Understanding the factors affecting UX and technology acceptance in the context of automated border controls

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***Abstract*—The purpose of this paper is to describe the complexity of an Automated Border Control (ABC) context and the factors influencing the experience passengers and border guards have when interacting with ABC systems. Automated border control is expected to make border checks quicker and more efficient as well reducing the cost. At the same time, the purpose is to enhance the level of border security. Automated solutions have been taken into use at many border sites over the past few years and a great deal of effort has been put into the development of ABC technology. But the effects may remain poorer than expected if the usage rates are low or if the process efficiency targets are not reached. One well recognised reason for this is that the process is too cumbersome for users. Thus, it is extremely important to pay attention to the usability and user experience when designing ABC solutions and environments so as to ensure user acceptance and positive impacts on technology integration. By deep research work and gaining an understanding of the field of border control, the main factors affecting the user experience (UX) and general acceptance have been identified. Suitability of technology, operational environment and user profile are all important factors that should be carefully considered in technology development.**

Keywords—automated border control; self-service; usability; user experience; technology acceptance

I. INTRODUCTION

Following the increase in traveller traffic, longer queuing times and increased security threats at borders, the border control authorities around the world have increasingly invested in automated border control solutions. The development of travel documents has emphasised the development by offering standardised secure technologies with biometrics. The increase in the border control technology market has been steady and is expected to continue [1]. In the EU the systems have been in use over the past decade. Altogether, installations are in use or have been piloted in 13 member states [2].

Ideally, automated border control systems allow for a smooth, fast and predictable border crossing, increased passenger satisfaction and enhanced security of the borders. In the Schengen area, the ABCs are to a great extent used by Schengen citizens. Third country nationals can use automated border control systems only in a registered traveller system or according to special arrangements. The main goal of ABC systems is facilitation without disregarding security [2].

The aim of an automated system is to introduce self-service processes which minimise involvement with the border guard [3]. Automated border control is self-service. In other words, passengers can use the system independently in order to conduct a border check. In general, people are using self-service especially in a situation of queues. Self-service is considered to be faster or queuing time to be shorter [4]. If queuing time for automated and personal services seems to be equally long, most often personal service is chosen. For eligible passengers the choice between a manual and an automated self-service border check also depends on the personal factors of the traveller; some users strongly prefer personal contact and they are more likely to choose personal service when possible. In addition, passengers' attitudes and stimuli [5] and role clarity, motivation and ability [6] best explain passengers' intentions to use and adopt the self-services.

It is assumed [7] that with the implementation of biometrics automated processes will reduce the need for human resources as well as improving security. Improvements in productivity can be measured for instance by the speed of processing time, number of mistakes in identification (i.e. false match), the amount of resources and queuing time saved. But as ABC is a socio-technical system, meaning that the deployment of that kind of technology will probably influence the environment and processes at different levels, the impacts cannot be measured only from a technical perspective. Implementation of new technology should be evaluated in terms of acceptance, adoption and usability. Successful integration of new technology is great at the level of subjective satisfaction; users feel they are able to use the system efficiently with a small amount of effort; it meets users' needs, and, moreover, they are willing to use the system again [11].

The standard border control process flow is described in Fig. 1. At external Schengen border to the EU citizen only minimum border checks are done. Minimum check consists of the following: document check, verification, random register enquiries and decision. To non-EU citizens a more thorough border check is done. It consists of interview, register enquiries, assessment/profiling and decision. In the different checking phases, several tasks can be automated by means of an ABC system [2]. In a normal border check for EU citizens only a minimum check is performed. If the passenger is pointed out, further checking is performed at the second line. Depending on the nature of the installation and legal

requirements, the ABC system can consist of different process steps and components. The two main components that can be identified in all installations are travel document authentication, to check validity of documents, and identity verification, to ensure that the holder of a document is its real owner, which is carried out by biometric identification. For biometric identification, there are several options available; however, face recognition is the most commonly used. [2] Additionally, ABC systems contain a monitoring module, which enables the border authority to control and supervise border control situations at self-services. The steps can either happen all at once as i.e. in the traditional ABC process, or they may be separated and located in distance, as in the so-called segregated-2-step process where the travel document reading and biometric capture take place in a separated installation at a distance from the actual border check point. The surrounding infrastructure may also set limitations for the installations.

Passengers use the ABC system individually, which means that they enter the gate one by one. Because of different challenges in the current systems and their usability, the border authorities often offer human assistance also to guide the passenger through the ABC. The development aim should be to tackle usability challenges the passengers are facing when interacting with self-services [8][9][10], and guarantee great usability, a pleasant user experience and fluent flow for all the passengers. In of the usability sense, passengers should be able to use ABC so that they achieve their goals **effectively**, **efficiently** and they are also **satisfied** with the use of system (as usability is defined in ISO standard [11]). Oostveen et al. [8] have evaluated the usability of current ABC installations at two airports in Europe. They observed that people are not able to use the systems efficiently, and have challenges using the passport scanner correctly as they fail to insert the passport into the scanner in the correct manner. Guidance was also reported to be insufficient and unsynchronised with the steps of passenger performance.

