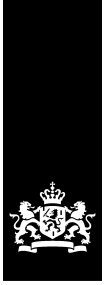

Ministry of Justice and Security

DTC1 pilot in The Netherlands

Final evaluation report

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Colophon

Directorate-General for Migration
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1 Preface

1.1 *Pilot background and purpose*

At the request of the European Commission (EC), the Netherlands implemented a pilot with a Digital Travel Credential (DTC) to enable border management processes to be conducted more effectively and efficiently, and to facilitate travellers whilst maintaining the security standards and respecting their privacy. The pilot was implemented from the beginning of January until 31 March 2024 with travellers on KLM flights from Canada to Amsterdam.

The pilot is a public-private cooperation of the Ministry of Justice and Security (*JenV*), the Ministry of the Interior and Kingdom Relations (*BZK*), the Royal Netherlands Marechaussee (*RNM*), the National Office for Identity Data (*RvIG*), Royal Dutch Airlines (*KLM*) and Amsterdam Airport Schiphol (Schiphol). The technology provider for the pilot was IDEMIA. Figure 1 illustrates the roles and motivations of all consortium partners for participation.

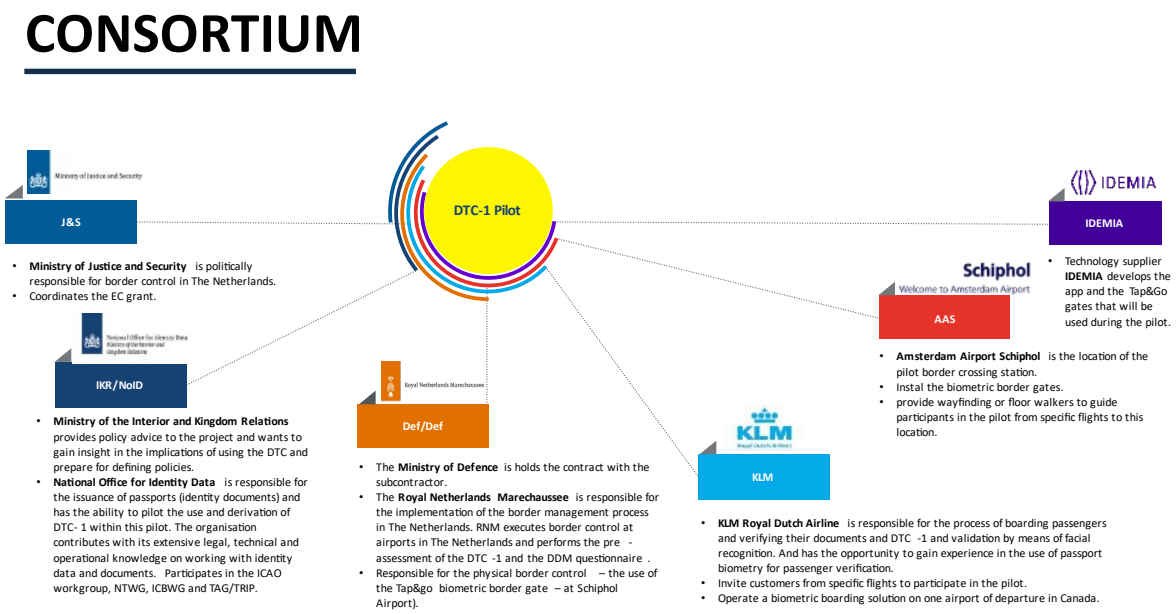


Figure 1: Consortium roles and interests

1.2 This report

The setup of this report resembles the set-up of the pilot project. First, a brief description of the pilot setup and purpose is given in chapter 2.

Chapter 3 summarises everything the consortium has learned during the preparation for the pilot. Developing the pilot system, creating the legal framework and preparing operations are the main focus points. Chapter 0 presents the learnings from pilot operation. It shows the outcome of travellers using the DTC for the purpose of biometric boarding and biometric border crossing.

Chapter 5 holds a number of discussions around use of the DTC. These discussions are pilot outcomes and answer questions that can arise around the use of the DTC. In Chapter 6 presents an overview of the pilot results and recommendation for future use of the DTC.

1.3 Research questions

The Grant Proposal stated the intention to provide information on a number of subjects. The table below shows where the information is provided within this document.

Subject	*Location in the document*
Test of the usefulness and reliability of the DTC-Virtual Component (VC), by comparing the DTC-VC to the actual electronic passport.	Paragraph 4.4.1 Common biometrical aspects
Experience in designing effective digital Entry-questionnaires.	Paragraph 4.4 Pre-assessment of travellers
Experience in assessment of digital Entry-questionnaire.	Paragraph 4.4 Pre-assessment of travellers
Effectiveness and reliability of biometric access gates.	Paragraph 0 Border crossing
The processing time of all new steps is recorded whenever possible. These figures on steps enable estimation of changes to future processing time.	Chapter 4 at the end of each paragraph
Experience in information led or even risk based border control.	Paragraph 4.4 Pre-assessment of travellers
Experience in using an app for sharing passport information.	Paragraphs 4.2 and 4.3 on enrolment
Effectiveness of the use of automated biometric passenger verification as an alternative for verification by airline agents.	Paragraph 4.4.2 Boarding, including experience boarding agent

Table 1: Research questions answered

2 The Dutch DTC1 pilot

This chapter gives a short summary of the DTC1 pilot. It contains an overview of the pilot concept. First, a short description of the DTC is given.

2.1 The DTC

The DTC standard was developed by the International Civil Aviation Organization (ICAO), which is part of the United Nations. This standard describes multiple options. A DTC is a combination of a virtual component (DTC-VC) and a physical component (DTC-PC). By using DTC type 1 the physical component remains the physical passport while in type 2 and type 3 the physical component could be a mobile device. The virtual component is the derivation of the chip data in the travel document.

Within this pilot we make use of the DTC type 1 standard, where the participant in the pilot will load the DTC-VC onto the mobile device.

In short, a DTC-VC is a copy of the digital information in the chip of an electronic passport. The DTC-VC is not an autonomous digital proof of identity. The passport, from which the DTC-VC is derived, is the proof of identity. Because of this, presenting the passport is required, but only a short interaction with the passport chip is performed.

In the rest of the document DTC is used as an abbreviation of DTC-VC.

2.2 The pilot process

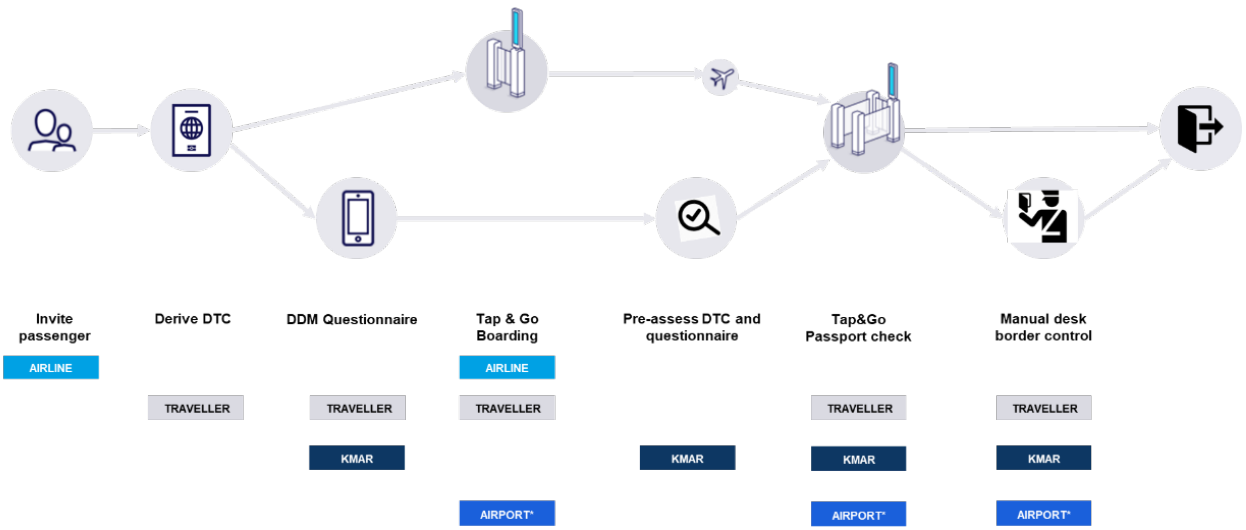


Figure 2: The DTC1 pilot process

Figure 2 shows the pilot process. Travelers who are eligible to participate in the pilot received an invitation by email from KLM at the email address that was used to book the KLM flight from Canada to the Netherlands. Due to the limited scope of the pilot only Belgian, Canadian and Dutch passport holders over 18 years old could participate in the pilot. Qualifying passengers on direct KLM flights from Vancouver,

Calgary, Edmonton, Toronto & Montreal to Amsterdam Airport Schiphol were invited for this pilot.

Passengers within the target group were invited to download a Government application - developed specifically for the pilot - on their telephone. The pilot participants first needed to use their phone to scan the Machine Readable Zone (MRZ) at the bottom of the page of the passport holder. After that, the passport must be held against the telephone to read out the passport chip. Upon creating the DTC, the pilot participant was asked to take a 'selfie', a photo, which was then compared to the photo contained on the passport chip. This prevented a person other than the passport holder from creating a DTC. Prior to the journey, the data could then be shared with RNM for the border process and / or with KLM for the boarding process.

Travelers departing from Montréal-Trudeau Airport in Canada could use the biometric boarding gate installed at this airport to biometrically board their flight to Amsterdam.

Canadian travellers were asked to fill out a digital entry questionnaire on purpose, length and means of stay in the Schengen zone. Upon their arrival at Amsterdam Airport Schiphol, pilot participants who shared their DTC with RNM before their flight could use a dedicated DTC Tap&Go-border gate. Based on the DTC and the answers to the entry questionnaire, RNM had already performed relevant border control checks prior to arrival at the border.

The DTC is retrieved at the border based on a facial scan. Pilot participants would then hold their (closed) passport against the border gate. If there is a match between the DTC and the passport presented and no particulars have arised from the checks previously performed, the pilot participant may pass through the border. A physical passport is therefore still required for the border passage.

The pilot is explained in a video: https://youtu.be/_eAywv_A4kw

3 Pilot preparation

3.1 Preface

This chapter contains the learnings gathered during the preparation for the pilot. The main element of the preparations were the realisation of the pilot system, the legal and policy preparations and the operational preparations of the organisations responsible for execution of the pilot.

3.2 Learnings of working within a Public-Private Consortium

This paragraph sums up the various learnings that have been gathered from working in a public-private consortium. They range from the day-to-day collaboration to operational and technical issues.

