevant components, a monitoring concept and an availability and business continuity framework. The modular system architecture and the results from the risk analysis were fundamental elements for establishing a security and availability concept. The system design provides input for the risk analysis which provides its results in form of a matrix, mapping actual risks to components, thus providing, adjacent to security standards and legal requirements, the greatest input source for the concept.

The concept itself is based on BSI Grundschutz[2] to ensure completeness and to have a regular updated basis. It covers not only the hardware components but also links to the process steps and to the used hardware/software assets as well as interfaces. The concept shows a security weighting respectively rating according to the CIA (confidentiality, integrity, availability). Furthermore, each of the different assets is assigned specific protection level and related security objectives (safeguards). Therefore a complete overview including security related information for all assets in use can be established.

[2] [2] https://www.bsi.bund.de/DE/Themen/ITGrundschutz/itgrundschutz_node.html

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SYSTEM DEVELOPMENT

The objective of system development was to develop and integrate a general ABC system for demonstration purposes, serving as a reference system for the rollout to airports, seaports and road borders. For that purpose a "Gate Process Module" integration platform has been designed, implemented and used as a framework for the integration of all relevant hardware and software modules. The results of this work have been the successful implementations of the different ABC scenarios for air-, land-, and sea borders that have been successfully demonstrated during the project.

Software Development

Based on the FastPass system design the "Gate Process Module" integration platform has been developed. This framework provides standard compliant interfaces for the integration of the sub-systems (e.g. BioAPI for biometric devices and algorithms, ePassportAPI and oPassportAPI for document readers, high-level-interface for e-Gates, etc.) and lays the ground for the flexibility to easily adapt to the different demonstration scenarios. Based on the results of the stakeholder analysis a "Traveller User Interface Module" has been developed and integrated. The main task of this module is to provide the traveller with visual feedback at either the ABC kiosk or the ABC gate that helps the traveller passing through the ABC system.

To address the border guard's needs when using an ABC system, a "Monitoring Software" has been developed. The task of the "Monitoring Software" is to provide the border guards a monitoring and ABC control interface for all involved e-Gates and kiosks. A set of interfaces to external systems (airport security systems, etc.) has been implemented as well as stubs for the simulation of these systems to ease testing and early software integration.

Along the FastPass project, this base framework was continuously enhanced and improved to address all variants of ABC that have been decided for demonstration. This covered different operational ABC process concepts as well as different hardware components.

Besides implementing the functionality, software development also considered the security concepts that have been created.

Integration and Setup of Test-Systems

For an efficient and easy integration and the possibility of early testing, the functional integration of hardware and software components has been performed at the integrator's premises in Munich. Here the integration started with the more portable hardware components including passport reader, video systems and biometric sensors. Parts of these components have been integrated using secunet biomiddle as framework. For other components (e.g. eGate hardware controller), FastPass has developed its own integration layers.

The integration and test actions have ensured that all connected devices can be accessed and efficiently integrated in the ABC process implementation. For the integration with the eGate and kiosk hardware, also eGates and a kiosk had been installed on-site at the integrator in Munich. This helped significantly in efficiently implementing the eGate process control and also in testing all the different operational scenarios (integrated two-step, segregated two-step with kiosk and a) passport as token, b) face as token). Having gate hardware in place helped also during the demonstration phase in being able to replay unexpected behaviour, fix and test it before updating it to the demonstration sites.

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DEMONSTRATION

The FastPass-solution has been demonstrated at three demosides: at the Vienna International Airport– Austria; at the land border in Moravita – Romania; at the Port of Piraeus – Greece. The challenges for the demonstration are the integration into the existing infrastructures as well as the training of the operating ABC-staff. For each demonstration a collection of significant evaluation data has been provided.

Demonstrator Integration

The air border scenario consisted of four different scenarios: Two scenarios featuring a state-of-the-art mantrap solution, and two innovative segregated 2-step systems with separate eGates and Kiosks. Both types of scenarios had distinctive differences on hardware and parts of the software. The mantrap solutions did not feature any traveler pre-registration and integrated all traveler interaction and identification (biometric face matching unit, pass readers) in the eGate, the 2-step systems used a kiosk for the initial passenger registration, similar to the sea and land border scenarios. The main distinctive features are the following:

- eGate:
  - Passport reader at entry door (Mantrap and Passport-Token Kiosk)
  - (touch) display mounted near the entry doors
  - Stereo camera (person separation)
  - Entry- and Exit doors (mantrap)
- Kiosk with fingerprint acquisition unit
- Configuration adaptions to border guard user interface according to the needs of the Austrian border guards
- Background Adaptor with access to national police databases, SIS, VIS and Interpol databases
- Schengen door, separating the international part of the airport from the Schengen area
- Passenger identification either with face or passport (configurable).