A lot of research [12][13][14][15] has been conducted in the area of biometric identification and usability of devices to capture a biometric sample. This research mainly relates to access control and identity management, although it is little reported in the context of border control. Nevertheless, there is a great amount of biometrics-related literature [16][17] from a border-specific context, but not from a usability perspective. Both context and purpose of use matter for the acceptance of biometrics. Using biometrics in passport control for instance, is considered to be more useful than using it for monitoring working hours [18].

Passenger's experiences of ABC may vary in the use of the system since user experience is always context-dependent, including the characteristics of user, functionality of the system and the situation where the usage takes place [19]. In case of ABC, positive user experience from a passenger's point of view means that the system is easy to enter, easy and comfortable to use, functions as expected, where the usage process is fluent and the use of the system is beneficial, for instance, it is fast when compared with traditional checks. It is also essential that passengers can be sure that the border check process is safe and secure.

For border guards, the ABC system is a relatively new way of performing border security inspections compared to manual checks. Thus, it is essential that the system supports all actions that the border guard has to perform (i.e. supervision and control, management of exceptions, communication and collaboration). Monitoring stations should enable effective and efficient conduct of border checks in all foreseeable operating conditions.

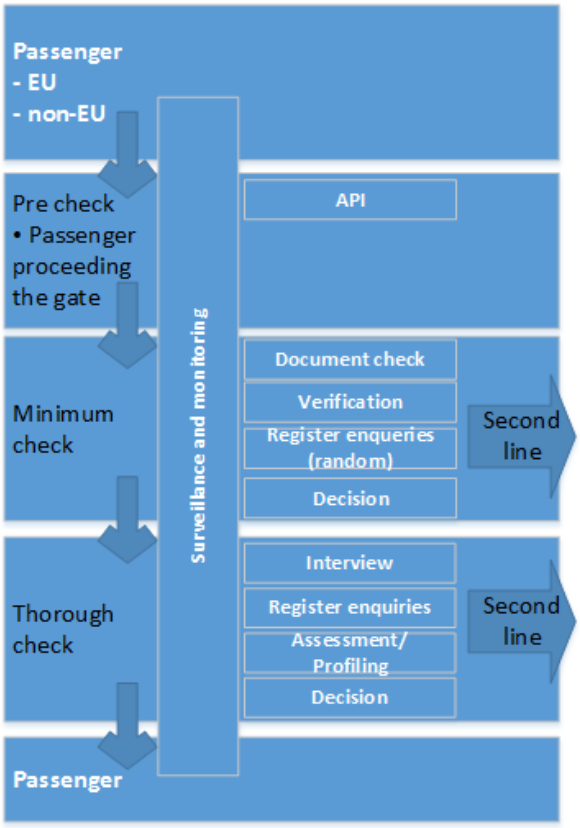

Figure 1. Generalised border check process flow (nodified from Frontex [2], [22]

In this paper, the complexity of the ABC context in matters of usability, user experience and technology acceptance are reported. The points of view of both passengers and border guards have been considered equally. First, the methodology for data collection is presented. Secondly, the general results of a field study and usability challenges in the use of the ABC system are presented. And finally, the last section provides two holistic models of factors affecting usability and acceptance from the perspectives of both the passenger and the border guard.

II. METHODOLOGY

In this study, current installations at several border crossing points in different countries were evaluated, and subjective experiences of ABC usage were collected. The main methods for information gathering are briefly described in what follows.

Expert evaluations of current installations were conducted in different locations Data was gathered by evaluating the

usability of different ABC systems and collecting data of usage of different types of installations.

Passenger observations were conducted in order to gain a deeper understanding of passengers' behaviour and the use of ABC in order to clarify the challenges of dealing with ABC services in a real-life situation. As the main purpose of observations was not to quantify mistakes, challenges or processing times, but rather to understand the quality of interaction with the ABC system, basically only the passengers struggling with the system were observed. Most observations were made from a distance so that it did not have any effect on passengers' behaviour, but because of some quiet moments and a very limited number of users at ABC's, the observers took a rather more active role by asking people to try out the ABC and guiding them in how to use the system. In that way, we had the opportunity for a rather closer interaction with users.

Border guard interviews were conducted at different border crossing points in order to gain a deeper understanding of the ABC processes and both passengers' and border guards' actions. The aim of the interviews was twofold; first, to gain a more detailed view of the passenger challenges, and secondly, to ascertain the challenges the border guards face while supervising the system.