3.2.1 *Collaboration Consortium & stakeholders*

Public and private partners within The Netherlands: the consortium consists of several partner organisations, both in the public as in the private domain. As such, it was at times difficult to oversee how internal procedures and resources have an impact on the overarching pilot. Furthermore, internal complexities could lead to delays for other organisations because many activities in the pilot preparation are dependent on the input from other stakeholders or earlier contributions. In addition to that, projects and developments in the border-domain (for example: the implementation of the European Entry Exit System) put pressure on the available resources, such as personnel, physical (test-)locations, and finances. Moreover, preparing joint statements and products could at times be challenging due to organisational differences and interests at stake.

International collaboration: From an international point of view, The Canadian Government and Aéroports de Montréal Canada have proven to be valuable facilitators in the pilot-preparation and they have demonstrated their experience, technical know-how, and knowledge on the subject of digital travel documents. Moreover, they have enabled the consortium to perform the pilot on their domestic airports and showed their co-operation on practical preparations.

3.2.2 *Operational dependencies*

On airports there are different regulatory/policy guidelines in the use of hardware (e-gate and Tap&Go-components), depending on airport policies itself but also depending on national regulations. These guidelines are related to (fire)security, but also to practical elements, such as different energy sources. In future projects it is very wise to clarify these regulations and guidelines before the hardware is chosen, otherwise it could lead to delays in the implementation of a (pilot) set-up.

3.3 Contracting

Idemia is the processor for all parties involved, joint and/or independent data controllers in the creation of the DTC-Virtual Component (DTC-VC), the boarding process, and the border process, as a supplier of hardware and software in the various stages of the pilot. The RNM, which is part of the Ministry of Defence, is responsible for purchasing the pilot system from Idemia and making the necessary agreements.

The Ministry of Defence already had a contract with Idemia to provide self-service kiosks in the context of the EES implementation. This contract enabled the consortium to contract Idemia as technology partner in the DTC-pilot. For the timely submission of the DTC project proposal, this opportunity had a positive impact. Elaborating on the EES contract led to Defence procurement also getting involved in the project and also had a very strong impact on the settlement of security measures in the preparation and implementation phase of the pilot.
Although enabling quick procurement, this contracting approach did not allow various market offerings to be evaluated. Since this pilot technology will not be retained, this risk was considered acceptable.

3.4 Policy preparations

Prior to commencing the pilot project, several crucial policy-related steps were undertaken. Firstly, authorization was sought from relevant authorities to present a pilot proposal. Subsequently, parliament was informed about the forthcoming pilot implementation. This briefing aimed to provide transparency and clarity regarding the project's objectives and methodologies. However it also sparked inquiries from members of parliament, particularly concerning privacy, security and the implications of the DTC in relation to existing border control protocols and other developments in border management. All these queries were addressed in a written response[1].

From the start of the pilot, it was evident that success would require not only technological progress but also a well-considered understanding of legal, security, privacy and operational aspects to ensure compliance with all legal and safeguarding requirements.

3.5 System design, build and test

This paragraph contains the learnings about the pilot system itself. The paragraph starts off with a short introduction of the pilot system architecture. Knowing the architecture will give better understanding of the system design.

3.5.1 Pilot system overview

Figure 3 gives an overview of the pilot system design. The arrows indicate the flow of information between the various components.

[1] https://www.rijksoverheid.nl/documenten/kamerstukken/2023/07/13/tk-vso-inzake-de-brief-deelname-nederland-aan-europese-pilot-met-digitaal-reisdocument

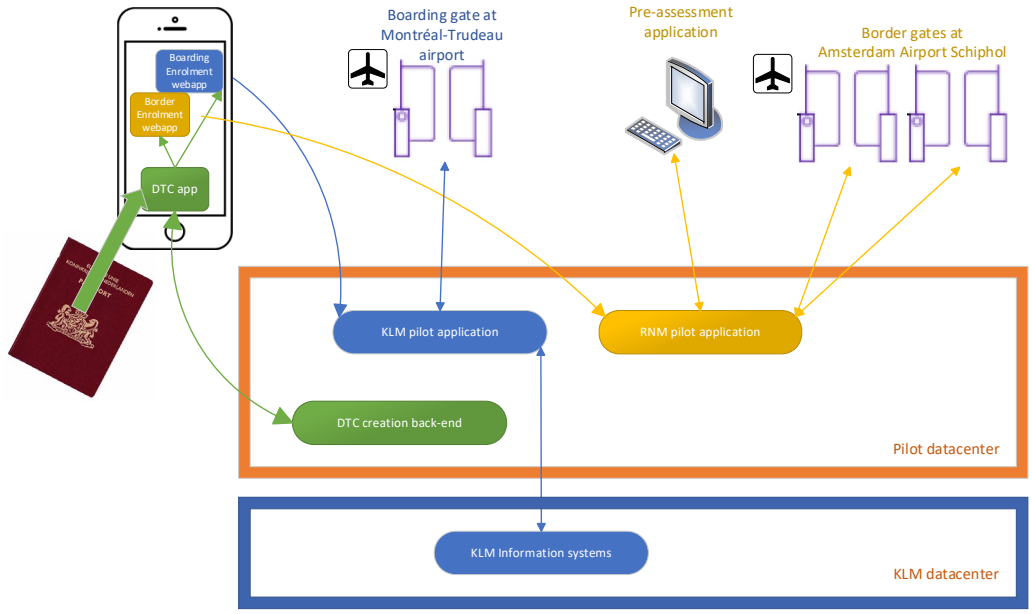


Figure 3: Pilot system architecture

The components are described in more detail, following the passport process:

- DTC app: this native smartphone application was available for the Android and iOS (Apple) platform. Only native applications can use Near Field Communication (NFC) functions on smartphone. This radio communication protocol is used to interact with the passport chips.
- The passport information was sent to a back-end system to verify the integrity and authenticity of the data. The back-end system also performed the selfie-verification. After successful verifications, the DTC was returned to the phone and remained only there.
- Boarding enrolment webapp: for enrolment, the DTC app redirects the user to a web application. For boarding this was web application in KLM-design. For enrolment, the traveller has to release his DTC from the DTC app.
- KLM pilot application: Upon receiving the DTC, the pilot application verifies the integrity and authenticity of the DTC. Next, the application calls out to a KLM booking system to check whether the traveller indeed is on this flight, using the information from the DTC. When this is the case, the pilot system received a KLM identifier from the pilot system and the DTC is propagated to the boarding gate.
- Boarding gate: The boarding gate tries to match an entering traveller to the facial images in his gallery. When this is the case and the traveller and the Tap&Go of the passport is correct, the KLM boarding system is informed that the traveller is present. The gate will open when an authorisation is received from the KLM boarding system.
- Border enrolment webapp: for enrolment for border crossing, the DTC app redirects the user to a web application in RNM-design. After having released his DTC to the pilot system, Canadian travellers were asked to complete an entry questionnaire via the same web application.
- RNM pilot application: After having completed the enrolment, the received DTC is checked for integrity and authenticity. Next, the traveller is enrolled in both the pre-assessment application and the border gates (but the traveller will not be able to cross the gate until the pre-assessment has been completed successfully).

- Pre-assessment application: The pre-assessment application is a web application available only to the TCB. It allows TCB to see the received DTC and entry questionnaire. TCB border guard perform the regular border checks using the DTC. And they evaluate the answers to the entry questionnaire. The border guards enter the outcome in the pilot system (approved, rejected)[2].
- Border gates: The border gate tries to match an entering traveller to the facial images in his gallery. When this is the case, the traveller and the Tap&Go of the passport is correct and the result of the pre-assessment was 'Approved' the border gate will open. Otherwise the gate remains closed and the border guard on location will further process the traveller.

3.5.2 Pilot system development

In general, a valuable learning experience is to start writing a general specification document as soon as possible, with efforts from the supplier and client-organisations. As became clear during the pilot, it takes a lot of time to agree upon the specifications between supplier and client-organisations. Moreover, the specification document can be used to design detailed accepting criteria in order to test the functionality of the products before they shall be accepted for operations. However, implementing new technology cannot be done with a fully written specification alone. Because it is new, iterations, demonstration, trial and redesign need to be incorporated in the design process. Due to the tight planning in this pilot, this happened less often than desirable.

Prioritising: the consortium has gained many interesting insights during the design- and development phase of the pilot that could potentially be relevant for future policy development. Even though these learnings are highly relevant, it was also important to narrow the scope when it comes to the operational preparations to Go-live. It is therefore necessary to prioritise the necessities. At times it was challenging to distinguish the 'need to haves' versus the 'nice to haves'. For example: some functional inconvenience could be identified as 'nice to have'. However, when a large number of potential participants drop out of the pilot because of it, is becomes 'need to have'.

3.5.3 DTC-Application

When designing a DTC-application, it is technically required to build a native app to create the DTC. The communication with the passport chips runs via Near Field communication. This feature of phones is only available to native apps, not to web-applications.

User Experience

The pilot solution clearly shows technical challenges between the DTC-app containing the DTC-VC and the enrolment web applications. Switching between the app and websites used is confusing for travellers and leads to a suboptimal performance. A customer journey centred approach can eliminate these design issues and could lead to one app that enables an integrated experience. Such an app would, however, be limited to the enrolment options it offers; wallet apps offer DTCs to any environment. But users will always experience the hand-over from the wallet app to the specific enrolment application. General purpose DTC storage versus specific, well supported use cases will remain a trade-off in solution design.

[2] 'Rejected does not mean that the traveller can't cross the border, only that he couldn't be processed via this pilot solution.

Types and makes of phones
Another learning to be shared is that there is not enough industry standardisation to ensure successful DTC-creation for an app on *all* phones. For example, will need to provide NFC communication support. At this point of time it therefore seems not feasible to oblige travellers to submit their DTC, but this process should remain on a voluntary basis. Even if there was such an obligation, it is simply not executable.

Issuance of the app
In the pilot set-up, the app is issued by the Dutch government, specifically for the purpose of this pilot. The DTC can be derived and submitted only for travelling in the pilot. In future, there are several options to do this:

1. Dedicated apps per application (basically the pilot concept). This dedicated app derives the DTC from the passport and is therefore able to perform specific security checks. The main advantage of dedicated apps is the possibility to fully control the DTC creation process and the verification of the digital security features. An additional check can be implemented to ensure that the passport holder is the one creating the DTC (facial image verification and liveness check). However, it generally requires creation of the DTC specifically for the app and reuse of the DTC is less likely. A solution would be a specific 'enter Schengen zone' app that could be used for crossing a multiple (all?) border crossing of the Schengen zone. Besides, it could combine other necessary digital preparation for travelling to the EU in one app: check of remaining free stay (EES), travel authorisation (ETIAS), visa, questionnaires on purpose, duration and means of stay, and custom declarations.
2. No specific apps, but a specified interface to allow basically any app to submit data. This would allow anyone to submit data. Contingency measures are required to eliminate abuse and must be implemented. Nonetheless, this option delivers the least reliable information since it is relatively open to abuse: submission of DTCs from stolen of lost passport cannot be prevented. This option, therefore, doesn't seem desirable.
3. A system of certification for apps that are entitled to submit information. Precondition can be set for apps to ensure reliable identity processing. Apps that meet these criteria can be allowed to submit information. Multi-purpose apps, like wallet apps would give the traveller more reuse of the DTC.