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Figure 14: FastPass' demo sites (upper: land border, middle: air border, lower: sea border).

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Following the harmonized FastPass approach, the sea border demo scenario uses similar components and workflows as the Face-Token air border scenario. Nevertheless, several changes were necessary:

- eGate:
  - Foldable and moveable between different locations
  - Stereo camera (person separation)
  - Only Face Token – no passport reader necessary
- Kiosk:
  - One kiosk installed on board of cruise ship
  - Data transfer of registered passengers via encrypted USB stick
  - Extended with a maintenance menu for data exchange
  - Port kiosk runs also SW components for process and databases
- Configuration adaptions to border guard user interface, running on tablet PC

The land border scenario is a two-step process (similar to air border one), where passengers first need to enrol at the Kiosk and then use the e-Gate, which in this case is a vehicle trap equipped with an entry and exit barrier. What makes the land border scenario distinct from others is that it is oriented only at registered travellers travelling by vehicles:

- eGate:
  - Automatic Number Plate Recognition for vehicle matching
  - Vehicle trap with two Safety devices for barriers (Induction loops and photo electric sensors) and two traffic signals
  - Two ABC terminals for passenger and co-driver, with face recognition unit, (touch) screen, passport reader, and distance sensor for safety.
- Kiosk with additional flatbed scanner for additional documents (insurance green cards, vehicle registration certificates, driving licences, Authorization letters) which would not fit standard passport readers
- Adapted border guard interface for showing the additional documents, APNR live stream, etc.
- Modifications to the process, in regard to the vehicle and the crossing of two travellers (driver and co-driver).

Demonstrator Operation

A multitude of evaluation data was collected and stored by the demonstration kiosks and eGates, which was extracted at the end of each scenario from the following sources:

- Database: Passengers' personal data, document data, background check information, timestamp, etc.;
- Technical Log files: Timestamps, personal data, errors and problems, logging for troubleshooting, etc.;
- Folders of the file system: Pictures from the person separation, left luggage detection and face recognition camera.

In order to facilitate the reading and analysis of the data, the content of the database was reformatted and reduced to relevant information.

The logfile data was prepared for evaluation by removing all irrelevant (mostly purely technical) information. At the end of the process, the data was anonymised and handed over to the designated project partners for evaluation.

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In order to share the data within the relevant members of the consortium we developed a precise process in order to guarantee the proper collection and protection of personal data gathered at the different demonstration sites in Austria (Vienna airport), Greece (Piraeus port) and Romania (Moravita BCP).

For the operational use of the system by the border guards we organised seven training cycles for more than 200 border guards and eGate assistants at the various integration sites.

In order to evaluate the success of the trainings, feedback was collected on a regular basis, both verbally and (anonymously) in writing. For this purpose a feedback form with nine – primarily multiple choice – questions was developed and distributed to the trainees. Since the training took place directly at the (sometimes very busy) pilot installations in between regular duty shifts of the trainees, an effort was made to keep the feedback form simple and easy to answer, with a strict focus on the core information that needed to be gathered for the assessment.

The response rate to this questionnaire was very satisfactory: of the 58 feedback forms which were distributed to border guards and eGate assistants who participated in one or more training sessions, 54 were completed and returned.

The verbal feedback was very positive as far as the training itself and the trainers were concerned. Whenever negative responses were received, they were to the relevant partners who, whenever possible, fixed the addressed problems immediately.

The written responses, collected anonymously through the feedback form, were also overwhelmingly positive. The 54 survey participants consisted of 25 Romanian border guards trained for the land border scenario, as well as 26 Austrian border guards and 3 eGate assistants assigned to and trained for various Air Border Scenarios. They were a diverse group with varying motivations and levels of familiarity with technology.