Border guard observations were conducted in order to gain a deeper understanding of border guard work situations, processes and the impacts of ABC on their work. The observations were realised in the monitoring station in an airport environment.

In total, 250 passengers were observed when using the ABC system in an airport and seaport environments, 17 border guards were interviewed at both land and air sites and 10 border guards working in a monitoring station were observed. The first phase of information gathering was focused more on the passengers' point of view; whereas in the second phase, the border guard's work processes and context were studied more deeply.

III. RESULTS

Data collected was analysed and categorised. The chapters following provide a short overview of the findings of the field study. The findings are divided into two categories: firstly, from perspective of the passenger and secondly, from the border guard's viewpoint.

A. Passenger

Challenges were noticed arising already before the passengers entered the border control area. It seems that a large number of passengers are still not aware of the ABC concept and the possibility of using self-service for border control. Lack of awareness causes inactivity in the use of self-service, as potential new users are not even able to search for alternatives to the traditional check. Frequent travellers, however, who are familiar with travelling processes in general and may have used ABC systems, already know what to look for in the border crossing situation. Passengers either do not know whether they are allowed to use the ABC line or that they need to hold a certain type of travel document to be able to use it. According to observations, many passengers who did not have a suitable travel document still tried multiple times to use the system.

Next, challenges appear when passengers are using the ABC system. In the observations, it was noted that passengers are facing a variety of problems. They are struggling with individual components of the system. They are unsure when to enter or exit the system; they do not know where objects are located and how they are used, where to insert the passport for instance. How to behave when inside the gate and during the reading, verification or capturing processes is also a challenge. Some current installations require a precise method of operation, e.g. for the travel document placement or actions during face capturing. This indicates that people are not very familiar with the steps the inspection process consists of and what kinds of actions are required. This is often realised as passengers' restless behaviour, cancelled actions and failures in task performance. Passenger' behaviour causes problems in identification processes and results in an extended time for the process, an increased number of no-matches and rejections as well retries. Clear guidance and careful design and positioning of different components could help to make the use of the system more intuitive and to prevent usage errors.

During the observations it was noticed that differences in passport design may cause difficulties in the use of ABC. This was also mentioned in border guard interviews. For instance, the dimensions of documents or materials used may cause problems in placing the document in the correct position. In these cases, the document cannot be scanned correctly and this leads to unjustified rejections.

In the interviews, border guards emphasized the importance of the first-time experience that passengers have while using the ABC. Positive as well less positive experiences will influence passengers' attitudes toward the ABC concept and their willingness to use the system in the future. Border guards have observed many unsuccessful interactions ending up in avoidance of service in future. It has also been noticed that people tend to learn from others by observing other people using ABC. Passengers disseminate experiences and are willing to guide their fellow travellers colleagues, in how to use ABC. Similarly, more unpleasant experiences are shared, but the impacts are not that positive.

Human assistance was seen as useful and valuable, as many passengers seem to be unable to accomplish the process totally alone. In some cases it was even seen as mandatory in order to improve effectiveness of the ABC. On the other hand, the request for human assistance was seen as an outcome of poor usability and inadequate guidance. Need for human assistance was also criticised as increasing the cost of border control, and by employing a more careful system and process design this need was expected to decline.

Oostveen, et al. [8] has also reported similar findings in their study.

B. Border guard

To border guards ABCs are tools for better border checks. The ABC systems have changed the border guard´s work by

introducing more technology. From the border guards' point of view, the main challenges relate to the quality and amount of information at their user interface used in order to supervise the system, fewer possibilities for profiling passenger's behaviour due to a lack of personal contact, and the ergonomics of working station.

A border guard has only few seconds in which to make a decision to allow or forbid the passenger to cross the border. The ABC system provides great support for the task, but the final decision is made by a person. In some countries the border guard's "decision" can be inaction, when the ABC does not need the border guard to press the accept button. The amount and quality of the information may complicate the border guard's work and reduce the efficiency. If the system frequently keeps providing information that is irrelevant, their concentration may be on the wrong issues. It was emphasised that careful prioritisation and organisation of information could make the information much more useful.

Passenger behaviour and problems while using the system were mentioned as a main issue that impacts the border guard's work and its efficiency. Passengers' mistakes reflect directly on the border guard's work as the correction of errors usually requires an instant border guard reaction. For instance, if a passenger does not stay still during face capturing, the image which is compared with the one stored in passport may be unclear and blurred. In that case, automated identification may not be possible and the border guard is requested to manually make the decision either to accept or reject the identification. Also, left luggage or a passenger's harmful behaviour causes alarm and requires reaction. In some installations the decisions are made automatically instead, and the border guard's controllability is more limited.

