

Technology Foresight on Biometrics for the Future of Travel

BORDER SECURITY OBSERVATORY
RESEARCH AND INNOVATION UNIT

FRONTEX

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 **EUROPEAN BORDER AND
COAST GUARD AGENCY**

Project Overview

Project Overview

1. Analysis of Research Context
2. Insight Hunt
3. Filtering Results
4. Deep Analysis
5. Mapping Capabilities



Project Overview

Research Team

Steinbeis 2i
Germany



4CF
Poland



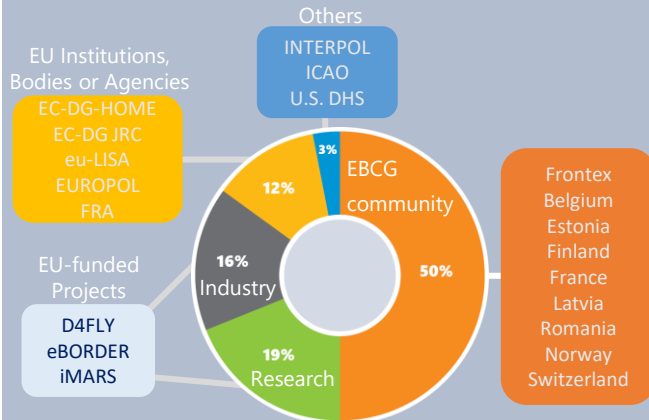
Erre Quadro
Italy



Institute of Optoelectronics
Military University of Technology
Poland



>40 Stakeholders actively involved
(strong focus on EU and EBCG)



2021



Motivation

Growing mobility of individuals and need for **Seamless Border Checks** pushing towards implementing:

- Digital Identity Management Solutions
- No-Gate physical solutions for seamless border checks at BCPs

COVID-19 pandemic

- need for technological solutions compatible with policies and measures typically taken in case of pandemics



Biometric Technologies

Border checks will have to transform to:

- Effectively safeguard EU's external borders
- Improve border crossing experience (seamless & contactless travel)

Biometrics is key enabler for **automated recognition of individuals** at BCPs

Use of biometrics in large-scale IT systems is a major priority for the EU

Foresight for pre-acting rather than re-acting



Objectives

Research study

Research study on the future opportunities that biometric technologies could provide to the European Border and Coast Guard (EBCG) community