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EVALUATION

The purpose of the evaluation effort was to provide insights on various aspects of the FastPass developments. This mainly regards the task of an overall evaluation with respect to the High Level Requirements captured in the beginning of the project, but also on specific aspects such as security or data protection. In summary, the final result of FastPass shows that the project has achieved innovation and promising new concepts that were detailed in the relevant evaluation reports. Furthermore, the evaluation methodologies for security and data protection constitute valuable results by itself that may influence the way in which ABC installations are used across Europe.

Security Evaluation Methodology

Automated Border Control (ABC) systems have been introduced for making border control more efficient and convenient while maintaining or even improving the current level of border security. However, there remains the question to what extent efficiency and convenience for the involved actors might affect security. In order to decide on this question, FastPass has elaborated a security evaluation methodology based on an ISO 31000 risk management concept. During risk analysis a comprehensive list of some 100 threats and vulnerabilities have been identified that could affect the security of an ABC. That list has been transformed into a catalogue of risks with appropriate risk acceptance criteria and mitigation measures. Security evaluation according to the FastPass methodology consists of checking the level of achievement of an ABC system against the planned risk treatment. The methodology proved its usefulness during application to the three FastPass installations at air, sea and land borders.

Furthermore, the evaluation methodology has been further elaborated towards a "Security Self-Assessment Scheme" for operators of ABC. For this purpose, the catalogue of risks has been enriched with questions that shall help the operator to understand the relevance of each risk for a specific installation.

Privacy Impact Assessment

As any other system in which personal data is processed, an Automated Border Control system has to comply with the relevant data protection legislation. With the new General Data Protection Regulation (GDPR), established in 2016 and becoming relevant in 2018, there is the obligation for data controllers to conduct a so-called Data Protection Impact Assessment (DPIA). Thus, FastPass aimed to develop a DPIA template that could not only serve the project to understand its own impact on privacy and other fundamental rights, but also to provide future deployments of ABC with such a template.

Through its work with stakeholders and social/legal analysis, FastPass collected more systematically the issues of ABC with respect to fundamental rights. That worked help to structure relevant evaluation criteria according to three dimensions: design for privacy and data protection, design for inclusion and design for dignity. The design aspect was introduced according to the idea that ideally DPIA is conducted during design phase.

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The resulting template works similar to the security evaluation: a catalogue of risks and risk revealing questions has been developed that form the core of the DPIA. Similarly to the security evaluation, the DPIA template has been successfully applied to three pilot installations.

Evaluation of System & Processes

Under the supervision of an Evaluation Board, an evaluation of the FastPass achievements against its high level requirements has been conducted. The task distinguished between the various border types and drew individual conclusions that in some cases could differ. Furthermore, achievements of Traveller Identification and Monitoring have been evaluated in order to cover also the future potential of ABC.

A particular concern regarded the maturity level of the FastPass demonstrators. It would have not been fair to assume for the FastPass demonstrators similar stability and reliability properties that usually can only be expected from production level systems. Priority has been put on the potential as long as this potential could be sufficiently demonstrated.

In fact, the evaluation could reveal clear evidence for this potential. In particular, the land border pilot showed great potential, leading to recommendation to follow up this potential in one or another way beyond the scope of FastPass.

Furthermore, FastPass has summarized its most important lessons learnt in a public Best Practice Report. The report targets all experts that develop, plan or use ABCs. It looks at the automated border control development and implementation interdisciplinary, taking into account the underlying factors as well as operational, technical, conceptual and organizational aspects to be addressed when developing automated systems for different borders.

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IMPACT

FastPass **development and demonstration of a next generation automated border control solution harmonised** for different (land-, sea- and air-) border control points across Europe, will have the following three main categories of impact:

- Impact on future ABCs and European border control (socio-economic impact, wider societal impact)
- Dissemination: raising awareness for ABC gates
- Exploitation of research results

SOCIO-ECONOMIC IMPACT

European harmonised approach to ABC gates - Raising EU ABC security and user acceptance

Border control is a major challenge for security and mobility within the EU. Serving both demands at the same time means to keep security at the highest level while increasing the speed of the process and the comfort for all legitimate travellers at all border control points.