As was stated in Frontex's handbook [2] one of the operator's tasks is to monitor and profile travellers queuing in the ABC line and using the ABC system. The importance of profiling was also highlighted in the interviews with border guards and a lack of personal contact with passengers was seen as a challenge in profiling.

Monitoring stations are not necessary always designed according the latest ergonomic requirements for workstations. However, a border guard often spends longer periods in a workstation and an uncomfortable workstation may reduce job satisfaction and productivity; in the long run, it may even harm well-being and cause safety issues.

IV. FACTORS AFFECTING UX IN AN ABC CONTEXT

As our findings show, the ABC context is complex, and passengers as well as border guards are facing multiple challenging situations. We have identified factors affecting the passengers' and border guards' experience of ABC usage. The impact of these factors may be either positive or negative. The main components are described in the following chapters.

The context of ABC consists of three overlapping layers: (1) ABC system, (2) environment and (3) user (Fig. 2 and Fig. 3). Again, two perspectives are presented: first, a passenger and then a border guard as a user.

A. Passenger experience

Passenger's ability to use the ABC as a self-service is an essential issue for the cost-effectiveness of border checks, because technology is fast already. Thus, efficiency can best be achieved by enhancing the passenger usability. In addition, the harmonization of user experience would enhance effectiveness, if all ABC installations would proceed similarly.

1) ABC processes and the physical appearance of an ABC system

The physical installation of ABC consists of multiple components that all influence the usability and the user experience. **Information and clear signs** about how to proceed play an important role in increasing general awareness of ABC, encouraging passengers to try the system and guide them successfully through the process. **Gate design and physical appearance** are the main factors affecting how easily the function of the system is recognised and usage learned. **Travel document and biometry** are the instruments for interaction between passenger and technology. Fig. 2 illustrates the factors identified as affecting passenger experience.

Guidance has two important roles in the ABC context depending on the purpose of the information and the moment when the information is needed. Firstly, the information given before the border crossing area has a more informative role in order to increase passengers' general awareness of ABC and the availability of self-service alternatives. As the interviews and observations showed, not all the potential users are aware of the option to conduct the border control processes via self-service. Secondly, the purpose of information given in an actual use situation is to guide the user successfully through the control process. Visibility of system status, indicators of progress through the process and clear guidance in case of errors are helpful to the user so as to enhance their sense of control and feeling of understanding the process. Synchronization of steps should be designed so that they support the passenger's actions, for instance, during face capture the passenger has to look at the camera and not read the instructions for the next step.

The importance of guidance has also been noticed by Frontex [2], which guidelines that in order to provide a successful passenger experience, attention must be paid to efficiency and utility of guidance. Visibility of information and diverse delivery channels are important factors in ensuring efficient communication. Also, Pirelli [22] suggests that redundancy of information may provide missing pieces of information as people often miss a part of each channel of information. Success of guidance relates to suitable communication channels for particular environments and situations. In noisy and hectic environments, as stations and airports often are, audio messages may be impossible to hear or understand, while an outdoor environment has its own demands for guidance. Another issue related to the form of guidance in an international environment is language and universal understanding. English is commonly used in signage and guidance but it is not understood by everyone. Instead of long verbal instructions, symbols and icons are preferred. Still, ambiguous symbols, cultural differences and complexity of

context make the use of icons and different language options challenging.

The design and outward appearance of the physical installation has an important impact on how easily travellers (especially 'novice' users) identify the system, how obvious is the purpose of the installation, and how attractive it appears in use. Design of physical frames also reflects the passengers' feeling of safety and attractiveness of the system. For some people, the physical appearance, the height, width and materials used in the walls and barriers of ABC systems may cause negative feelings and even anxiety about them. In addition, moving parts must be designed so that passengers will not be hurt or their property damaged.

Variance in document dimensions, materials, printing and quality of electronic and data components have an impact on the speed and accuracy of the document scanning and authentication process. Difficulties in document processing appear to the passenger often as an extended time used for the control process, and an increased number of rejections and retries. Passengers hold a wide range of different types of official travel document. Besides passports, EU member state national ID-cards can be used for border crossing within Europe. The reading process for different types of travel documents may differ a great deal, and if different types of documents are accepted in the automated process, the style of handling the documents should be harmonised.

2) Operational environment

An operational environment consists of physical elements such as **terminal building layout**, the location of different authorities and actions, **passenger itineraries** and elements of **environmental conditions**. ABC could be located in different operational environments: airport terminal buildings or land/sea-borders for vehicle and foot passenger crossing points. These different operational environments can be huge and complicated places and thus challenging for the passenger. Several authorities and operators operate in the same facilities and seek to attract the passengers' attention. Different kinds of advert, information boards and signage are used, that may confuse inexperienced passengers.