The pilot design showed that, along with the DTC, additional data is very important, such as the flight number and date. The information used to manage the pre-processing workload.

Biometric identification during creation
The pilot uses biometric verification of a selfie photo with the passport photo. In addition to that, a liveness check is performed. Both are implemented to ensure that the passport holder is the one deriving the DTC and creating DTCs from stolen or lost passports is more difficult in this case. This prevents travellers from identity fraud and service providers from processing false information. Business processes and travellers identity protection profit from this check. However, processing biometric information needs a strong foundation under GDPR. Further legal assessment must determine whether a foundation in law is required.

3.5.4 Content of the DTC

The ICAO doc 9303 states that the Machine Readable Zone (MRZ, datagroup 1), the photograph (datagroup 2) and the security object (SOD) on the chip of the traveldocument are mandatory, the other datagroups are optional and will be

decided by the member state. Our design of the pilot, the DTC contained datagroup 1, 2, 11 and the SOD.

3.5.5 *Passport verification*

At current eGates, all passport checks are performed during the actual border crossing. The main parts are:

- Optical reading and verification of the holder page
- Open the chip with data from the holder page
- Perform Passive Authentication. Frontex discerns this in 8 separate checks.
  - EF.SOD verification
  - DS certification signature verification
  - Certificate validity period check
  - DS certificate revocation status
  - Comparison between EF.SOD and EF.COM
  - Data Group integrity check
  - Comparison of optical and electronic biographical data
  - Issuing country comparison
- Perform Chip Authentication, when supported by the passport. When not supported, perform Active Authentication, when supported by the passport.

In the pilot system, the checks are performed at multiple stages. Figure 4 shows the setup of the pilot verification.

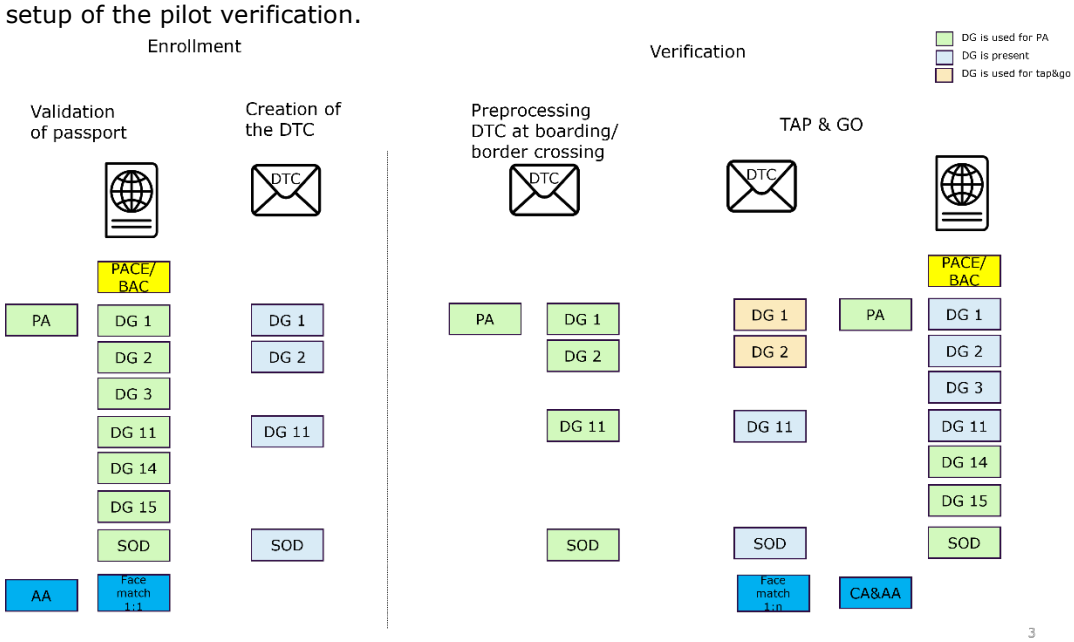


Figure 4: DTC content and checking in the pilot

The main moments of inspection are:

- DTC creation on the travellers phone. Checks are possible at this stage. However, the checking is done in an uncontrolled environment. It is therefore less reliable then checking at a border station. The level of control also depends on the issuance of the app. Whether a specific check done during DTC creation is sufficiently reliable for border control purposes, needs closer examination.
- Immediately after DTC submission
- During airline boarding and border crossing at Tap&Go-gate.

The following table shows which checks were performed at each stage of the pilot.

Check	*Enrolment*	*Submission*	*Border crossing*
Optical verification of the holder page	the MRZ	NA	No
Open the chip with data from the holder page	Yes	NA	Yes
PA: EF.SOD verification	Yes	Yes	Yes
PA: DS certification signature verification	Yes	Yes	Yes
PA: Certificate validity period check	Yes	Yes	Yes
PA: DS certificate revocation status	Yes	Yes	Yes
PA: Comparison between EF.SOD and EF.COM	Yes	Yes	Yes,
PA: Data Group integrity check	Yes	Yes	Yes
PA: Comparison of optical and electronic biographical data	Yes	Not applicable	Yes
PA: Issuing country comparison	No	Not applicable	No
Chip Authentication	No	Not applicable	Yes
Active Authentication	Yes	Not applicable	Yes

Table 2: Performed checks per stage in the pilot

Our pilot shows that verification of Passive authentication is necessary at border control when the public keys for Chip Authentication and Active Authentication (DG 14 and 15) are not stored in the DTC.

The learnings above can be summarised as follows:

- The DTC allows verification of the digital information. Issues related to the chip can only be identified when interacting with the chips.
- The checks should be done in a reliable way. Equipment at the border crossing station is a reliable way. Transferring checks to the enrolment can only be done when the reliability of the check on a travellers phone are comparably reliable.
- CA or AA must be performed at the border crossing. It seems wise to add all chip checks that couldn't be done (reliably) before border crossing.
- Whether or not the holder page must be examined, is a separate policy choice.

3.5.6 Transmission Protocol

A transmission protocol for submission of the DTC-VC to stakeholders need to be established global interoperable. The ISO workgroup SC17/WG3 has taken this as an action item.

3.5.7 Design Choices

A number of design improvements were identified during the pilot design- and development phase. This paragraph contains these learnings. The improvements were not implemented because of pilot scope limitations: limited design/

development time, the lack of integration into regular production systems or the limited availability of the technology with our technology provider. Nonetheless, they are valuable for future implementations.

User experience
It would be recommendable to inform the end-users of the status of their DTC-enrolment via push-notifications. These push-notifications can also be used to inform the traveller on where they can find the dedicated DTC-gates/Tap&Go-locations on a specific airport. This would increase the level of assurance from a passenger perspective (confirmation to have done the right things in a correct way), and it would help to guide the passengers to the correct 'DTC-lanes' (avoiding to be scanned by facial recognition cameras while not enrolled). It also provides a better control for the airline at the boarding gate when airline agents have an overview of which passengers have correctly enrolled for the biometric passenger verification and boarding process.
The learning regarding user experience is to develop a Service- and UX/UI design. This can be used as reference for the technical (app) development and will prevent a "technical" implementation that is hard to understand by the end-users.

Technology
A number of items were not implemented due to the temporary nature of the pilot system. They are noted in this paragraph and will be implemented with permanent solutions.

- Chip Authentication (CA) needs to be implemented. Pilot limitation allowed only for Active Authentication (AA). CA and AA are interchangeable ways to check whether a the chip is cloned. CA additionally adds encryption of the chip and passport readers communication. Therefore, this protocol is preferred, when available. To enable this, it requires new EU-regulation.
- Empirical evaluation of biometric performance. Periodically, the Ministry of Justice and Security has the biometric border control systems evaluated for meeting the standards set. For this pilot the normal evaluation couldn't be performed, because an evaluation project would be at least ten times the size of the intended pilot. The consortium therefore evaluated the performance of the used algorithms using the Facial Recognition Vendor Test of US standards organisation NIST[3]. This showed that the algorithms used performed within the boundaries set by the Dutch government. The good performance with various ethnic groups was also confirmed by NIST research.
- In the pilot, public certificates from the ICAO Master list are used for Passive Authentication. The Dutch Government has services in place for certificate management. Future production systems on the border must use these systems.
- Threshold settings for the biometric matching at enrolment and in the gates preferably are aligned.
- In the pilot, the matching of travellers happened in the gates. In future implementations a different architecture will be required when traveller can potentially use a large number of gates. A centralised matching solution will be logical.

Accessibility
A wide variety of people travel by plane. This requires apps and websites that are widely accessible. The public expects this from technology that is partly deployed at the initiative of the government. Dutch[4] and European[5] law require that

[3] Face Recognition Vendor Test (FRVT) | NIST
[4] wetten.nl - Regeling - Tijdelijk besluit digitale toegankelijkheid overheid - BWBR0040936
[5] Directive (EU) 2016/2102

governmental apps or other web-content is widely accessible, while there are exceptions for situations in which this is disproportionate. These requirements are for instance for users with disabilities. This means for instance that for people with certain disabilities, text in an app can be enlarged, or that an external key board can be used. The technology supplier indicated that the technology is generally Web Content Accessibility Guidelines (WCAG)-compliant. However, this was not officially tested with WCAG specialists or special needs users. In the development of a more final DTC app, this should be taken into account. In this specific pilot situation, in which there are limited participants and with a clear alternative in place – being the regular border and boarding process – the accessibility of the technology was considered sufficient.

3.6 Legal preparations

This paragraph focusses on the legal context of the pilot.

3.6.1 Lack of legislation on digital travel credentials

The use of digital travel credentials in the travel industry requires participation of various types of organisations, that work within different public and private legal frameworks. Formal regulation and/or agreements to structure responsibilities, roles and cooperation are desirable. The current lack of legislation on digital travel credentials also limits the possible legal grounds for processing of personal data as laid down in the GDPR. User consent as the legal ground worked for the pilot, but it is undesirable as a permament legal ground for public tasks like border control. New legislation needs to create a solid and specific base for data processing for both creating and using a DTC as well as for subsidiary processing that is necessary for safeguards, such as facial recognition. New regulation should be consistent with other (future) relevant legislation, such as the SchengenBorderCode, ETIAS, eIDAS and GDPR.