All European border crossing points (BCPs) can potentially benefit from the FastPass results at air, land and sea borders. BCPs that have ABC border crossing infrastructure in place, shall be able to better manage and control their passenger flows, using advanced and innovative features. BCPs that not yet apply ABC shall be enabled to operate next generation ABC systems and the number of BCPs with a positive effect by the implementation of ABCs shall be increased. The resulting technological advances and processes will in general streamline the passenger traffic and increase the throughput, whilst reducing the waiting times. Furthermore, the integrated technologies will be enhanced to the requirements of the addressed infrastructures, which further increases the throughput and the security. The balance of fast and secure technological modules has to be found individually according to the requirements of the different stakeholders and the overall risk situation. Additionally, the FastPass results provides means for harmonization – starting from a common reference architecture to a common methodology for risk and security assessment.

FastPass has followed a user-centric approach with high integration of Border Guards and Passengers. The output of the project will contribute by improving several elements of the border crossing process: (i) analysis of the situation in front of the eGate (ii) optimized readout of passport data (iii) reliable separation of individuals (iv) optimized database connection (v) fast person identification. This clearly results in an improvement of workflow and functionalities in ABC gates and can therefore help to reduce the number of additional checks by border guard personnel. In this way border guards have more time to focus on potential risks.

Several key issues from social and legal perspectives were addressed throughout the project. This resulted in several recommendations, which will have key impact for future ABC designs and implementation: i) Legality - controlling the conformance with regulations, particular those relevant for border control and data processing. ii) Sociality - evaluating the impact of the particular solution, proposing additional requirements for future ABCs and iii) User acceptance - efficiency, effectiveness and ergonomics need always be checked by experts from infrastructure operators, public authorities and end-user associations.

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Implementation of ABC gates increases the EUs Safety and Security as well as EU citizens and foreigners ease of travel (which was a central aspect in the initiation of Schengen). The contradictory demands of border controls (easy travel for legitimate travellers, identification of threatening passengers) can best be achieved by ABC gates in combination with well-trained border guards. The ABC gates must be available at a cost-benefit ratio low enough to ensure wide implementation, thereby ensuring EU wide Safety and Security.

The FastPass project has resulted in a reference implementation for all types of borders which indicates the potential for harmonisation and interoperability at the European level. The reference implementation can be integrated at all types of border points with its open system architecture and so it guarantees easy to integrate future development and changes in this area.

Enhancing the competitiveness of the European security industry

Development of new European and common international standards for security as a means to reduce the security market fragmentation, counteracting the lack of competitiveness of the Security European Industry detected by ECORYS study.

FastPass partner Giesecke & Devrient split its businesses and formed a new entity in a joint venture with German Bundesdruckerei with the new brand Veridos. Several FastPass partners are very active and successful on the international market. Veridos provides border control systems for Morocco, Modi is active for security lines in Egypt. Secunet provides ABC gates in several countries. It can be shown that FastPass results contributes strongly to the positioning of European industry in the global market and contribute already to the security of the North African region.

The European security research strategy is being implemented through the projects funded by the EC in the Framework Programme. Therefore FastPass has linked up with most of the precursor projects to ensure a continuous implementation of the strategy of European security research. Project Partners and Advisory Board members are involved in running FP projects on predecessor and adjacent technological developments.

Standardisation complements market-based competition. FastPass has brought together developers of various components of ABC Gates, and, together with standardisation bodies, and initiate the development of standards for ABC gates. FastPass contributed also to Frontex activities on harmonization and initiated work on security and risk assessment. Further standardization activities have been proposed.

WIDER SOCIETAL IMPLICATIONS

Support to EU Security strategy

The European Union has formulated a new Global Strategy for the European Union’s Foreign and Security Policy. Its first priority is the Security of Our Union. Within this strategy the security of borders is a key element, where several actions are performed and new EU regulations are proposed. FastPass has contributed to the discussion and development of this process by constantly interacting with major stakeholders in the field – the commission (DG Home, DG REA), the parliament and agencies of the European Union such as eu-LISA, Frontex or Fundamental Right Agency.

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The results of FastPass with respect to ABC systems will broadly influence the future developments in the field. ABC systems will be a key element on proposing new automated border control concepts and to implement the upcoming regulations in a secure and at the same time convenient and efficient way. The presented FastPass concept enables a large variety of innovative border crossing concepts by separating the time-consuming data capture process from the pure border process and it also enables paperless processes.

With novel technologies in passport scanning, video surveillance and biometrics, the overall capacity and reliability of ABCs systems will additionally contribute to the acceptance and effectivity of automated systems at European borders.