Clear terminal design and careful design of passenger itineraries and guidance of passenger flow are essential for the efficient functioning of the border checkpoint and ABC system. In order to ensure a high utilisation of self-service, ABC lines should be highly visible and located logically in relation to other border control activities, otherwise the traditional face-to-face service easily becomes the default.

It is very common that in unfamiliar situations people copy the behaviour of others, e.g. by observing how other passengers interact with the system. Crowds of people in a terminal area may obscure the signage and instructions or prevent passengers from seeing the system used by others. Thus, in an ideal situation, layout of the control area and location of ABC lines would support that natural behaviour.

Environmental conditions such as lighting, natural or artificial, temperature and changes in weather, dust, dirt and noise or other distractions have an influence not only on the function of technology by causing malfunctions and errors, but also on passengers' willingness and ability to use the system.

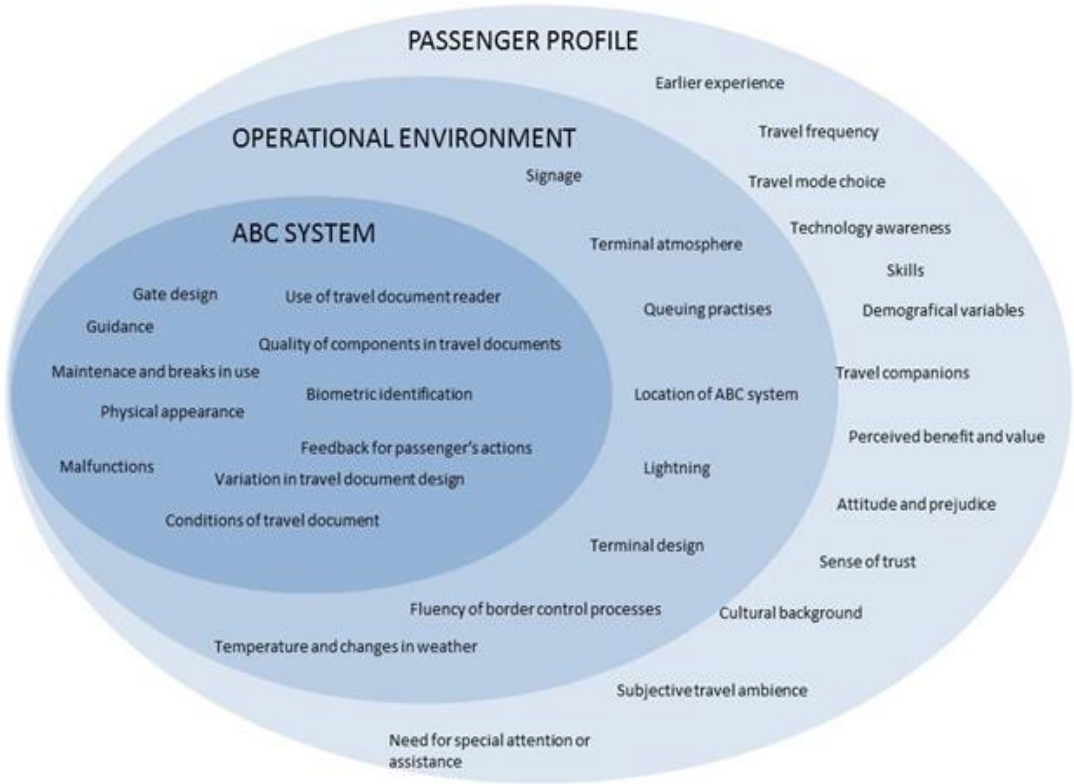

Figure 2. Factors affecting passenger experience

Direct sunlight or illuminations impact on the efficiency of the system, preventing users from reading instructions and complicating interaction with the system. Changes in weather and an unhygienic environment are not comfortable for the user and may also damage the technology. As the border crossing environment is often hectic and people are in a hurry, noise from different sources near the control area may reduce concentration on the self-service processes.

3) Passenger profile

Passenger profile consists of components relating to **personal characteristics**, **travel settings** and **passenger background**. All these components have a significant role in creating subjective opinions, impact on the user's satisfaction and influence the user's willingness and ability to adopt new services and technologies.

Demographic variables, such as passenger's age, gender and nationality, are characteristics which influence the traveller's opinion of and ability to use the system, as well how ABC is experienced. Age, for instance, produces some physical and legal limitations. Elderly people may face difficulties due to impaired hearing or eyesight, reduced mobility or memory. Minors may not be allowed to use self-service because of legal issues. Extreme variations in height may complicate the use of physical installations. People wearing spectacles may face difficulties in the facial recognition phase, not only because the image matching may take longer but also because of the inconvenience of removing them and trying to read instructions, etc. A large number of people prefer for one reason or another personal contact and face-to-face service, and it might be challenging to encourage those people to try out ABC systems. Preference for face-to-face communication has also been reported in other studies [3][4].