3.6.2 Challenges and possible risks from a border control perspective

The use of digital credentials in the travel industry creates challenges and possible risks from a border control perspective, because it changes the ways of identity- and document-verification. The use of biometrics (facial recognition) can mitigate some of these risks, but creates other types of risks and demands from a legal privacy (GDPR)-perspective. More concretely the following issues were identified:

- Current legislation like the SchengenBorderCode (SBC) allows processing digital identity information by reading the passport chip during border crossing. The SBC does not cover the derivation of the DTC from the passport chip by the traveller. In the pilot, this DTC is sent some time (up to several days) before arrival on the border. The traveller may decide not to cross the border at all. In the pilot, the ground for processing the data before arrival on the border, is the travellers consent. But this requires all GDPR precondition for processing on consent to be implement. A legal foundation to keep (voluntarily) submitted information during the time between submission and expected border crossing, would simplify information processing.

- And in succession to this: how long before an intended border crossing can databases (SIS, SLTD, national databases) be checked with the submitted data? This has at least two sides: the earlier it is done, the higher the risk that new information arises during the period between the check and the

actual border crossing. Secondly, checking the traveller in these databases can have serious implications for the traveller. So explicitly extending the legal foundation for this, may be appropriate.

- Current directives and guidelines for border control assume a physical inspection of the travel document. In the pilot solution, the happy flow depends entirely on digital information processing and its trust mechanisms. The passport remains closed at the border crossing. When this is to be implemented, directives and guidelines need to be updated accordingly.

- According to the ICAO doc 9303 standard, either Chip Authentication (CA) or Active Authentication (AA) must be performed during border crossing. EU directives prescribe that CA must be used when both methods are available (Implementing Decision 7774-2018 and Frontex Guidelines). When passports support neither protocol, border crossing using the full Tap&Go-concept isn't possible. Some countries have neither CA nor AA. But it can still be beneficiary to send the DTC-VC of the passports upfront to do a pre-assessment of these travellers. Upon border crossing a regular passport check should occur.

- EU directive and guideline contain requirements for passport 'Inspection systems'.

    - How is the pilot environment to be viewed?
    - Is the entire solution an 'Inspection systems', or are the individual components inspections systems? And in line with that: do the requirements to these 'Inspection systems' apply to the entire solution of to the individual components?

3.6.3 Legal/privacy risks for civilians

Specific legal risks for civilians include uncertainty on the (scope of) responsibility of involved organisations and therefore insufficient clarity about where a data subject can exercise their rights or can receive information, as there are multiple data controllers with different processes. Especially for third country nationals it shall be difficult to understand the exact nature, tasks and goals of these controllers. Other risks are the possible use of digital credentials by fraudulent parties or individuals, and the possible broader use of digital identities by involved organisations for other purposes than allowed or agreed upon. Data Protection Supervisors tend to pay specific attention on the transparency and clarity on these aspects towards data subjects.

- One concrete finding is the fact that data sharing with the DTC is a package deal. ICAO doc 9303 states that Data Group 1 (DG1, biographical data, the Machine Readable Zone), Data Group 2 (DG2, the photo) and the security object (SOD) are mandatory parts of the chip and therefore on the DTC-Virtual Component. The sharing of attributes for example out of datagroup 1 might be preferable from a privacy perspective for specific purposes, but this doesn't meet the standard. Removing specific biographic data, like for example the birth date, invalidates the checksums on the datagroup and makes it impossible to check the authenticity of the data. The DTC-VC is a valid carrier where the receiver is entitled by law or by traveller consent to process the full DTC. However, the carrier is inadequate where only a subset of the information is to be shared.

- *The retention time*. The consortium chose to create the DTC and keep it on the users phone for one journey, because reuse the DTC during the three months pilot was unlikely. The Dutch government, issuer of the app in the

pilot, also wanted to minimise the risk of leaking this data. In future situations with multiple usages of the DTC, there is likely to be sufficient reason to keep the DTC on a travellers phone for future use. The responsibility of this storage must be well defined between the traveller, the issuer of a wallet app and the receiver of the DTC. At all times the traveller should be able to remove the DTC from his wallet.

- *Consent and its withdrawal.* The processing of information was done by users consent. A consequence of this foundation is the need for a same or highly similar mechanism for withdrawal. In the pilot this was implemented via an e-mail request. Future systems working in this basis should implement this option in the apps or website. However, for border crossing a foundation in law is preferable. A submission of the DTC should be considered an intention to cross the border and the legal basis for this should apply. The current information systems on the border are not designed to handle withdrawal.

- The use of *algorithms for biometric comparison* have been extensively discussed during the preparations. The consortium did an Impact Assessment Fundamental Rights and Algorithms[6] to structure these discussions. This instrument, developed by Utrecht University on behalf of Ministry of IKR, provided useful insights in the consequences of using the face image algorithms.

3.6.4 Challenges in legal demands towards supplier

As stated above, various types of organisations can be involved with digital travel credentials. It is however desirable to have the same or a highly similar type of product(s), which makes it necessary to work with the same supplier or perhaps have a very high level of coordination to reach compatible products.
Since the number of suppliers able to provide the technical hard- and software as well as the scale needed for the use of digital travel credentials is limited, there is also limited room for selection. At the same time, the different types of organisations are likely to have different types of technical, operational and compliancy demands towards suppliers which are sometimes difficult for those demands to meet. Reaching the necessary legal agreements with the supplier to formalise these demands, has therefore proven to be highly challenging.

3.6.5 Lack of legislation on the use of digital travel credentials and biometrics for passenger facilitation by airlines

The current legislation (like Vreemdelingenwet (Aliens Act) – linked to Schengen Border Code) describes what airlines need to do, but not how to do it. The question is if this provides sufficient legal grounds for deriving, processing and temporarily storing the complete DTC, as well as the use of Biometrics. Furthermore the DTC holds more information than legally required for the purpose(s) of the airline, but the concept of DTC is not to alter the DTC, as this would mean the authenticity and integrity can no longer be guaranteed.
On a side note – but seriously complicating the pilot for the airline – Dutch Passports contain the BSN (Burger Service Number, Dutch Civil Service Number) which may only be processed with a legal grounds according to the dedicated Law for the use of this number. For passenger verification by airlines, there is no legal ground. The processing of the "BSN" is for the airline "unwanted and unnecessary", but unfortunately also "unavoidable" in the concept of DTC. As such, without either

[6] Impact Assessment Fundamental Rights and Algorithms | Report | Government.nl

legal grounds or alteration of the pilot, Dutch Passport Holders had to be excluded from the "Airline Boarding"-part of the pilot.

3.7 Operational preparation by KLM

KLM is the airline partner involved in the pilot. This chapter contains the learnings from their perspective.

3.7.1 General considerations

From an airline passenger perspective, it is key to know well in advance which travel documentation is required, and how to prepare the trip well in advance before coming to the airport. If (electronic) travel permissions are required, they need to be timely obtained by the passenger.

For international travel, the airline is typically required by laws (related to ICAO Annex 9) to verify the identity of the passenger for aviation security purposes, and to ensure that the passenger is in possession of the correct travel documentation (admissibility). In many cases the airline needs to provide advance passenger information (API) to the authorities that is provided via manual input, or swiping or scanning of the MRZ on the Passport-page. In some instances the airline also needs to verify the identity of the passenger in view of an exit check (Advance Passenger Information on Departure). The relevant legislation typically prescribes *what* has to be done, but not *how* it should be done. As a consequence, airlines can only invite passengers to use the biometric process and offer them the choice to opt in (free and informed consent).

IATA's Global Passengers Survey indicates passengers willingness to use facial recognition, as it enhances their travel experience, and - especially since COVID-19 – provides a touchless way of navigation through the airport.

Technology allows to verify to a large extent if passengers are properly documented. Examples are the checks done through "Automated Doc Checks" against databases such as IATA Timatic, or ICTS TravelDoc, and responses given by authorities through so called interactive-API, like will be the case in the (near) future with ETIAS. The airline then still has to ensure that the document, used for this automated check, is indeed belonging to the passenger holding / presenting it, and the name matches with the name on the boarding pass. This process can be automated through facial recognition. From an airline perspective, KLM expects that automation can perform this task better than trained agents, and leave agents to focus on passengers requiring additional care (such as families with small children, people with a disability).

It should also be noted that not all passengers will be eligible to use a fully automated process, as their documents, or trip does not – yet – allow for a fully automated verification process, and still some manual checks are required. The airline is capable of identifying that in their systems, and will be able to prompt for this manual verification.

At present the use of DTC and Facial Recognition for Boarding is voluntary and based on free and informed consent. Participating passengers were at Boarding in Montreal be invited to make use of a dedicated eGate which was positioned next to regular Boarding Lanes. There were signs to alert travellers to only use this when having enrolled for the DTC Pilot.

3.7.2 Learnings

During the design phase of the DTC 1 pilot KLM has listed some learnings.

Data minimalization

For the airline, it is relevant to understand that the (DTC) information is obtained from an authentic passport, and that the airline can verify at boarding that this passport is physically present. This is why the airline designed the "Tap&Go" after recognition of the passenger presenting the passport. However, the current process where a full DTC comparison is done requires a significant amount of data to be transferred (either to the gate, or from the gate to where the original DTC data is stored). The question arises if not a lighter check on (limited) elements is also sufficient for this purpose, and what alternative "signatures" would then work. The full data group 1 (DG1) of the DTC-VC is necessary to check the integrity of the data by means of Passive Authentication (PA). But after this check only parts of the passport information are necessary at the next stages of the boarding process.

Next, it is necessary to link the passport to the identification of the traveller booked on a specific flight. This resolves into a unique identifier: the DID. At the boarding gate only the following data are required:

- Photo (data group 2) for biometric identification at the gate
- Document number, birth date and expiry date to open the chip of the passport
- DG14 or DG15 to whether the DTC is derived from this unique passport(chip) via Chip Authentication or Active Authentication.
- DID.

It is not necessary to process other data and not in line with data minimization principles stipulated in the GDPR. This gives uncertainty with respect to how to deal with the processing of data that is in the DTC. In general, this is required from a GDPR perspective.

Contact information

Again for "data minimalization"-reasons the airline currently did not have contact information of the passengers that have enrolled for the "Tap&Go"-service. As such, the airline cannot prompt them that they have successfully enrolled, and remind them in the time-window before boarding that they can use this service. Neither did the airline staff know which passengers have successfully enrolled, and which passengers have not. In an end-state design, the airline would redesign this to ensure better passenger guidance through this process.

Integration to airline app

For the pilot we work with a dedicated App to create the DTC and enrol for Boarding. In a normal airline process the airline would invite the passenger to opt in for this process during the trip preparation of check in process, and read out the chip at that moment (compared to an OCR Scan that is currently done, and only serves to gather the relevant MRZ data, and not the passport photo). One of the airline's objectives is to understand how easy passengers will find this process.