MAIN DISSEMINATION ACTIVITIES

FastPass has disseminated the results of the project to the general public, interest groups, technology developers, networks, clusters, and any other related groups. Throughout the period of the project, a wide variety of dissemination activities have been undertaken by all the partners, aiming to create awareness of the FastPass project, to promote FastPass within the context of European policies on the subjects involved, and to present results, outcomes and findings from the project at both national and EU-level.

The dissemination covers scientific publications, presentations, demonstrations, workshops, exhibitions, competitions, social media, manuals on updated operational procedures and related training, and dissemination within standardization processes, and so on, targeting different groups of interest people. Through these activities, FastPass has reached out to a wide range of interest groups of people including legal and policy makers, border agencies, academic researchers, end users, technology providers, and general public, and received useful comments, feedback and interests in collaboration or exchanging knowledge. The feedback has always been beneficial to the project and which has helped shape and improve the technology in many ways. Disseminating the results in a timely fashion has kept interest groups updated with the development progress of the project, and most importantly, dissemination has increased the public awareness of the FastPass project as well as the knowledge and technology of Automated Border Control (ABC) concepts.

Public Website

A public website for FastPass was created and available at http://www.fastpass-project.eu/ since the beginning of the project. The website provides general information about the project and its development progress to the public, such as project vision and goal, elementary organisation, news, research results via selected publications, demonstration and other selected results, events, and contact details, etc.

The website has been created and maintained. The website has been used to inform the public, especially interest groups, about the research and development results and activities. It also clearly states the implication of the project with regard to data protection and evokes the results of the work done in terms of societal aspects, such as privacy or ethical and legal complications in innovative, and ABC technologies.

The website has also been used to publish dissemination materials such as the FastPass film, and FastPass newsletters. Moreover, a selection of the FastPass presentations and publications has been provided and regularly updated.

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Dissemination with related projects

FastPass has supported and co-organized an activity that was started by the European Association on Biometrics (EAB). Since 2014 the research projects have been organising a research project conference which covers the majority of the European Projects on biometrics and related fields. This two day conference was repeated yearly since then and had around 100 participants. Results of FastPass have been presented every occasion since the conference was founded.

The European Agency for the operational management of large-scale IT systems in the area of freedom, security and justice (eu-LISA), as well as the Directorate-General of Migration and Home affairs (DG Home), has supported the event by contributing keynote talks. Moreover, both institutions, as well as the European Agency for the Management of External Borders (Frontex), discussed current and future research objectives in a panel discussion "Mind the gap – what research is needed for current and future operational biometric systems". DG Home was also providing an overview of current research projects and the future work programme in the field as supported by the Horizon 2020 "Secure Societies" challenge.

In addition, FastPass has cooperation contracts with MobilePass and BODEGA, two closely related European research projects. Dissemination activities via common project partners was achieved. FastPass has also cooperated with the EU border security project ABC4EU, by having regular contact and by disseminating results in The Situation Scope Seminar in Ylläs, Finland.

Dissemination between project partners

Cooperative work is one of the most important issues to ensure the successful completion of a research project involving partners from different countries. Therefore, the project established and used a set of tools that allows efficient communication and control.

Demonstrations

FastPass demonstrations took place at three different locations in Europe. As those demonstrations were publicly visible and also directly used by different stakeholders they represent - besides their importance for the results in terms of demonstration and evaluation - a very relevant aspect in the dissemination.

The demonstrations were used by more than 10,000 travellers, operated by more than 200 border guards from three different member states. The demonstrations were placed in infrastructures of air, sea and land borders, which involved personal of those infrastructures and in this way disseminated the project information to airport staff, port and cruise ship personal. It directly attracted media (e.g. Romanian television) and raised interest evidenced by numerous requests by media and consultants.

Exhibitions

Industrial partners have attended and presented their products and systems at a variety of exhibitions through different events. Exhibition is probably the most direct way to disseminate the results and outcomes to the public, in which case people cannot only see the real products, but also try the technology out people to understand the concept and technology. FastPass partners have presented at 14 exhibitions across Europe and also in the US, including Passenger Terminal Expo, Intertraffic, World Border Security Congress, Frontex ABC Conference and Exhibition and others.