Passenger background referring to passenger's skills, knowledge and earlier experiences with technology, e.g. ABC or similar systems, may help a passenger to become acquainted with automated border control technology. However, a lack of standardisation in ABC functionality may negate this advantage. On the contrary, lack of experience or negative experience impacts on the passenger's ability or willingness to use such services. Some passengers, especially first-time users or those with lower technology skills, often lack the confidence to interact with ABC, and they may not even want to try it out. In addition to earlier subjective experiences, media articles, discussion with other people or observing others using ABCs creates prejudices and attitudes toward self-service solutions. As a result, lack of information and incorrect information may negatively affect passengers' acceptance. As people tend to compare the use of new technologies and services with earlier experiences, it might also cause difficulties when the style of interaction differs from the past (e.g. traditional border control).

Travel purpose varies from regular business travel to occasional holidays. It is assumed that the opportunity to use self-services for airport processes in general is more important for business travellers than those who are travelling for leisure

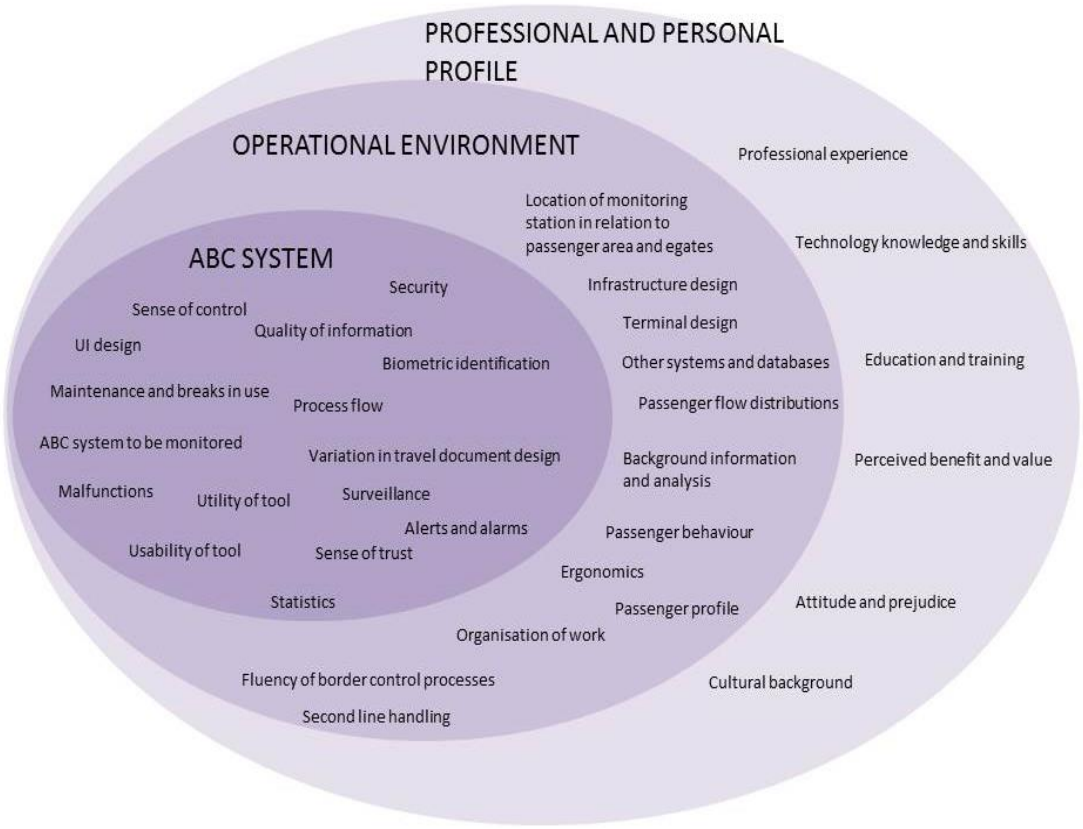

Figure 3. Factors affecting border guard experience

[9]. The more the passenger is used to travel, the more they are assumed to be aware of processes related to travelling, border crossings and controls in general. As business travellers often travel frequently, they might already have experience on ABC system at different border crossing points. They rarely face major problems when interacting with travel-related self-services, and may also more easily overcome usability problems. The challenges are emphasized in the situation of first time usage or after a period of non-usage. Thus it is important that with an infrequently used system it is easy to remember how to use it and for untrained and non-habitual users with no technological background to understand easily how to start usage.

