Testing the borders of the future

Smart Borders Pilot: The results in brief

Co-funded by
the Internal Security Fund
of the European Union

eu-LISA

ISBN 978-92-95208-00-1
10.2857/598631

Contents

Background

Border management is currently going through significant transformation. To address the need for the Schengen Area to move towards more modern [1] and efficient border management by using state-of-the-art technology, the European Commission proposed the 'Smart Borders package' on 28 February 2013. This package contained legal proposals for establishing two systems that should help to speed up, facilitate and reinforce border-check procedures for third-country nationals (TCNs) travelling into the Schengen Area:

- **EES** – a central *entry/exit system* to record the time and place of entry and exit of all third-country nationals travelling to/from the Schengen Area;
- **RTP** – a uniform *registered traveller programme* to allow pre-vetted and frequent travellers from third countries to enter (and exit) the Schengen Area with minimal border checks.

In order to further assess the technical, organisational and financial impacts of the various possible ways to address border-management challenges, the Commission subsequently initiated – with the support of the European Parliament and the Member States – a proof-of-concept exercise aimed at identifying, assessing and testing technical options for implementing the Smart Borders package.

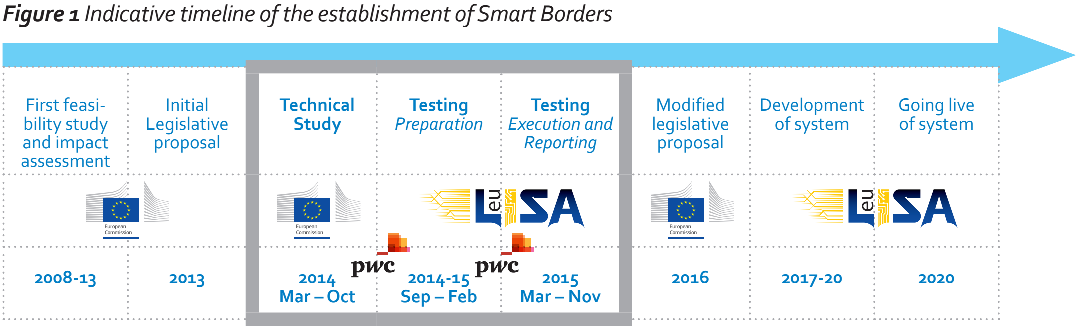
This exercise consists of two phases:

- **first phase – a Commission-led technical study** aimed at identifying and assessing the most suitable and promising options and solutions, as well as cost estimates. This study was delivered at the end of 2014; and
- **second phase – a pilot (also called 'testing phase')** entrusted by the Commission to the European Agency for the operational management of large-scale IT systems in the area of freedom, security and justice (eu-LISA).

The main objective of the pilot was to test a limited set of technical options (identified within the technical study) against specific measurable criteria in operational and relevant environments. These criteria are accuracy, effectiveness and impact on border-crossing duration. The testing phase aimed to contribute to defining the best technical solutions for faster and more secure border-control processes, respecting the highest principles on data protection and fundamental rights.

The Commission announced it would submit a modified legal proposal by early 2016 which – once adopted by the co-legislators – would allow eu-LISA to develop the system and start operations by 2020.

***Figure 1** Indicative timeline of the establishment of Smart Borders*



1 e.g. removing manual stamping and increased reliance on automated verification and identification methods.

Smart Borders: a unique and large-scale EU pilot

The targets and challenges set for the pilot were high and unique. More than 100 questions had to be addressed through either desk research or operational testing (or both). The limited technical options to be tested and researched amounted to 13 different test cases (TCs), such as the enrolment of four, eight and ten fingerprints, or the use of self-service kiosks [2]. It required the involvement of numerous stakeholders. Therefore, eu-LISA involved the EU institutions and other agencies in both the preparation and execution phases, such as the European Data Protection Supervisor (EDPS), the Fundamental Rights Agency (FRA) and Frontex. Progress reports were regularly communicated to the European Commission, the Member States as well as to the European Parliament. The tests in the pilot were carried out successfully across Europe in 12 volunteering Member States between March and September 2015.