3.8 General Learning Experience from RNM on pilot preparation

The RNM is part of and under the management of the Ministry of Defence and carries out border control under the authority of the Ministry of Justice and Security. This framework defines the involvement of the RNM with the DTC pilot.

The RNM operational preparation initially started determining the organisational components involved. In the case of the DTC pilot, these were the border brigade at Schiphol airport (the border guards) and the Targeting Center Borders (TCB). TCB was tasked with the pre-assessment activities like the judgement of the DTC, the answers with regard to the purpose, means and duration of stay in the Schengen area and the check in the European detection systems. After determining the service units involved, the number of involved staff was determined. Together with the staff the ideal working process was determined and together with the existing legal framework the training material was developed. The training of the involved staff was also focused on security measures as a result of all kinds of security policy requirements that had been imposed. The preparation also focused on cooperation with the other parties involved in the execution of the pilot, such as cooperation with Schiphol's passengers assistants. Finally, together with Schiphol the installation of the three DTC-gates was determined. A challenge given the limited space at the border crossing points and the preventing of disrupting the regular passenger process.

The preparation and - at a later stage – the operational activities were located at the border crossing point at Schiphol Airport, where they already face a lot of challenges:

- Running the daily operations, which is currently under a lot of pressure
- Infrastructural restrictions in the border control area
- The preparation of EES and the uncertainty with regard to the Entry into Operation (EiO).

As for the digital settlement of the control of purpose, duration and means of stay, representatives of the border brigade and TCB sat together to draft it. They also thought about the information the Canadian nationals had to send along in support of the answers they gave to the questions. Finally, it was jointly determined how the assessment was to take place.

Against this background it is challenging to plan and to execute new pilots, such as the DTC Pilot. It is important to finish ongoing projects first before starting a new pilot in the daily operations.

3.9 Operational preparations by Schiphol

Schiphols effort in preparing the operational pilot where divided into two main activities, the deployment of the physical infrastructure and operational preparations such as hiring/instructing passenger assistants and informing the operational departments involved in the border process at the airport.

3.9.1 Deployment of physical infrastructure

Installation of hardware at Schiphol can be challenging, especially in a situation where there is little room to implement additional gates next to the current process. During the design phase of the pilot architectural drawings were made to decide on the gate locations. During this phase is became clear that for two filters there was no or little room to place an e-gate. The third filter had enough space but was not in direct route of the passengers arriving from the KLM flights from Canada. Various set-ups where discussed with both RNM and Schiphol operations leading to the decision to not place a gate at the arrivals filter closest to the KLM flights arriving (arrivals 1). Instead, a kiosk was placed in the second filter (arrivals 2), and e-gates were placed at arrivals 3 and the non-Schengen arrivals filter.

During the operational pilot preparation RNM stated that the setup at arrivals filter 2 was not operationally viable and could not be used. Unfortunately there was not enough time left to change the setup. As a result, only arrivals filter 3 (furthest from the KLM arrivals) could be used. This posed several operational challenges. One learning of this pilot is to make sure that all partners have full commitment with their operations on the decision made during the design phase of the hardware deployment.

3.9.2 Operational preparations

During the preparation it became clear that the guiding the passengers at the airport from the gate to the DTC e-gate was challenging. Due to the small size of the pilot it was not possible to use any special wayfinding while the closest and most logical rout led to border filters without DTC gates. As result the team predicted a "loss" of passengers at the airport, meaning; passengers were enrolled but were not able to find a DTC gate.
Various options where discussed. To overcome this issue special airport staff, passenger assistants, were hired to guide the participants at the pilot locations during the execution phase. This consisted of two passenger assistants during the time window of the KLM flights arriving from Canada (0600-1100) for 7 days per week during the entire 3 month testing period. Additionally, banners were placed at the entrance of the border filters.
Due to the small number of passengers arriving per flight, the passenger assistants were able to retrieve the enrolled passengers at their gate of arrival. This worked well, but would not have been possible if the scale of the pilot had been larger. Therefore a learning for this pilot is to make sure that the placement/location is in direct route of the passenger, and to design for the most "fool proof" flow at the airport.

3.9.3 General considerations on pilot

Recent implementation of new legislation, for example the European Entry/Exit, will put further burden on the border control processes at Schiphol. Simulations indicate potential long waiting times and queues at the airport, as a result of addition checks and increased process times.
Adding new infrastructure or staff in is not always possible, especially in the current labour market, and deemed costly.
For the airport, any process that can be executed before passengers physically arrive at the airport, will benefit the passengers and result into a more streamlined operation. As such, the usage of DTC for border control has the potential to deliver these improvements. And when used in high passenger volumes, potentially solve bottlenecks at the airport. Therefore, the implementation of DTC is seen as a crucial development and key in future developments.

4 Pilot implementation

This chapter follows the customer journey of pilot participants within the pilot. The various paragraphs set out the outcomes and deliverables of the pilot, both in quality and quantity.

4.1 DTC derivation

When participating in the pilot, the first action that is required from the participant is to download the DTC pilot app and to create their DTC. This paragraph describes the pilot experiences in this area.

4.1.1 Statistics

Step	*Number of Events*	*Number of People*
Downloads of the DTC pilot app		1349 iOs 151 Android 1500 total
DTC derivation starts	1722 events	1584 people[7]
Completed passport reads	2713 events 197 not eligible by nationality 42 not eligible by age 110 Canadian passports without AA 1348 failed chip readings 916 Successful	
Selfie verifications	1461 liveness sessions start 313 uncompleted 378 failed on liveness checks 6 failed on facial verification 764 successful	
DTC creations		763 Successful

Table 3:Statistics of DTC creation

The analytics logging of the pilot gives good insight in the DTC derivation processing. First of all, it shows that all passports that were not eligible for pilot participation were successfully blocked from participation. The refusal of Canadian passports without Active Authentication (AA) needs further explanation. In May 2023 Canada has removed AA, replacing it with Chip Authentication. Due to pilot limitations and to avoid delays with the pilot implementation, these Canadian passports without AA could not be used within the pilot.
The average pilot participant needs 2.5 attempts to read his passport chip.

[7] When a derivation ends before the passport is read, it is not possible to match the session via hashes of the DTC to other sessions. This explains the higher number of starts than the higher number of downloads.

The selfie verification also takes several attempts for the pilot participants: by average 1.9 attempts. The events log shows that almost all of the fails are caused by the liveness detection. Only 6 fail on the facial comparison.
The average time users need to create their DTC is 185 seconds: 3 minutes and 5 seconds.

4.1.2 *Security controls*

This paragraph sets out the various security features in the DTC creation process

Passive Authentication (PA)
The DTC pilot system performs Passive Authentication on the chip content to check whether the data on the chip has indeed been written by the issuing authority (authenticity) and hasn't been changed since (integrity). Almost all PA's were successful. The pilot system has had six events where PA has failed, all of them within the same session. Presumably one person attempted several times to create a DTC with a manipulated chip. This attempt failed, because the pilot system refused to process this document.

Active Authentication (AA)[8]
The pilot system performs an AA on the passport chip during enrolment. AA is a required step at the Tap&Go-gate. It is tested during the enrolment. AA verifies that the chip data isn't cloned in another chip. Testing during derivation also ensures that the traveller can successfully pass the Tap&Go-gate.

Country	*Successful AA*	*Failed AA*
Belgium	6	0
Canada	751	73
The Netherlands	159	5
Total	916	78

Table 4: AA at DTC derivation

Table 4 shows the numbers of AA validation with the DTC derivation. The Canadian numbers do not include the model 2023 passports without AA. In close to nine percent of the cases, AA fails. PA was successful in all of these cases, so the passports most probably are genuine. The most likely explanation for these cases is that travellers already have started removing their passport from the backside of their phone. AA is the last part of the chip interaction.

Liveness detection
Liveness detection is a critical component of biometric verification systems. Its primary purpose is to ensure that the biometric data being captured is from a living, present individual rather than a static image or a recording.

Liveness detection poses a significant challenge to successful enrolment, with users requiring an average of two attempts to pass this test, as indicated in Table 4. Utilizing a brief video proves to be an effective verification method, as it successfully rejects moving AI-generated images. However, more than half of the unsuccessful selfie attempts are attributed to the system raising liveness warning flags (378

[8] Chip Authentication (CA) is a valid and even preferred alternative to AA. This protocol could not be included in the pilot system in time due to pilot constraints. However, future DTC-solution must support CA.

times). Although presentation attacks are highly improbable in a quarter of the selfie verifications, this feature remains crucial and therefore warrants improvement.

Facial image verification
Facial recognition technology is employed to establish a match between the individual creating a Digital Travel Credential (DTC) and the rightful document holder. This measure serves as a mitigation strategy to prevent the creation of a DTC by an unauthorized person.

The number of rejects from the facial verification of passport photo and traveller selfie image is very low (6 on 1461 attempts). This may be caused by the selfie comparison being performed after the liveness detection. It is reasonable to assume that facial recognition would not proceed if an apparent spoof is detected. However, it remains uncertain how frequently travellers may have attempted to circumvent this mechanism and whether such attempts account for the low number of non matches.

4.1.3 User experience

The statistics show that a happy flow without any retries hardly ever happens. Almost every pilot participant has to perform either reading the passport chip or selfie image verification multiple times. The passport chip reading element is hard to change as this is caused by technology that is often not mature enough. It is necessary to align the NFC reader in the phone correctly with the chip and its antenna. However, the position of these components vary per phone and passport model. So the traveller cannot be handed specific instructions on the relative positioning of passport and phone. The liveness check often requires a number of retries as well. Here technological improvement is necessary for future use.

Within this pilot a successfully created DTC remained available on the users phone for 72 hours. The main reason was that during the relatively short duration of the pilot-only 3 months- reuse was unlikely. When reuse is possible in the future, longer retention of the DTC for frequent travellers must be considered to make this process more user-friendly. Users are mostly positive about DTC derivation. However, are even more positive about the total experience. This indicates that DTC derivation was the less favoured side of the total experience, but not blocking them from participating (see Appendix 2: Participants feedback).

4.1.4 Conclusions

The following conclusions can be drawn from the enrolment process:

- The enrolment process effectively selected the qualifying passport and eliminated both non-eligible and fraudulent documents.
- The liveness detection in the selfie process was too strict in its evaluation. It needs to be adjusted or replaced by a different technology.
- Improvement of the user experience is possible, but even the current solution is generally regarded positively.

4.2 Enrolment for boarding

Having successfully created the DTC, the pilot participant is offered the option to enrol for biometric boarding with KLM, biometric border crossing upon arrival at Schiphol airport or both. The traveller starts this process by selecting his flight. This paragraph describes the results of the enrolment for boarding, which is only available for travellers flying on a KLM-flight from Montréal-Trudeau airport to Schiphol.