The current settings for travel refer to the travelling circumstances on that particular journey. When travelling in a bigger group or with people who are not able to use ABC, e.g. small children, people with disabilities, or people holding different types of travel documents, the willingness to use ABC may decline. Fear of being separated or getting lost is often the reason to stay together and choose an option everyone is entitled to use. Also, luggage and other objects the passenger has to deal with during the control process may impact a willingness or ability to choose a certain type of service.

B. Border guard experience

To enhance this smoothness of passenger flow and efficient performance of border control the ABC system has to provide border guards with a suitable, efficient and easy to use tool to monitor and control the use. As stated earlier, the border guard's working environment may be hectic and demanding. The average time a border guard can concentrate on one passenger is calculated only in seconds. The decision must be made quickly but must be trustworthy. The ABC system provides information that supports decision making, but often the border guard is the one who makes the final decision. To meet the needs and guarantee the efficiency of the monitoring tool, it is important to understand the working environment, work tasks and capability to use technology. Functions of the system and the performance of technology have a great impact on job efficiency and satisfaction, but just as important is to take organization of work, design and ergonomic of working station, suitability and support tools into consideration so as to guarantee the usability and usefulness of tools. If there is a conflict between work tasks, practices and tool, the intended benefits may remain unrealized. Fig. 3 illustrates the identified factors of border guard experience.

1) ABC system monitoring tool for border guards

Usability and usefulness of tool can be enhanced by careful user interface (UI) design. The relative importance of any information must be carefully assessed and, to support the operator's concentration, only relevant information should be visible during monitoring. For instance, administrative tasks and modification of settings should be clearly separated from routine monitoring tasks.

2) Operational environment

The system should provide the border guard with an efficient and sufficient way of profiling the passengers and provide an easy way to make a closer examination of a suspicious case when necessary. Location of the monitoring room and terminal design may support profiling and observing the passenger flow.

A passenger having problems with tackling ABC often requires a border guard's action, and in that way the passenger's challenges in use of ABC reflect directly on the border guard's work.

Environmental conditions impact not only on the technology but also on the humans utilizing the technology in order to complete work tasks. The equipment must be suitable for use in different environments and weather conditions.

Good ergonomic design improves functionality of a monitoring station. Environmental factors such as lightning, temperature, air condition, noise and humidity affect the ability to work and must be carefully taken into account. Good ergonomic design also improves the functionality of a monitoring station.

3) Professional and personal background

Similarly to passenger experience, a border guard's personal characteristics, background and knowledge influence their acceptance of, ability and willingness to use technology. But in contrast to passengers, only professional border guard personnel are allowed to use the system. They are provided with training to ensure an appropriate level of skills and the ability to use tools and properties of the system efficiently and to guarantee the continuous border security.

V. CONCLUSION

By gathering information and experiences from the perspectives of the passengers and the border authorities at both air and land borders, we have gained a deep understanding of the border control environment, passenger behaviour and the needs of the ABC system. We have identified factors that affect either positively or negatively the UX and acceptance of ABC systems. The purpose of this paper was not to provide a universal list of detailed requirements, but instead to provide greater understanding of the complexity of the ABC context and to identify factors that can be used to guide technology development in order to provide easy-to-use, efficient, acceptable, useful and secure self-service solutions for border control. The paper presented a structured view of the layers affecting the UX and also the technology acceptance of an automated border control system; both the traveller and the border guard point were considered.

Passengers are still facing challenges when interacting with ABC systems. The main challenges include the fact that potential users are not aware of the ABC concept or the possibility to conduct border control by using self-service. This may indicate that not enough information channels have been used to inform people about ABC and the existence of self-services. Thus, quality of guidance and carefully designed delivery methods are essential in order to improve awareness of ABC.

Poor usability may cause negative attitudes, which are also shared by a bigger audience, causing a variety of rumours and negative prejudices. That may increase general awareness of

the ABC concept but not necessarily in the way desired. For this reason, it is important to pay attention to the first-time usage so as to enable a fluent process, positive experiences and also ensure active and efficient use of ABC in the future.

Previous experience is recognised to have a significant influence on technology acceptance. Those who have had a positive experience are often eager to try out new technologies and solutions; those whose previous experiences were not so positive may want to avoid similar situations in the future. Thus, it is important to pay attention to system design and development so as to produce attractive and accessible solutions that encourage people to get familiar with the ABC concept and try it out.

Impacts of poor usability and unmet user needs may come out as a low utilization rate of the system, slower processing time, greater number of incorrect actions and increased number of complaints. Also the need for human recourses may unexpectedly increase when more assistance is needed to help and convince people to use the system. Passengers' hesitation and incorrect actions with the system will have direct impacts on the passenger flow at a self-service border check. It is also quite evident that border guards' fluent and error-free work in monitoring stations enhances smoothness of passenger flow in ABC.