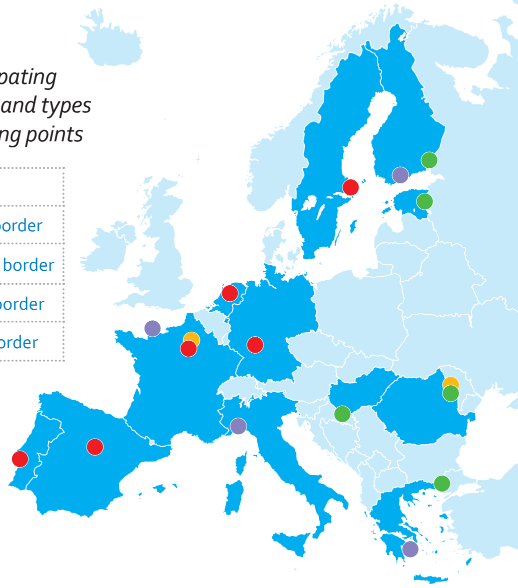
The scope did not include end-to-end [3] testing with real data from travellers. The pilot was conducted in compliance with existing legislation. Traveller participation was completely voluntary. All the tests were conducted by the Member States under the close supervision and cooperation of national data-protection authorities.

The pilot lived up to expectations: it managed to deliver evidence-based results based on high participation rates from travellers, who were of various nationalities and all ages. One out of two travellers also provided feedback, and 89 % of respondents said that they were satisfied or very satisfied with their experience of the pilot. Participating border guards expressed positive feedback. eu-LISA also invited the FRA to look into the use of biometric technology on third-country nationals at the borders. The aim was to complement the third-country nationals' experience of the pilot with perceptions regarding the use of modern technology. Following this, the FRA carried out an independent small-scale survey at seven border-crossing points where the Smart Borders pilot took place to look into attitudes of third-country national travellers regarding the use of biometrics at BCPs and their opinions on various associated fundamental rights aspects.

Smart Borders Pilot in a nutshell	
Scope	Air, sea and land borders crossing points (BCPs)
Member States	12 (DE, EE, EL, ES, FI, FR, HU, IT, NL, PT, RO, SE)
Border crossing points	18
Test cases	78 test variations
TCN travellers	58 000
Border guards involved	About 350
Biometrics	Fingerprints (FP), Facial Image (FI) and iris
Process accelerators	ABC gates, kiosks
Desk research	Spoofing, VIS and travel document number, web service

Figure 2 *Participating Member States and types of border-crossing points*

Key
Sea border
Land border
Rail border
Air border



2 All 13 Test Cases are described in the Methodology chapter in an annex to the Final Report.

3 An end-to-end pilot would have encompassed recording personal data at entry into a central database simulating the EES and matching this data at exit. In that instance, the tests would have required a mock-up central EES system to be set up and personal data to be stored in that system. This would have required a specific legal framework allowing it.

Pilot results

This report presents the results of operational testing and desk research, providing **an important evidence** basis for the feasibility of the system(s) and processes proposed by the Smart Borders package.

Where possible, the results have been consolidated according to the same biometric identifiers. However, due to the differences in border crossings (e.g. conditions, volumes, processes, integration and set-up level of new testing equipment), not all the results from the same test cases at the different border-crossing points could be compared [4]. Instead, similarities and differences were considered from a duration, security or equipment-performance perspective.

Key findings from operational testing

Fingerprint (FP) enrolment

***Table 1** Summary of locations per type of border where fingerprint enrolment was tested.*

4 fingerprints (TC1) – **at 11 border-crossing points**, 8 FPs (TC2) – **at 8 BCPs**, 10 FPs (TC3) – **at 6 BCPs**	
Air	Frankfurt (DE) • Schiphol (NL) • Madrid (ES) • Charles de Gaulle (FR)
Sea	Helsinki (FI) • Piraeus (EL) • Genoa (IT)
Land (road)	Kipoi (EL) • Udvar (HU) • Vaalimaa (FI)
Land (train)	Iaşi (RO)
Outcome	the pilot confirms that it is feasible to enrol fingerprints at all types of borders in various set-ups. However, in practice, enrolling four fingerprints is faster than enrolling eight or ten, although a higher number of fingerprints will deliver better accuracy for subsequent use. The quality of the fingerprints enrolled is generally fit for purpose. Enrolling fingerprints in controlled conditions is seen as the biometric identifier that is the least intrusive to travellers, according to both travellers' and border guards' feedback.

Main findings

Success/quality

- The quality of fingerprint enrolment cannot be directly linked to the number of fingerprints enrolled.
- There are currently no certification standards for contactless scanners.
- When the success rate was below 30 %, this was mainly due to set-up and technical constraints.
- Identification accuracy can reach around 99.3 % based on performance predictions provided by a number of vendors and with a database containing four FPs each from 100 million records. When performing a verification of a known traveller, performance is known to be a fraction less than 100 % [5].