4.2.1 Statistics

Table 5 shows the number of pilot participants using their DTC for biometric boarding. A hash of the DTC is used to correlate actions of travellers. In this phase of the process we can therefore move from events to passengers. If a passenger performs a step multiple times, he will only be counted as one.

Step	*Events*	*People*
DTCs created		763
People flying from Montreal-Trudeau airport		148 Canadians 35 Dutch 183 Total
Enrolment for boarding	303 started boarding enrolment 249 started DTC transmission 202 finished DTC transmission	147 started boarding enrolment 102 completed successfully 22 failed on determining DID in KLM system

Table 5: Numbers for boarding enrolment

In total 183 participants indicated to use their DTC for biometric boarding from Montréal-Trudeau airport, 148 Canadians and 35 Dutch passport holders. Of this group, 136 participants started the enrolment for boarding. 122 travellers completed the enrolment. However, 22 of them were not successful.

The enrolment process is relatively simple. After having selected the flight, the traveller has to give consent to sharing the DTC with KLM and consequently needs to release the DTC from the app by entering their PIN.

Remarkable are the around 25% of times where the DTC transmission doesn't complete. Travellers have already given consent to KLM, so their intention to share is clear. During this process users have to enter the PIN that they have set during DTC derivation. Travellers might have forgotten the PIN or reconsidered their consent. However, based on several users experience reports is it very likely that this DTC transfer process fails for technical reasons. The transfer mechanism (Open ID Connect) and/or its implementation need to be reconsidered in future implementations. The average time participants needed to submit their DTC to KLM was 46,4 seconds

4.3 Enrolment for border

The other option for travellers that have successfully created their DTC, is enrolment for biometric border crossing at Amsterdam Airport Schiphol. This option is available to all travellers.

4.3.1 Statistics

Table 6 shows the number of pilot participants. If a passenger performs a step multiple times, he will only be counted as one.

Step	*Events*	*People*
DTCs created		763
Submission of DTC	1220 started border enrolment 1023 started DTC transmission 669 finished DTC transmission	673 started border enrolment

Step	*Events*	*People*
Submission of entry questionnaire	622 form displayed 382 form completed	411 people started 364 people completed
Completed enrolments		435

Table 6: Numbers for border enrolment

The border enrolment process is relatively simple for EU-travellers. They need to give their consent and release their DTC from the app. Not surprisingly, the processing time is similar to that of submission for boarding. At border enrolment the high number of unfinished DTC-submissions are also visible. In this case, it is 35% of the times. Again, we suspect this is caused by technological issues.

Canadian travellers have entirely different processing times. They are also required to submit a digitalised entry questionnaire for their means, purpose and duration of stay. The majority of the travellers presented with the form, completed and submitted it (89%). This despite the fact that besides the questions, proof of certain information needed to be uploaded. Apparently there is willingness to do so.

Step	*Enrolment time*
EU travellers	47,2 seconds
Canadian travellers	8 minutes 59 seconds

Table 7:Processing time of border enrolment

4.4 Pre-assessment of travellers

The pre assessment of the participants went very well. The pilot has given us a lot of insight in the digital check of entry questions prior to the actual border crossing. We got a lot of learning experience in the operational assessment, process and technical solution. The following detailed experiences and learnings have been gained:

- The DTC pilot system was separated from regular border control information systems. Because of this, finished assessments (accept or reject) are no longer available for consultation. This is seen as a shortcoming of the system. Since the DTC enrolment can be done well before the intended flight, it happened that the DTC is approved 2 days in advance. After assessment, it was – for example - no longer possible to see in the DTC application if someone is a Canadian, Belgian or a Dutch citizen
- The overview screen gave limited information (name - creation date, flight date) but no nationality or final destination. This made it difficult to indicate a destination and the arrival post (arrival Netherlands or other Schengen country)
- Another finding which relates to the above is that DTC applications are often made shortly before departure (at check-in). In the pilot, this happened in the evening in The Netherlands, which can make it difficult to contact people/companies to verify the information from the entry questionnaire. This could lead to a less thorough investigation into the entry questions. This is further enhanced by the limited opening time of TCB (06:00-22:30).
- The attachments in the DTC application are sometimes very small or illegible. Viewing a (return) ticket is sometimes very difficult despite enlarging the image. If there are minimum dimensions/requirements that an image must meet, it would facilitate the assessment. Legibility could also be checked automatically.
- Flights from Canada and participating nationalities are a low risk factor as far as the DTC program and entry questionnaires are concerned. However, one may be flagged in OPS/(n)sis. This matching is automated in the

Advance Passenger Information (API) system which is used by TCB. In future DTCs should be processed automatically in the same way as API-data to deliver the same usefullness for TCB.
- In this pilot the number of applications were manageable. But automation and integration with regular border control systems is mandatory with increasing number of DTCs. This will also eliminate the risk of manual data entry, as there is no means of verification.
- In addition, there is also a risk in case the DTC request arrives 72 hours in advance, a manual search takes place where it is not yet certain whether the traveller will actually make the flight. The travellers backgound check may have occurred without the traveller crossing the border.

For further use and other initiatives with regard to the digitalisation of border control processes like the digital settlement of entry questions, the use of DTC and the use of travel apps some learnings that are relevant to take into account:
- The border guards missed a search back and restore function (if you accept or cancel a person, the option should be present to restore this and further useful to see case for previous consideration;
- Display airport/nationality/flight arrival time in the choice screen;
- Option to indicate reason for rejection in the system for the border guard (this was left out on purpose to limit the amount of sensitive information in the pilot system);
- Offer the traveller the possibility to Indicate whether he is travelling alone or with other people (this may affect their means and purpose);
- For the entry questions assessment, information is sent along, for careful consideration this was regularly too small or illegible. This led to a fair number of rejections on this section. For greater accuracy and reliability, it is desirable to receive more information;
- Preference for open-ended questions;
- Preference for more specific entry questions. Example: 1 to 15 days, 0-500 euro is not specific enough; too general;
- Automatic consultation via public order and national security registers instead of via API or manually;

Pre-assessment average processing time
Reviewing documentation entry questions and manually consulting detection records takes an average of 2 minutes per passenger. Note that this time can NOT be used estimating future workload. In the pilot there was no integration with regular border control information systems. Every check had to be done manually. In future with integration in place, the regular traveler with hits from register checks will need no attention of border guard.

Border crossing using the DTC- Tap&Go e-gate

4.4.1 Common biometrical aspects

The way the identity of the traveller is established is identical for the boarding and the border gates. The results can therefore be combined. In the logical flow the following steps occur:
- The traveller enter the gate
- The gate takes a picture of the traveller, whilst making sure that a real traveller is in front of the camera.
- The gate compares the photo with the enrolled DTC images and tries to find a match above the threshold (1:n comparison). When no match is possible, the gate shows an orange light and refers the traveller to the local agent.
- The passenger is asked to present his passport.

- The gate tries to open the passport and verifies the security features.

Step	*Number of Events*
Person seen	1576 events passenger_detected 78 events multiple_face_detected
Person identified	1137 events person_not_found 298 event person_found
Passport requests	298 events passenger_scan_passport_requested 4 events AA/AC failed 6 events BAC/SAC failed 18 no chip detected 270 Successful

Table 8: Numbers of gate identification combined for boarding and border

Table 8 shows the figures with identification in the various gates. The first element is to identify one human being. In 78 cases the gate identified more than one person. In this case, the gate halts processing, warns the travellers and retries the transactions after a number of seconds.

The gate contains liveness detection. This has positively been tested during the acceptance tests. This feature does not give log entries, so it is not clear whether liveness detection kicked in.

Of all detected persons 298 could be matched to photos in the biometric gallery. 1137 could not be matched. A small group may have had issues with the difference in strictness of the biometric comparison between DCT derivation and the gate. The intention have these settings identical. However, this apparently was not the case. The setting of the app was less strict than the gates. With 26 events the matching score was in the range between the two settings. But since algorithms and photos differ, this certainly isn't a full explanation. Another explanation is that unenrolled people can have entered (or stood front of) the gate. The number of events of completed enrolment for KLM and the border are 846. The number of persons not found is roughly 300 higher. So there must be a significant number of unenrolled persons among those.

Passport verification is generally successful. The 18 times that the chip wasn't detected is probably due to late or incorrect offering of the passport.

There were 6 events for three different people with the error 'BAC/SAC failed'. All events were on border gates. When this occurs, the gate cannot open the passport chip with the data derived from the matched DTC. This was once with a Canadian and twice with a Dutch passport the case. In all of these cases, there is a facial match well above the threshold. An explanation could be that the traveller used different passports during enrolment and on the border.

There were four events for four different people where the AA/AC verification went wrong. In all of these cases multiple attempts were made where passport reading ultimately succeeded. So this is probably cause by misplacing the passport or withdrawing the passport too quickly from the Tap&Go-facility.

4.4.2 *Boarding, including experience boarding agent*

The number of travellers that passed the boarding gate are in Table 9.

Step	*Number of people*
Successful crossings	39 people
Unsuccesful crossings	12 people
Processing time	Average processing time12.8 seconds Fastest processing time 7.6 seconds

Table 9: Numbers of boarding gate crossing

Due to low number of participants in boarding aspect of the pilot (couldn't invite passengers with Dutch passport from before September 2021 due to the social security number issue, substantially limiting number of possible participants), agents at Montréal-Trudeau airport (YUL) invited passengers at the airport to join the pilot. Many passengers expressed reluctance due to data privacy concerns. This does not correspond with the feedback we received on the feedback email (see 3.6), however could be explained due to the fact that passengers approached at the airport had less time to read through the privacy statements and information website.
The performance of the eGate (the biometric gate in YUL) was sub-par. This included issues with the performance of the camera of the eGate, which ended up needing to be replaced. Moreover, the tablet to turn on the eGate and start the biometric boarding process was not intuitive nor easy in use and had performance issues.
The biometric boarding gate required constant monitoring from an agent, which is difficult during the high-stress moment of boarding. Especially in cases of disruptions (such as a delayed flight), the agents are continuously approached by passengers concerned about their connections or with other questions, limiting their ability to focus on the eGate and guiding passengers through the pilot process. When the eGate did work well, it would work very fast.

4.4.3 *Border control learnings*

The number of travellers that passed the border gates are in Table 10.

Step	*Number of people*
Succesfull crossings	113 people
Unsuccesfull crossings	27 people due negative result pre-assessment
Processing time	Average processing time14.3 seconds Fastest processing time 6.5 seconds

Table 10: Numbers of border gate crossing

The experiences and learning moments related to border passage and the experiences of the border guards involved are diverse. Both positive and negative. In particular, the low number of participants was not conducive to border guards' involvement in the pilot. Overall, the DTC process worked well and happy flow passengers went through border control quickly and easily. We experienced fast processing time tap-and-go functionality versus the regular SSPC-gate and regular

control booth. It also became clear that participants did not always reach the border filter despite having completed the enrolment process. Choices in advance in the designation of border control filters for the DTC pilot and the lack of sufficient way finding contributed to this. More consideration should be given to this for the next pilot.