Identify specific research and innovation activities

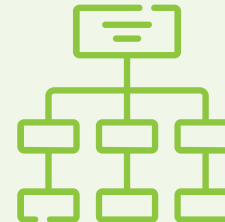


Knowledge on how to maximize future benefits of biometric technologies

Desired outputs



TF Methodology and Supporting Tools

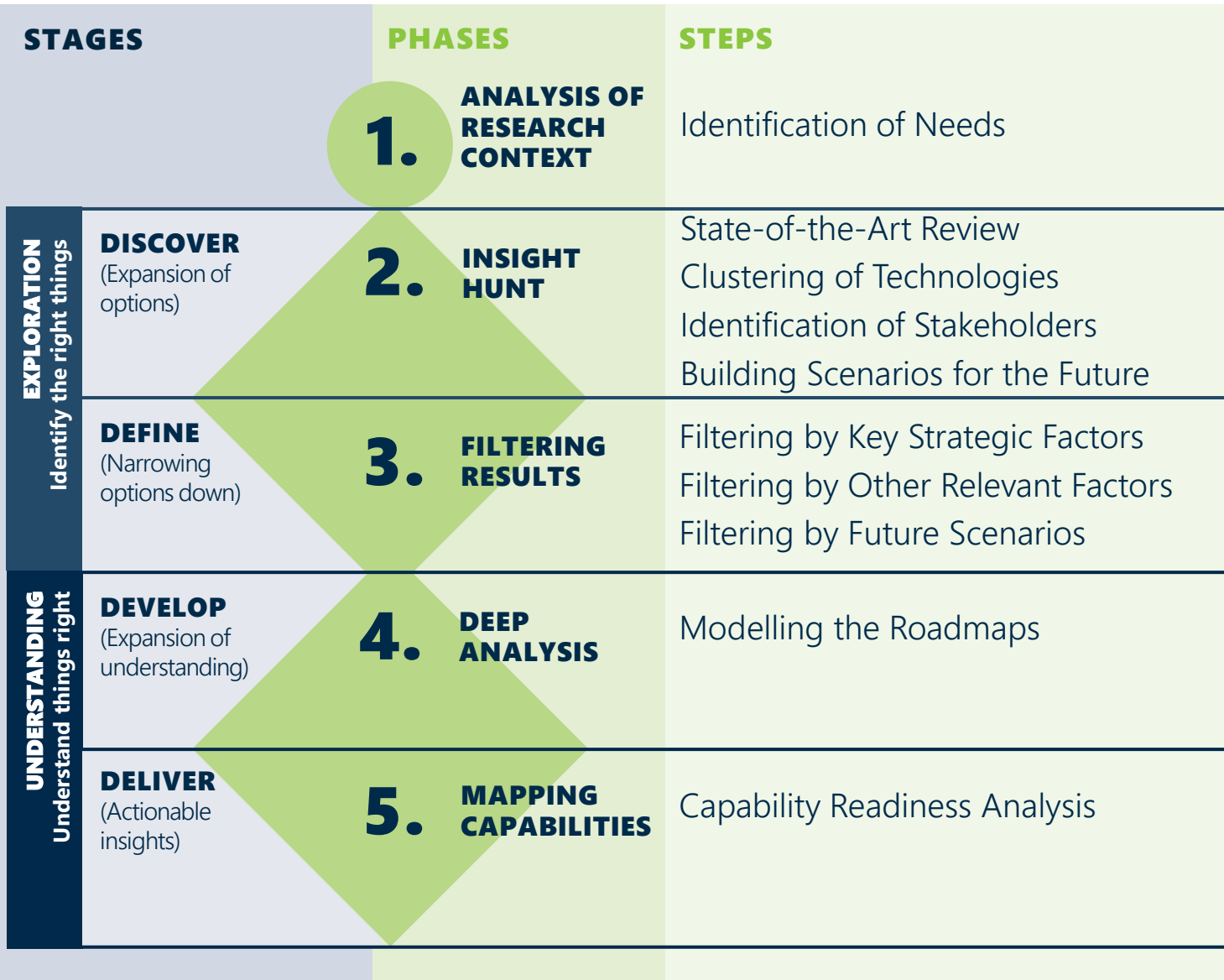


Taxonomy of biometric technologies



Research Study

Methodological Framework



METHODS

Matrixes of needs & functional requirements

Desk research

Patentometric & bibliometric analyses

Delphi Survey

4CF Matrix

Rip Van Winkle Method

Futures Wheel

Forecasting/Backcasting

Scenario Analysis

Weighted Criteria Matrix

Workshops

TOOLS

4CF HalnyX

Miro Board

Domain Terminology Extractor

Smart Ranker

Weighted Clusterer

1. Analysis of Research Context

Project Overview

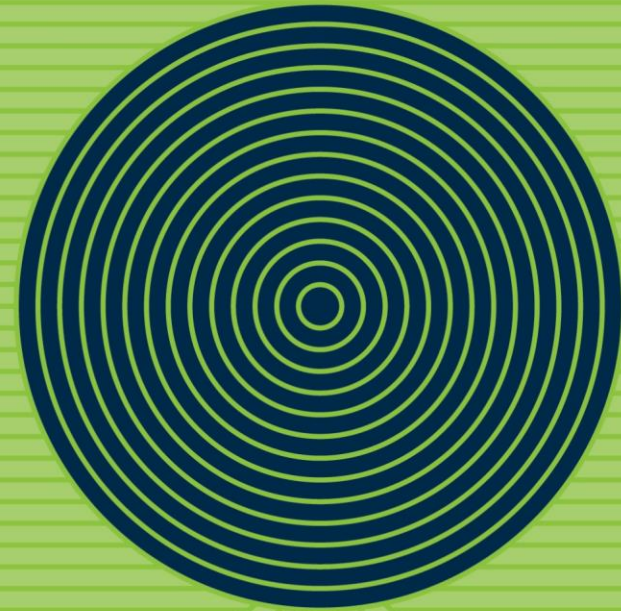
1. Analysis of Research Context

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Identification of Needs

Analysis of Frontex needs for key functions of biometric technologies



Aim

- Needs analysis to specify the field and scope of the research and to set the goals for the study
- Tailor the Technology Foresight Methodology to Frontex needs



4 “must-haves” for biometric technologies identified for reference in later phases of the project

- Seamlessness
- Compliancy with fundamental EU values and regulations
- Applicability within pandemic-specific restrictions
- Low vulnerability to adversary attacks

2. Insight Hunt

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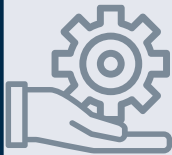
State-of-the art Review