4 In addition, a comparison of the results according to different biometric identifiers has been made with great caution due to the following factors:
- verification could only be tested for facial image and not for fingerprints and iris;
- only the vendors' quality thresholds could be used for FI and iris;
- kiosks were implemented only in limited operational settings; and
- iris is the newest biometric type and mostly unknown to border guards, whereas FP and FI are already used (FP for verification against the VIS; and FI at ABC gates).

5 Data on single-finger verification transactions is available from the on-going Fingerprint Verification Competition run by the University of Bologna (https://biolab.csr.unibo.it/fvcongoing/UI/Form/Home.aspx).

Duration

- The added duration of the border-control process is directly linked to the number of fingerprints enrolled and the desired quality: enrolling four FPs had the least impact [6] on time and is considered to have a relatively limited impact on the border-crossing process, with the vast majority of cases being performed in under 30 seconds on average. At air borders, average durations ranged from 17 seconds for 4 FPs to 60 seconds for 10 FPs. At sea, duration ranged from an average of 20 (4 FPs) to 46 seconds (10 FPs), and at land borders from 21 (4 FPs) to 49 seconds (10 FPs).
- In a nutshell, enrolling eight fingerprints took roughly twice as long as enrolling four (≈+126 %), while enrolling ten fingerprints took almost three times longer (+185 %).

Technology [7]

- The technology used to acquire four fingerprints was assessed as mature at all locations. A specific set-up might still be required at certain locations. In general, enrolling FPs in outdoor and moving conditions can sometimes raise issues (e.g. extreme temperature conditions, direct UV light on the optical lens).
- It is important that the system provides real-time feedback to both the traveller and the border guards during the enrolment process.

Experience

- Fingerprints are the type of biometric tested which seem to be the most favoured by travellers and border guards.
- Enrolling eight or ten fingerprints is perceived to be substantially more time-consuming.

4 FPs	✈	🚢	🚗	🚆
Success/quality	🟢	🟢	🟠	🟢
Duration	🟢	🟢	🟢	🟠
Technology	🟢	🟢	🟢	🟠
Experience	🟢	🟢	🟢	🟠

8 FPs	✈	🚢	🚗	🚆
Success/quality	🟢	🔴	🟢	🟢
Duration	🟢	🟢	🟢	🟠
Technology	🟢	🟢	🟠	🟠
Experience	🟢	🟢	🟢	🟠

10 FPs	✈	🚢	🚗	🚆
Success/quality	🟠	🔴	🟠	N/A
Duration	🟠	🟠	🟠	N/A
Technology	🟠	🟠	🟠	N/A
Experience	🟢	🟢	🟢	N/A

Key			
Success/quality	🟢 ≥ 75 %	🟠 ≥ 50 % - < 75 %	🔴 < 50 %
Duration	🟢 < 30 s	🟠 ≥ 30 s - < 60 s	🔴 ≥ 60 s
Technology	🟢 Mature	🟠 Medium maturity	🔴 Low maturity
Experience	🟢 ≥ 65 %	🟠 ≥ 35 % - < 65 %	🔴 < 35 %

6 Based on the conclusions outlined in the European Commission's 2014 Technical Study.

7 Technology is assessed as 'mature' if it is already widely available on the market and in working condition, and is not highly impacted by environmental conditions. Medium maturity means being available on the market but sensitive to environmental conditions. Immature means that the equipment available on the market is not fit for purpose, has shown too many deficiencies and/or is too heavily impacted by the environment and therefore cannot be deployed at this type of border.

Facial-image (FI) enrolment and verification

***Table 2** Summary of locations per type of border where facial-image enrolment and verification were tested.*

Enrolling live facial image (FI) (TC4): capturing FI from eMRTD (TC6), verifying FI captured from eMRTD against live facial image (TC7) – **at 10 BCPs**	
Air	Madrid (ES) • Charles de Gaulle (FR) • Arlanda (SE)
Sea	Helsinki (FI) • Piraeus (EL) • Cherbourg (FR) • Genoa (IT)
Land (road)	Vaalimaa (FI) • Sculeni (RO)
Land (train)	Iaşi (RO)
Outcome	the pilot confirms that enrolling a facial image, capturing the image from the eMRTD chip and performing the verification are technically feasible at all types of borders in terms of success rate, quality, duration and experience.