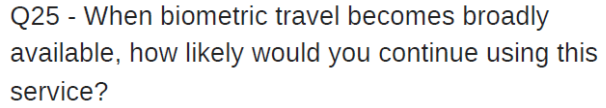
The experience from the border guard point of view is mixed. Because of the low participation numbers, the majority of the staff did not gain experience in new working methods. Despite these low numbers, there are some learnings that can be used in follow-up projects. Border guards found it difficult in having their work assessed by others than themselves. They find it difficult to let the assessment and decision-making depend on TCB and technology and not by themselves. They would have liked it if the pre-assessment outcomes were also known to them so that they could act right away in case of rejection. For the border guards involved it is an added value to have insight in the results of the pre-assessment of each participants. For further use they recommend a DTC solution at a manual control booth instead of a separate tap and go gate, so that when unhappy flow occurs, they can act immediately in accordance with the SBR.

4.5 Travellers experience

During the pilot, a feedback process was initiated by distributing emails to passengers seeking their insights about their experiences with the pilot. This survey provided valuable insights. The full results are presented in Appendix 2: Participants feedback.

Overall, the response has been largely positive, with passengers expressing satisfaction across various aspects of the pilot. Most passengers expressed an excellent experience with 1) the use of the app 2) enrolling for their experience 3) the biometric boarding or border crossing and 4) the information provided regarding privacy.

Interestingly, the answer to the question “Would you recommend biometric border control and / or boarding to your friends and family?”, 47% of the answers were classified at “Detractors”, 36% as “Promotors” and 17% as “Passive”. However, in another question, we asked “When biometric travel becomes broadly available, how likely would you continue using this service?”, which resulted in an overwhelming majority of passengers answering “Extremely likely”.



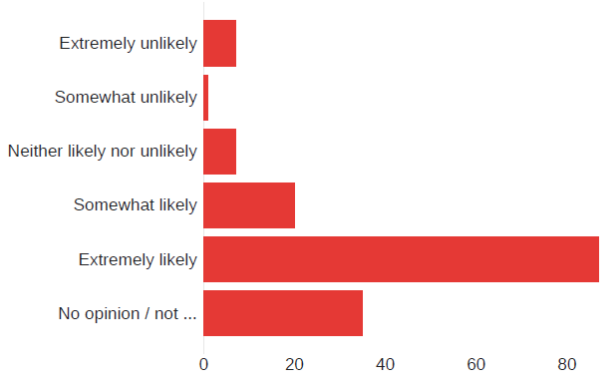


Figure 5: Traveller survey results

For many questions, the answers were mainly positive, but also with a high number of answers being "Poor", and less so passengers choosing answers between "Excellent" and "Poor" (such as "fair", "good", "very good"). From this, we deduce that either the app or border/boarding experience went well or failed completely. So, when it works well, it is regarded as a very positive experience. However, if something goes wrong, it results in a negative experience entirely. This corresponds with our own experiences during the User Acceptance Testing phase. When all aspects worked, it would be a smooth and fast process. However, if for instance chip reading failed, or creating of the DTC took very long, this often resulted in a cumbersome process.

Important to note is that as the scope of passengers able to participate in biometric boarding was much smaller compared to biometric border crossing, most answers relate to the experience of passengers participating in biometric border crossing.

4.5.1 *Response to DTC1pilot@rijksoverheid.nl*

A small number of people reached out to the consortium via the created mailbox. Their e-mail had the following purpose:

- Two people mentioned technical issues using the app and asked for guidance to resolve the issues.
- One person requested to have his/her data removed.
- One person gave extensive feedback on the pilot experience.

The reactions were responded and – where applicable – handled according to the predefined procedure.

5 Discussions

This chapter combines the learnings from the previous chapters. These discussions are intended to ensure a solid rationale for investments in DTC processing. This chapter is not intended as a bundle of policy decisions, but an overview of:

- DTC versus other data
- The position of the physical travel document in DTC

5.1 Why use DTC instead of other data?

The information transferred via the DTC is biographical information and a photo. All this is also available on the holder page of the passport. By sending a photo of the holder page, a traveller can send the same information. And every smartphone is capable of doing that. So why not asking information that way? Or by entering information manually on a website?

	Manual	*Photo of holder page*	*DTC*
Errors in information	Typing errors and upload photo	OCR errors. Low facial image quality	All changes are detected
Available for	Everyone with a computer or a smartphone	Everyone with a smartphone	Smartphones with NFC
Ease of submitting data	Much work	Fast and easy	Some work and technically more complex
Proof of authenticity	None	Very limited: comparison to template	Full check of DTC possible (not of passport!)
Easy of fraud	Simple: enter wrong data	Relatively simple: alter photo	Very difficult to falsify digital signatures
Reading the MRZ	Not necessary	Necessary	Necessary
Passport checks on the border	Full	Full	Limited (usually AA/CA only)

Table 9: Comparison of ways for pre-enrolment

The key difference between DTC and other ways of sending information is the presence of digital signatures of the issuing authorities on the data. They prevent both errors and fraud. Errors will hinder both border control (wrong traveller prechecked) and the traveller (for example when the data to open the chip has OCR-errors). Fraud will hinder border control.

On the border itself the limited passport chip check with only AA or CA is possible with the DTC, assuming that authenticity and integrity of the DTC have been checked during pre-assessment. With the other ways of enrolment all data must be read from the passport and check for integrity and authenticity.

Using other methods that the DTC for enrolment and pre-assessment will always require a full inspection of the passport on border crossing. No time gained there. And if there are differences between information received for pre-assessment and the passport data, a new background check must be performed. Time gains on the border will therefore be significantly lower, with the same effort required for pre-assessment.

5.2 The position of the physical travel document in DTC

A physical travel document is required in this pilot. This is imposed on the one hand by the DTC type 1 standard, and on the other hand by existing national and international legislation and regulations in the field of border crossing and travel. The current physical document has advantages:

- There are procedures developed over many years for the request and issuance of physical documents that ensure quality;
- The holder page can be read without tools and is therefore accessible worldwide, even for countries with limited technical resources;
- The generally good quality of the document issuance processes, together with the easy readout, make the physical travel document multifunctional: it is used in many areas other than travel;
- It does not depend on personal devices, which pose limitations in terms of security and support;
- Easy placement of (visa) stamps and stickers.
- When accessing information systems, information security most of the time requires two or more factor identification. Why should border crossing reduce the number of factors to one: the facial image verification? Presenting the physical passport is additional certainty that the traveller indeed is who he says he is.

At the same time, this pilot shows the advantages of a digital component of a travel document. The obligation to carry a physical document and present it at the Tap&Go-points in this pilot is somewhat illogical from a user perspective. Traveling with the help of biometrics and a (preferably personal) digital device that is already worn makes sense. With full digitalisation, various barriers will have to be overcome. Choices must be made:

- Is a fully digital ‘document’ secure and universal enough, or is a physical document needed as a fallback?
- What is the source of a DTC's data if there is no physical document? Not every country has a high-quality population register.
- Is the DTC only suitable for (one-off) trips, or also for completely different applications, as is currently the case with physical documents?
- Which data is accessible to which party? Can hotels also use elements of this digital component? Or should they connect through other digital identification initiatives?

Also, the national passport is more than a tool. It is an expression of sovereignty and for many people an expression of their origins. This emotion is difficult to capture in a digital medium.
Solving these issues requires an integrated approach that takes into account all forms of identification. This is not possible without involving other developments in the identity field, including the identity wallet and other DTC developments.

6 Conclusions

6.1 Summary of learning and conclusions

The Netherlands has conducted a DTC pilot within the confines of existing legal frameworks. Despite certain operational, legal and technical challenges and considering that this pilot may have been modest in scale and participants numbers, however the learnings and insights gained are very valuable for the further development and implementation of digital travel credentials in the Netherlands, other EU Member States and the rest of the world.

- First of all, the pilot was implemented successfully. This proves that the DTC can be applied effectively in border control processes and identity verification at boarding.
- Our pilot implementation has underlined the large potential of DTC in the border management process as it expedites identity verification processes and as a result is significantly faster, even compared to the processing times in the Self Service Passport Control e-gates (SSPC). Processing border control checks in advance enables bona fides travellers to cross the border more smoothly.
- Implementing digitalized entry questionnaires has proven to be effective. Ninety percent of the travellers that were offered the online questionnaire in the app, completed it. It allowed for either quicker or more thorough checks due to the extra time available. However, the total human effort in evaluation must of course not exceed the current effort for examining purpose, length and means of stay.
- The actual border crossing can be significantly quicker than current SSPC e-gates at Schiphol. The average DTC processing time with the Tap&Go gate in the pilot was half of the processing time of the current e-gates; on average 14 versus 30 seconds. This is caused by the expedited passport checks and pre-assessment. Participating travellers recognised this speed.
- The DTC and the Tap&Go identification process is well suitable for identification at boarding. It also ensures that the traveller carries this passport with him (proof of possession).
- Despite different roles and interests, positive public, private cooperation, there was a good atmosphere to make the DTC pilot a success, despite many issues before the go-live.

6.2 Future use of the DTC

The learnings imply a number of recommendations for future implementation of the DTC, which are outlined below.

6.2.1 Practical / operational

From an operational perspective they are the following suggestions and ideas:

- Future implementation must focus strongly on usability and user friendliness.
- In future, participation should remain on a voluntary basis for travellers.
- In the pilot it was difficult to create an app that worked well on a various types of phones and with a limited number of passports. Given the current state of technology, it might remain challenging to create an app that derives DTCs from all passports on all types of phones.

- The traveller must invest time to create and submit his DTC. In future implementation, the time gains at the border should remain available to these travellers. Also, long term storage of the DTC on the users phone must be considered, to reduce the time investment of frequent travellers.
- In the pilot we were unable to have direct contact with the pilot participants, due to a strict interpretation of data minimalization. In future communication to the traveller for example by push messages or e-mail is desirable in case of any unforeseen technical or operational issues.

6.2.2 Legal

In conclusion our pilot has highlighted the necessity of developing comprehensive legislation at the EU level to harmonize the implementation of DTC across Member States. By establishing unified standards and protocols, EU legislation can mitigate fragmentation and promote interoperability. It is evident that DTC holds tremendous potential to shape the future of travel and border control, offering innovative solutions to streamline processes and improve the overall experience benefitting travellers, border control authorities, carriers and airports.