Taxonomies



Aim

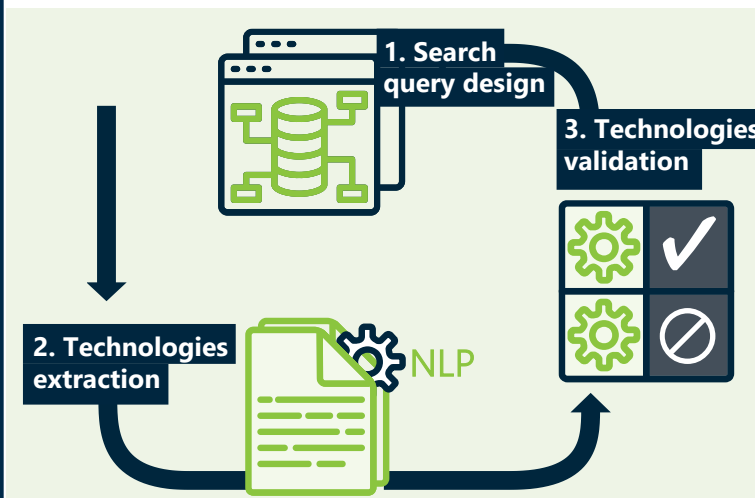
- Establish a common systematic understanding of the biometrics domain
- Create reference documents which could enable future R&I activities



Output

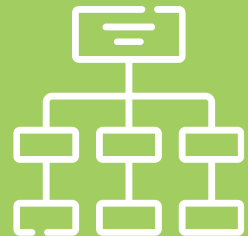
- Taxonomy of biometric technologies
- Taxonomy of biometrics-enabled technological systems

- **Highly iterative** process based on the extraction of terminology from patents and scientific literature
- **Automatic tools** (embedding NLP) for analysis of massive technical and scientific documentation



Three-level Taxonomy of Biometric Technologies

- 57 biometric technologies
 - 5 biomolecular
 - 39 morphological
 - 13 behavioural






Two-level Taxonomy of Biometrics-Enabled Technological Systems



State-of-the art Review

Taxonomies

- 1 **BIOMOLECULAR BIOMETRICS** 
- 2 **MORPHOLOGICAL BIOMETRICS** 
- 3 **BEHAVIOURAL BIOMETRICS** 

BIOMETRICS TECHNOLOGIES	1.1 DNA biometrics 	1.2. Other biomolecular biometrics 	2.1. Face recognition 	2.2. Friction ridge recognition 	2.3. Iris recognition 	2.4. Vascular pattern recognition 	2.5. Physiological signals biometrics 
	2.6. Hand geometry recognition 	2.7. Other minor morphological biometrics 	3.1. Keystroke recognition 	3.2. Gait recognition 	3.3. Handwriting recognition 	3.4. Speaker recognition 	3.5. Other minor behavioural biometrics 
	1. Self-service systems 	2. Identity document readers and verification sub-systems 	3. Full-body scanning systems 	4. Systems based on personal devices 	5. Movable systems 	6. Large-scale IT systems 	7. Virtual traveller identity schemes 

Clustering of Technologies

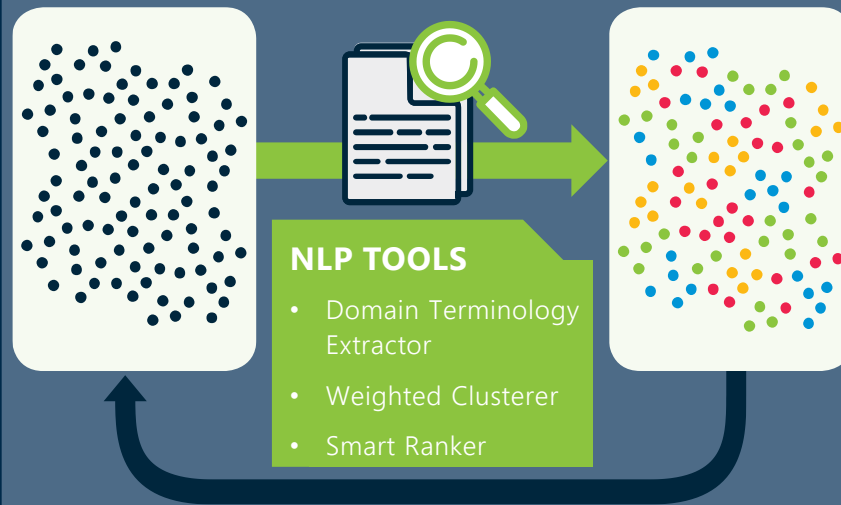
Identification of Technological Clusters