Despite the fact that over 200 passengers were observed and more than twenty border guards were involved in the study, we have only scratched the surface of the context of ABC. More data is needed to analyse the factors in more detail and to prioritise them in order to better understand the importance and impact they have on UX and acceptance. When this work is done, more detailed guidelines can be outlined to support the design and avoid the pitfalls.

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REFERENCES

[1] Global Border Control and Biometrics Market Assessment – Universal Adoption of e-Documents will become a Necessity for International Travel. Frost & Sullivan. Feb 2013.

[2] Best Practice Guidelines on the Design, Deployment and Operation of Automated Border Crossing Systems. Frontex. 2011. Release 1.1

[3] Rosenbaum, S. (2010, July). Creating usable self-service interactions. In *Professional Communication Conference (IPCC), 2010 IEEE International* (pp. 344–349). IEEE.

[4] Gelderman, C. J., Ghijsen, P. W. T., & van Diemen, R. (2011). Choosing self-service technologies or interpersonal services—The impact of situational factors and technology-related attitudes. *Journal of Retailing and Consumer Services*, *18*(5), 414–421.

[5] Lu, J. L., Chou, H. Y., & Ling, P. C. (2009). Investigating passengers' intentions to use technology-based self check-in services. *Transportation Research Part E: Logistics and Transportation Review*, *45*(2), 345–356.

[6] Meuter, M. L., Bitner, M. J., Ostrom, A. L., & Brown, S. W. (2005). Choosing among alternative service delivery modes: an investigation of customer trial of self-service technologies. *Journal of Marketing*, *69*(2), 61–83.

[7] MacLeod, V., & McLindin, B. (2011). Methodology for the evaluation of an international airport automated border control processing system. In *Innovations in Defence Support Systems-2* (pp. 115–145). Springer Berlin Heidelberg.

[8] Oostveen, A. M., Kaufmann, M., Krempel, E., & Grasemann, G. (2014, July). Automated Border Control: A Comparative Usability Study at Two European Airports. In *8th International Conference on Interfaces and Human Computer Interaction (IHCI 2014), Lisbon, Portugal*.

[9] Wittmer, A. (2011). Acceptance of self-service check-in at Zurich airport. *Research in Transportation Business & Management*, *1*(1), 136–143.

[10] Zhang, N., Liu, Z., & Shen, Z. (2010, January). A user-centered resources model for redesigning self-service check-in system based on distributed cognition. In *Logistics Systems and Intelligent Management, 2010 International Conference on* (Vol. 1, pp. 220–225). IEEE.

[11] *ISO 9241-11: Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs): Part 11: Guidance on Usability*.

[12] Coventry, L. (2005). Usable biometrics. Designing Secure Systems that People Can Use. O'Reilly, 175–198.

[13] Toledano, D. T., Pozo, R. F., Trapote, Á. H., & Gómez, L. H. (2006). Usability evaluation of multi-modal biometric verification systems. Interacting with Computers, 18(5), 1101–1122.

[14] Theofanos, M., Stanton, B., & Wolfson, C. A. (2008). Usability & biometrics: Ensuring successful biometric systems. *National Institute of Standards and Technology (NIST)*

[15] Riley, C., Johnson, G., McCracken, H., & Al-Saffar, A. (2009). Instruction, feedback and biometrics: The user interface for fingerprint authentication systems. In *Human–Computer Interaction–INTERACT 2009* (pp. 293–305). Springer Berlin Heidelberg.

[16] Kumar, V. N., & Sprinivasan, B. (2012). Enhancement of Security and Privacy in Biometric Passport Inspection System Using Face, Fingerprint, and Iris Recognition. *International Journal of Computer Network & Information Security*, *4*(8).

[17] Cantarero, D. C., Herrero, D. A. P., & Méndez, F. M. (2013, August). A multi-modal biometric fusion implementation for ABC Systems. In Intelligence and Security Informatics Conference (EISIC), 2013 European (pp. 277–280). IEEE.

[18] Patrick, A. (2008). Acceptance of biometrics: things that matter that we are ignoring. In International Workshop on Usability and Biometrics, NIST: Washington, DC http://zing. ncsl. nist. gov/biousa/docs/workshop08/day1/7Patrick/Andrew-Patrick-Acceptance-of-Biometrics. pdf.

[19] Roto, V., Law, E., Vermeeren, A. P. O. S., & Hoonhout, J. (2011). User experience white paper. Bringing clarity to the concept of user experience.

[20] Best Practice Operational Guidelines for Automated Border Control (ABC) Systems. Frontex

[21] Pirelli, G. (2009). Usability in Public Services and Border Control. In HCI and Usability for e-Inclusion (pp. 532–552). Springer Berlin Heidelberg.

[22] Best Practice Technical Guidelines for Automated Border Control (ABC) Systems. Frontex. 2012. Version 2.0