Main findings

Success/quality

- Live facial images can be acquired using a standard off-the-shelf (web) camera, which can produce a high image quality for verifying travellers' identity. Very high success rates can be obtained, with verification accuracy reaching 93 %.
- Facial image as the unique biometric identifier cannot be used for identification purposes with large-scale databases.

Duration [8]

- The duration of the process was generally deemed acceptable except at border crossings on moving trains, where acquiring a live image was affected by changing conditions due to the movement of the train. In general, chip-image capture never lasted more than 3.5 seconds on average at air, sea and road borders; live image capture took 5.5 seconds on average; and verification was always done in less than 1 second at all types of borders.

Technology [9]

- To ensure that the live facial image captured is of a high quality and to guarantee subsequent high verification success rates, backlighting and reduced lighting should be avoided.
- The technology needed is widely available on the market today.

Facial Image	✈	⛴	🚌	🚆
Success/quality	🟢	🟢	🟠	🟢
Duration	🟢	🟢	🟢	🔴
Technology	🟢	🟢	🟢	🟢
Experience	🟢	🟢	🟢	🟢

Key			
Success/quality	🟢 ≥ 75 %	🟠 ≥ 50 % - < 75 %	🔴 < 50 %
Duration	🟢 < 15 s	🟠 > 15 s - < 30 s	🔴 ≥ 30 s
Technology	🟢 Mature	🟠 Medium maturity	🔴 Low maturity
Experience	🟢 ≥ 65 %	🟠 ≥ 35 % - < 65 %	🔴 < 35 %

8 For comparison purposes, the thresholds set for assessing FI duration were adapted in order to reflect the difference in processes of enrolling FP and iris. Indeed, for FI the assessment was made on the whole facial image process (i.e. enrolment of biometrics, capture of chip and verification) which performed extremely fast.

9 Ibid.

- Capturing the image from the chip can be done using equipment which is already available at most borders.
- The camera must be user-friendly and suitable for local environmental conditions at the BCP.
- An auto-adjustable camera is an advantage as it ensures image quality by adapting to travellers' height and position.

Experience

- Taking a facial image is very common at borders where ABC gates are in use, which could explain the positive feedback left by travellers.
- Feedback from border guards and travellers was positive; automatic verification increased the border guards' confidence in the correctness of their decisions.

Iris enrolment

Table 3 *Summary of locations per type of border where iris enrolment was tested.*

Iris pattern enrolment (TC5) – **5 BCPs,** at 2 of which the test was combined with FI	
Air	Lisbon (PT)
Sea	Cherbourg (FR)
Land (road)	Sculeni (RO) • Kipoi (EL)
Land (train)	Iaşi (RO)
Outcome	the pilot confirms the feasibility of using the iris as a biometric identifier within the context of a future EES system at all types of borders, and validates it as a possible complementary biometric identifier along with a facial image and/or fingerprints for registered travellers. Facial image and iris appeared to be a more effective combination than iris and fingerprints.

Main findings

Success/quality

- High success rates for enrolment were achieved at a set quality threshold.

Duration [10]

- Using fixed equipment for enrolment added only limited time, while the use of mobile equipment was more time-consuming. Indeed, at sea and road borders where fixed equipment was deployed, enrolment never took longer than 4 seconds on average. This duration increased by up to 20 seconds on average with mobile equipment.

Technology [11]

- The technology required currently exists and is available in terms of both fixed and mobile solutions.
- Fixed devices are easy to use, and capturing irises at a distance (usually around 1 m) worked in under five seconds in 78 % of cases.

10 For comparison purposes, thresholds set for assessing the duration of iris enrolment are the same as for fingerprints.

11 Ibid.

Iris	✈	🚢	🚐	🚆
Success/quality	🟠	🟢	🟢	🟢
Duration	🟢	🟢	🟢	🟢
Technology	🟢	🟢	🟠	🔴
Experience	🟠	🟠	🟠	🟠

Key			
Success/quality	🟢 ≥ 75 %	🟠 ≥ 50 % - < 75 %	🔴 < 50 %
Duration	🟢 < 30 s	🟠 > 30 s - < 60 s	🔴 ≥ 60 s
Technology	🟢 Mature	🟠 Medium maturity	🔴 Low maturity
Experience	🟢 ≥ 65 %	🟠 ≥ 35 % - < 65 %	🔴 < 35 %

- Enrolling an iris pattern in outdoor conditions or on moving trains is more problematic due to time and space constraints. It took about 26 seconds on average.
- Hot weather conditions and bright or dim light conditions impacted the functioning of the mobile equipment.
- Elderly people were reported to have difficulties in enrolling their irises, as well as people with almond-shaped eyes with epicanthic folds (majority of Asian travellers).
- Iris enrolment was assessed as being no more prone to spoofing than any other biometric identifier.