Aim

- Group the large set of biometric technologies into **clusters** to assure the usability of the taxonomy in the different phases of the Tech Foresight
- Create homogeneous datasets of patents and scientific publications suitable to conduct patentometric and bibliometric analyses

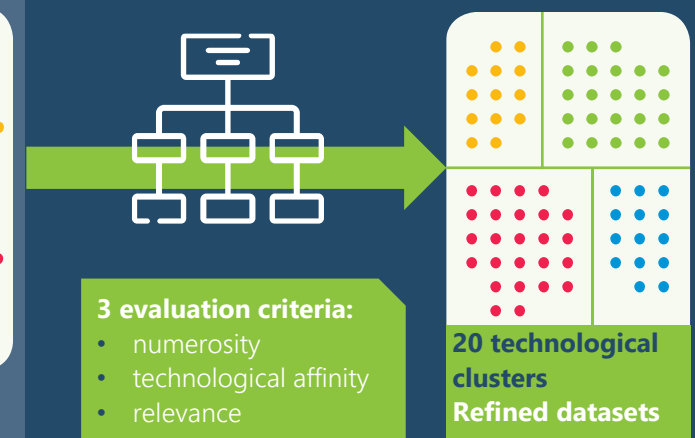
PRELIMINARY AUTOMATIC STEP



NLP TOOLS

- Domain Terminology Extractor
- Weighted Clusterer
- Smart Ranker

CONTROL STEP























3 evaluation criteria:

- numerosity
- technological affinity
- relevance

20 technological clusters
Refined datasets

Clustering of Technologies

Identification of Technological Clusters

1.  DNA biometrics	6.  3D friction ridge recognition	11.  Iris recognition at a distance	16.  Periocular recognition
2.  Infrared face recognition	7.  Contactless friction ridge recognition	12.  Eye vein recognition	17.  Keystroke recognition
3.  2D face recognition in the visible spectrum	8.  Contact-based friction ridge recognition	13.  Hand vein recognition	18.  Gait recognition
4.  3D face recognition	9.  Iris recognition in the NIR spectrum	14.  Heart signal recognition	19.  Handwriting recognition
5.  Infrared friction ridge recognition	10.  Iris recognition in the visible spectrum	15.  Hand geometry recognition	20.  Speaker recognition

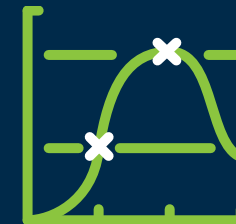
Clustering of Technologies

Patentometric and bibliometric analyses of Clusters



Aim

- **Analyse the lifecycle** of 20 Biometric Technological Clusters to gather information about their evolution
- **Theory of Technology Lifecycle applied**
- Datasets of patent families and scientific publications were used to **study technological evolution**



Technological life-cycle assessment



Proprietary patent database
(based on EPO's Database)



OpenAIRE database
(scientific publications)



CORDIS database
of EU-funded projects

DATA ANALYSIS



Geographical distribution of R&D, manufacturing and commercial activities



Most prolific R&D entities

Clustering of Technologies

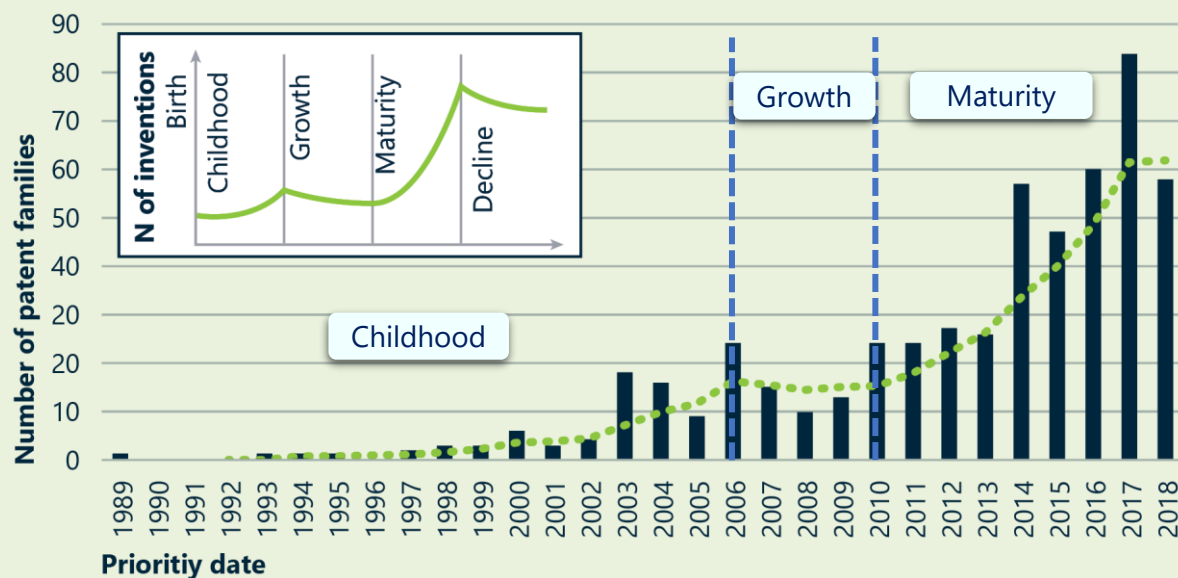
Patentometric and bibliometric analyses of Clusters