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Competitions and workshops, publications, presentation, posters and tasks

The FastPass Consortium has intensively cooperated with EU-bodies, public authorities and user groups. Multiple workshops have been organised or participated or panelled by FastPass partners on different topics, targeting different interest parties and engaging with end-users to transfer and exchange knowledge. These workshops bring together the expertise from different regions to share knowledge. Also, organised competitions on biometric recognition have been successful to attract academic researchers and promote the research topic in the biometric research community. Examples are CrossEyed Cross-spectra Iris/Periocular Recognition Competition 2016 and 2017, Workshop on privacy and data protection 2015 and 2016, ISBC workshop 2015 (AVSS) and others.

Publications and presentations are the major outcomes of FastPass's dissemination. A significant amount of publications of high quality and presentations that covered different topics related to automated border control and security. FastPass partners have also attended a variety of relevant meetings to present the concept and development results of the project. Over 150 activities represent a wide range of audiences that have been reached out through these events.

FastPass film and newsletters, social media

Apart from the activities focussing on more specialised fields, FastPass has also undertaken dedicated dissemination activities to present the project to the wider public. Towards the end of the project, FastPass created professional films to disseminate the project outcomes. Newsletters have been regularly published and made available on FastPass website to keep the interest parties updated with the development of the project.

Dissemination activities have also been achieved widely through different social media and internet services, for instance, blogs, Facebook, online video, news article, video interview, etc. As social media has become the essential communication method in our everyday life, dissemination via social media have been able reached out to the more general public. Section A provides the detailed list of all the dissemination activities taken through various social media.

Dissemination within standardization processes and manuals on operation and training

To develop a harmonised, interoperable system, standardisation is important for developing technologies and methods for ABC. Within FastPass, several standardisation works have been undertaken during the project, focusing especially on participation to working groups, contribution to evolving future standards, as well as general standardisation activities. Section A below lists all the standardisation activities achieved within the project.

In the framework of this project operational control procedures and a multitude of training materials (training plans, training manuals, presentations, check-lists, feedback forms, etc.) were developed for each scenario and disseminated to the designated end users, the border guards assigned to the eGate pilots. Though originally not foreseen as target group, eGate assistants were included as well and received not only training but also documents with operational instructions.

EXPLOITATION OF THE RESULTS

Exploitation is performed to create a business awareness related to the project, its objectives and main results to the Industry and end-users, to foster and facilitate the industrial use of the results that

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are developed and demonstrated in the project, to prepare their commercialization, and to organize trainings events with respect to derived best practices.

Relevant information and material has been collected and analysed in order to produce an exploitation plan. In this document, 64 main exploitable results were listed, with details on how each can be exploited. The emphasis was put on finding ways of exploiting the FastPass work to raise European know-how and competitiveness. In other words, the research results of projects such as FastPass must not disappear into an archive after the projects ends but rather make a difference – technically, practically, and economically. The only way this ambitious goal can be realised is if the research results are used by the wider industry and by the Consortium partners for further commercial ventures. For several partners, the connections established during the FastPass project allow for closer cooperation in the future. Co-operation will be realized in various forms including commercial tenders created together with subgroups of partners from the consortium; optionally completed with other necessary parties. Other co-operative exploitation examples are technology standardization and further research project initiatives.

For technology providers such as Deltabit and Modi the natural cooperation is with the gate providers Magnetic and Gunnebo to help them offer a solution including fingerprint technology and face recognition. Important exploitation leader is Veridos acting in the role of system integrator. Technologies and components developed in FastPass are a solution pool that will be utilized when offering systems for customers. Selected set of components and technologies is not fixed but vary according to particular customer needs and wishes. Possible technologies and components in the pool are:

- Veridos (eGate and kiosk ABC process control module, backend integration, software integration of all components, (A)BC management server)
- Mirasys (border guard UI, gate area video surveillance)
- Magnetic (eGate hardware controller adapter for Magnetic gates)
- Gunnebo (eGate hardware controller adapter for Gunnebo gate)
- secunet (framework for integration of passport readers and biometric devices)
- Regula (document reading and document verification module)
- Deltabit (fingerprint scanner and fingerprint matching module)
- Modi (face capture and face matching module)
- AIT (Background System Adapter, Person Separation Module, Left Object Detection Module)

Partners will also exploit the lessons learned and gathered knowledge in future research project calls such as H2020-BES (Border Security and External Security) and H2020 Secure Society. At least the following FastPass partners have indicated interest and seek to participate in the aforementioned calls: VTT, FhG, AIT, Intrepid Minds, OeSD, BMI, VIE, Veridos and ITTI.

Public website

www.fastpass-project.eu

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