Experience

- Feedback from border guards and travellers was generally positive.
- Based on border guards' feedback, capturing irises seems to require fairly little training and instructions.

ABC gates

Table 4 *Summary of locations per type of border where ABC exit of TCNs was tested.*

ABC gates for exit checks for TCNs (TC9) – **at 7 BCPs**	
Air	Charles de Gaulle (FR) • Schiphol (NL) • Lisbon (PT) • Frankfurt (DE)
Sea	Helsinki (FI)
Land (road)	Narva (EE)
Land (train)	Gare du Nord (FR)
Outcome	the pilot confirms that using ABC gates at exit for TCNs and performing bearer verification on the basis of the facial image are technically feasible.

Main findings

Success/quality

- ABC gates performed as well for TCNs as they currently do for EU citizens.

ABC gates	✈	🚢	🚐	🚆
Success/quality	🟢	🟠	🟠	🟢
Duration	🟢	🟠	🟢	🟢
Technology	🟢	🟠	🟢	🟠
Experience	🟢	🟢	🟢	🟢

Key			
Success/quality	🟢 ≥ 75 %	🟠 ≥ 50 % - < 75 %	🔴 < 50 %
Duration	🟢 Lower than baseline	🟠 ≥ baseline - ≤ 125 % of baseline	🔴 > 125 % of baseline
Technology	🟢 Mature	🟠 Medium maturity	🔴 Low maturity
Experience	🟢 ≥ 65 %	🟠 ≥ 35 % - < 65 %	🔴 < 35 %

Duration

- The time taken to cross the border was assessed as comparable with manual control times. Average durations for the whole process ranged from 14 to 41 seconds on average.
- Passive authentication took less than 6 seconds.

Technology [12]

- The main environmental constraint identified was lighting, which impacts live facial-image capture and subsequently verification.
- The technology is already in place and operational at several borders across the Schengen Area.
- While the BCP environment may need to be adapted in some cases, the two primary remedies (removing or adding light) can be implemented easily.
- In terms of security, authenticating the travel document automatically was seen as having a positive impact on border guards' confidence in the decisions they make at the border.

Experience

- In general, feedback from travellers was very positive.
- Border guards highlighted that ergonomics and a user-friendly, uniform interface are essential for ensuring traveller acceptance and usability.

Kiosk

Table 5 *Feasibility assessment of kiosk per type of border where the use of kiosks was tested.*

Use of self-service kiosks (TC10) – **at 3 BCPs**, pre-border checks at land borders (TC11) – **at 1 BCP**	
Air	Lisbon (PT) • Madrid (ES)
Sea	Helsinki (FI)
Land (road)	Sillamäe (EE)
Land (train)	N/A
Outcome	the pilot confirms that using kiosks at entry for capturing data from travel documents (eMRTD) and enrolling/verifying four or eight FPs and FI are technically feasible in controlled environments. Land borders seem less suited to kiosk deployment at entry lanes due to constraints in available space (i.e. waiting area). However, the number of participants in the kiosk test case at land borders remained too low to draw meaningful conclusions. There was no kiosk test case at a train station or on a moving train.

Main findings

Success/quality

- In general, kiosks are able to capture data from the travel document and enrol fingerprints at a similar quality to that achieved with manual booths.

12 Ibid.

Kiosk				
Success/quality	●	●	●	N/A
Duration	●	●	N/A	N/A
Technology	●	●	●	N/A
Experience	●	●	●	N/A

Key			
Success/quality	● > 70 % completion of the process without errors	● ≥ 50 % - < 75 % completion	● < 50 % completion
Duration	● +/- 20 % difference with manual booth	● 20-50 % difference	● > 50 % difference
Technology	● Adapted and working	● Some constraints	● Not adapted
Experience	● ≥ 65 %	● ≥ 35 % - < 65 %	● < 35 %

Duration

- Less time is spent at the manual booth when tasks are performed at the kiosk, i.e. there was a reduction of up to 35 seconds (including capturing four fingerprints).

Technology [13]

- Unfavourable light conditions can impact the quality of the live facial-image capture.
- The technology needed to assemble a kiosk exists today. Some further refinement in terms of their user interface would be an improvement.
- The impact of extreme weather conditions could not be assessed, since kiosks were always installed in indoor environments.
- Human supervision is required to strengthen security, primarily to prevent unauthorised persons being enrolled.
- Automatic height adjustment resulted in good facial-image verification (often superior to manual booths).