The following legal issues need to be addressed further for future implementation:

- A legal ground for processing traveller data after enrolment, but before actual border crossing. The pilot worked with travellers consent as the legal basis. This implies the option for the traveller to withdraw consent at any time. However, current border control systems are unable to support this because they are based on foundation in law.
- The legal ground should give also as much guidance as possible on the intended processor and its responsibilities, retention times, permitted use and reliability safeguards (facial image comparison).
- Changes to directives and guideline to perform a digital only passport inspection, including the condition under which this can be applied.
- Using a biometric selfie-verification upon DTC derivation may require a legal ground. When so, this either needs to be created or the risks of refraining from it should be accepted.
- Using the full DTC derived from Dutch passports older than September 2021 by private parties is legally limited due to the presence of the BSN.
- The greatest privacy risk for data subjects lies in the security of their personal data, which parties get access and for which purposes. If the aim really is to facilitate the travel and border process, it should also be limited as much as possible in regulations to that end, as was done in the Pilot.

6.2.3 Technical

- The DTC pilot process relies heavily on digital information. A reliable full passport chip inspection must be performed. This could be done via a fully trusted app or – preferably - at the border with fully controlled inspection tools.
- The DTC for border control must – in addition to the mandatory data groups DG1 and DG2 – contain the data groups DG11, DG14 and DG15 when available in the passport.

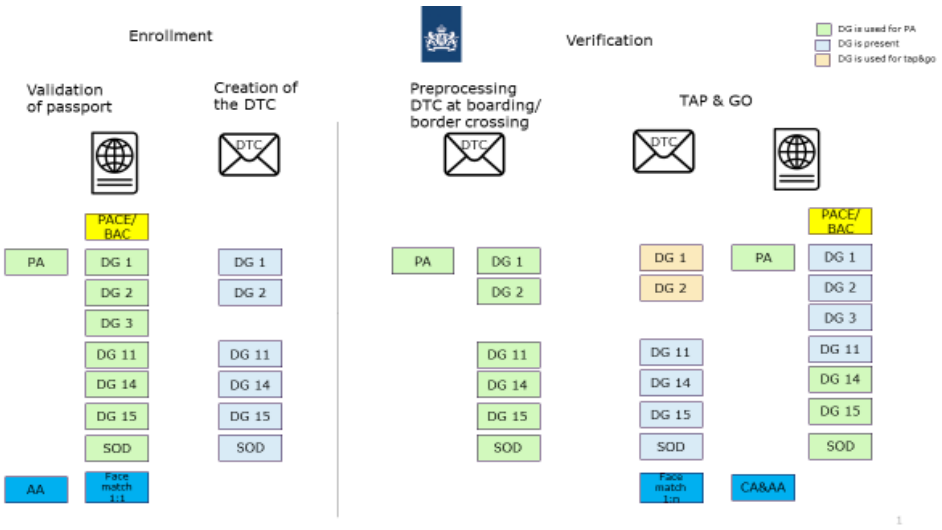


Figure 6: future DTC content and checks

- The suggested future setup of chip- and passport data checks are shown in Table 11. The removal of the Passive authentication check at border control would save processing time. The removal of Passive authentication is acceptable if the passport supports chip authentication or active authentication. Note to verify the chip/ active authentication the public key out of the DTC should be used in combination with the private key in the chip.

Check	*Enrolment*	*Submission*	*Border crossing*
Optical verification of the holder page	the MRZ	NA	To be investigated
Open the chip with data from the holder page	Yes	NA	Yes
PA: EF.SOD verification	Yes	Yes	Conditional if the passport doesn't support CA or AA
PA: DS certification signature verification	Yes	Yes	Conditional if the passport doesn't support CA or AA
PA: Certificate validity period check	Yes	Yes	Conditional if the passport doesn't support CA or AA
PA: DS certificate revocation status	Yes	Yes	Conditional if the passport doesn't support CA or AA
PA: Data Group integrity check	Yes	Yes	Conditional if the passport doesn't support CA or AA
PA Issuing country comparison	Yes	Yes	Conditional if the passport doesn't support CA or AA
Comparison between EF.SOD and EF.COM	Yes	NA	Yes
Comparison of optical and electronic biographical data	Optional	NA	To be investigated
Chip Authentication	Yes	NA	Yes
Active Authentication	Yes	NA	Yes

Table 11: Passport check in check in future systems

- The selfie-verification at DTC derivation is valuable. However, the method used for liveness checking was too strict.
- It seems logical to split DTC derivation and submission/enrolment in two different apps with different processors and responsible organisations. The DTC derivation may well be done by wallet apps, as long as they provide the DTC to border control according to the ICAO DTC standard.
- A global interoperable transmission protocol is needed to submit the DTC-VC to the different stakeholders when the split mentioned before is implemented.
- DTC transmission during enrolment failed too often. In future systems this must be resolved, preferably by using a standardised protocol to share DTCs.
- The pilot system was not connected to the normal border control environment. Future implementation must be integrated. This will eliminate manual pre-assessments and improve information provisioning to border guards.
- Due to international threats, future technological solutions using DTC high security standards in line with other border control information systems.

7 Appendix 1: Glossary

Abbreviation or concept	*Explanation*
AA	Active Authentication: passport chip verification protocol verifying that the content of the chip was originally issued this chip.
CA	Chip Authentication: passport chip protocol ensuring encryption of the communication between the passport chip and the reader. Also serving the same purpose as AA.
DTC	Digital Travel Credential
ICAO	International Civil Aviation Organization
IATA	International association of airlines
PA	Passive Authentication: verification of the authenticity and integrity of the passport chip content by means of the digital signatures of the issuing authority.
(DTC-)PC	Physical Component of the DTC
SOD	Security object. File in an electronic passport chip containing the digital signatures of chip data.
(DTC-)VC	Virtual Component of the DTC
YUL	Airport identification code for Montréal-Pierre Elliot Trudeau International Airport in Montréal, Canada

Table 12: Glossary

8 Appendix 2: Participants feedback

This appendix contains the result of pilot participants survey.

Question	Answers						
Would you recommend biometric boarding border control and / or boarding to your friends and family?	Detractor		Passive		Promoter		
	47%		17%		36%		
How would you rate the usage of your digital passport?	Poor	Fair	Good	Very good	Excellent	No opinion / not applicable	
	26	7	5	12	49	58	
When biometric travel becomes broadly available, how likely would you continue using this service?	Extremely unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely	No opinion / not applicable	
	7	1	7	20	87	35	
In what parts of the pilot did you participate?	None, I didn't participate	Boarding at Montreal-Trudeau airport	Border at Schiphol, Amsterdam				
	87	7	74				
If you answered "I didn't participate": why didn't you participate?	I didn't have time	I don't want to share my data	was unclear to me what the purpose of the pilot	I didn't know what I should do	Other		
	5	5	9	15	70		
					Was no opportunity		
					Was concerned about finding the gate and how much time it would take		
					I tried but my country passport wasn't compatible		
					I couldn't figure out how to scan my passport etc.		
					I have 2 passports and used my EU one so I did not need to participate		
On what flight number to Amsterdam did you participate on the biometric test?	KL0672 (YUL to AMS)	KL0676 (YEG to AMS)	KL0678 (YYC to AMS)	KL0682 (YVR to AMS)	KL0692 (YYZ to AMS)	KL0698 (YYZ to AMS)	Other
	23	18	28	26	22	1	17
							Not sure was last sept
							45373
							KL0695
							KL0696
							I did not participate
How would you rate your experience of the app when registering?	Poor	Fair	Good	Very good	Excellent	No opinion / not applicable	
	14	18	32	21	30	14	
Did you experience issues when submitting your data for biometric border control?	No	My passport could not be read	There was an issue when making the photo	The face match failed	Other		
	41	7	9	4	8		
					Several tries to read passport, several tries to load photo, unclear what information was loaded (ex: question "proof that you reserved a hotel and if it's paid. I have a hotel in Barcelona and an apartment rental in Rome, but it didn't seem to matter what was loaded. Having said that, I did finally get a successfully submitted to police.		
					Every time I opened the app it was like starting from the beginning. I think I did that 3 times		
					Issues reading passport and matching face images		
					No one at Schiphol was ready for this so I didn't get to use it		
					Machine not working. Was brought to passport control by employee		
Did you experience issues when submitting you data for biometric boarding?	No	I didn't know my flight information	It took too long	I received an error message	Other		
	4	0	1	0	1		
					The requirement of adding passport information to KLM before submitting data wasn't clear		
Did you experience issues while registering for border control?	No	I couldn't answer the entry questionnaire	It took too long	I received an error message	Other		
	51	1	3	6	8		
					PDF format wasn't accepted. Instructions were unclear. CC/Cash questions seemed redundant as most carry both and choices were mutually exclusive.		
					The available answers were not sufficient to fill our the form correct some questions were not applicable, initial submission did not work		
					The KLM website was buggy		
					Was still closed		
How do you rate the explanation of the privacy statement?	Poor	Fair	Good	Very good	Excellent	No opinion / not applicable	
	2	14	41	26	20	25	
How do you feel about the protection of your data?	Poor	Fair	Good	Very good	Excellent	No opinion / not applicable	
	1	24	34	24	16	29	
Did you successfully complete your registration?	Yes	Partly	No	No opinion / not applicable			
	96	8	15	9			
How do you rate your boarding experience at Montreal?	Poor	Fair	Good	Very good	Excellent	I didn't use biometric boarding	No opinion / not applicable
	1	0	0	0	5	0	0
What issues did you experience during biometric boarding?	None	I wasn't recognized	My passport could not be read	The gate remained closed	Other		
	5	0	0	0	1		
					KLM crew had no idea about DTC-1 Pilot, there was no equipment		
How would you rate the findability of the biometric boarder control gate?	Poor	Fair	Good	Very good	Excellent	I didn't use biometric border control	No opinion / not applicable
	12	8	12	12	18	4	3
How do you rate your experience at border control when arriving in Amsterdam?	Poor	Fair	Good	Very good	Excellent	I didn't use biometric border control	No opinion / not applicable
	12	6	7	8	28	5	3
Why didn't you use the biometric border control when arriving in Amsterdam?	I didn't see the biometric border control gate	I used the regular border control as I thought this would be quicker	changed my mind about participating in this pilo	It was closed / out of order	Other		
	1	0	0	2	1		
					Received an error message when answering questionnaire, so used regular border control...which was very quick		
Did you experience any issues while passing biometric border control in Amsterdam?	None	I wasn't recognized	My passport could not be read	The gate remained closed	Other		
	43	2	5	10	59		
					It took awhile to find someone who knew what to do. Everyone was very friendly.		
					There was no equipment, no gates, few of the staff and border control knew about the pilot		
					I didn't know where to go		
					I was directed through the regular passport line		
					The gate was not available because of lack of supervision staff		