Experience

- Feedback from travellers and border guards was generally positive.
- According to border guards, travellers almost always need guidance, when using these systems for the first time.
- A human interface and ergonomics are essential for guaranteeing traveller acceptance and usability.

13 Ibid.

Key findings from desk research

In addition to operational testing, desk research was conducted to address some further issues covered by the Terms of Reference of this pilot, in particular:

- potential fall-back scenarios in the event that the EES is unavailable or unreachable, and describing related procedures, architecture and consequences;
- VIS border checks while using the travel document number (instead of the visa-sticker number);
- web services for travellers and carriers; and
- equipment costs.

The table below summarises the key findings for each of the four topics.

Desk-research topic	Key findings (the following measures should be considered)
Fall-back scenario	• High-level availability (similar to the level of SIS II, i.e. 99.99 % per month) should be developed at central level. • Member States should aim to achieve the same high level of availability. • If the EES is temporarily unavailable, solutions for local electronic buffering and later synchronisation with the central system should be developed and implemented. • Manual (correction) procedures should be developed in case an entry or exit record is missing from the EES.
VIS border check using travel document number	• Searching the VIS by using the passport document number simplifies the border-control process and makes it easier for visa holders to use automated solutions (i.e. self-service kiosks and ABC gates). • Several options for consulting VIS based on the travel document number (instead of the visa sticker number) were assessed and considered feasible from a technical perspective. The technically preferred option is to use the alphanumeric search engine.
Web service for travellers and carriers	• For travellers to be able to consult the system, the proposed option would be to use data from the passport and provide a simple but discrete OK/NOK answer. • A credential-based system is proposed for carriers, whereby using travellers' passport data as an input, a simple OK/NOK answer is provided if a single day of stay remains. The option to introduce a proof-of-check mechanism was also assessed in order for the carriers to confirm that they performed the check.
Equipment costs	• The estimated average acquisition prices [14] for biometric devices have been provided in the report. However, the final costs will depend on the choice of biometric identifiers made.

14 Installation and maintenance costs have not been included in the analysis.

Survey conducted by the FRA – key findings

There are a number of fundamental-rights implications related to the use of identification and verification technology in the context of border control. A small-scale survey conducted by the FRA looked into third-country-national travellers' attitudes and opinions regarding the use of biometrics at BCPs and various associated fundamental-rights aspects (e.g. the right to dignity, the right to respect for private and family life and the right to protection of personal data). Travellers' perception is believed to be an arguably subjective yet highly relevant element that needs to be taken into account when assessing the compliance of certain measures with fundamental rights (in addition to legal analysis).

The results show that the majority of respondents do not perceive that the use of biometrics at borders might compromise their right to dignity. There is also a tendency not to perceive the provision of fingerprints and facial image at borders as compromising the right to privacy. This is however not the case for iris-scan, which is considered the most intrusive option.

However, travellers expressed concerns with regard to the reliability of the system in the future. The majority of respondents believed that they would not be able to cross the border if the system malfunctioned. Similar concerns emerged in relation to the right to rectify the data, whereby half of the respondents believed that if there was a mistake in the data, it would be difficult to correct.

Conclusion

The pilot confirms the feasibility (in terms of accuracy, effectiveness and impact) of deploying biometric identifiers at Schengen external borders. Depending on the choice of biometric identifiers, the use of biometrics adds relatively little duration to the border-crossing process. Desk research proves that this time can be saved if some processes are better streamlined (e.g. by searching the VIS using the passport number).

The deployment of accelerators such as ABC gates and kiosks could further decrease border-crossing times. It was observed that the technology set-up and integration, as well travellers' interaction with it, influences the results much more than the type of border.

In addition, border guards felt that training was needed to prepare them for new equipment and processes. These key observations and considerations should now be put together and analysed further in developing successful combinations of biometrics for the future of Schengen borders.

The final report of the pilot was submitted to the European Commission as planned. The results of the pilot are representative and conclusive given the broad support provided by the Member States for the pilot, the number of the executed test cases for all types of borders and the amount of statistical evidences collected. The results of this unique project, conducted over a year, will contribute to the work on the modified legal proposal for Smart Borders.

Publications Office

ISBN 978-92-95208-00-1
doi:10.2857/598631
Catalogue n°: EL-04-15-806-EN-N