#	Technological clusters	No. Patent families	No. Patents	No. Papers	State in technology lifecycle	Concentration of inventive activity (%)	Concentration of publishing activity (%)	Concentration of editorial activity (%)
20.	Speaker recognition	1,760	7,468	848	Maturity	34.7	6.4	67.9
8.	Contact-based friction ridge recognition	1,758	8,599	158	Maturity	24.1	60	100
3.	2D face recognition in the visible spectrum	1,437	5,012	580	Maturity	20.7	8.8	68.8
19.	Handwriting recognition	1,273	6,347	821	Maturity	18.2	15.5	77.7
12.	Eye vein recognition	1,048	5,117	544	Maturity	18.4	12.1	60.7
2.	Infrared face recognition	1,047	5,111	151	Maturity	27.9	24.2	81.6
7.	Contactless friction ridge recognition	811	3,974	25	Maturity	19.5	40.4	84
9.	Iris recognition in the NIR spectrum	650	3,068	30	Maturity	30	56.7	100
4.	3D face recognition	561	2,545	269	Maturity	27.9	18.6	74.7
13.	Hand vein recognition	532	1,958	457	Maturity	42.2	17.7	77.2
1.	DNA biometrics	473	2,556	168	Maturity – minor relevance	19.6	23.4	58.9
15.	Hand geometry recognition	428	2,349	186	Maturity – minor relevance	36.9	21	71
17.	Keystroke recognition	378	1,482	129	Maturity – minor relevance	28.8	65.9	79.8
14.	Heart signals recognition	267	1,207	134	Growth	30.1	32.1	76.9
11.	Iris recognition at a distance	259	1,285	77	Growth	46.7	39	84.4
10.	Iris recognition in the visible spectrum	222	1,212	40	Growth	37.4	47.7	100
5.	Infrared friction ridge recognition	195	843	66	Growth	34.2	36.4	84.8
6.	3D friction ridge recognition	120	571	41	Growth	54.9	126.8	100
18.	Gait recognition	32	163	67	Childhood	68.7	73.1	100
16.	Periocular recognition	27	197	38	Childhood	88.8	84.2	100

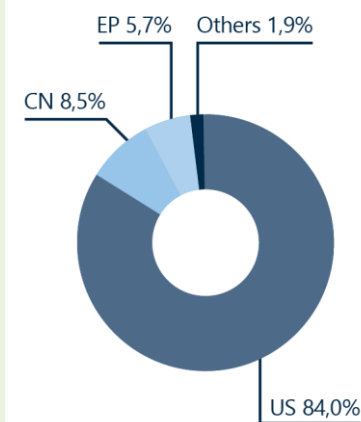
Clustering of Technologies

Patentometric and bibliometric analyses on Clusters

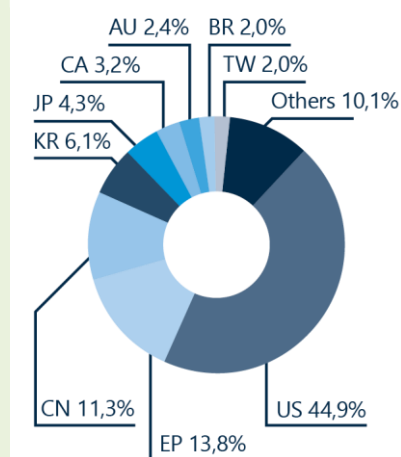
3D face recognition



Geographical distribution of **priority patents**



Geographical distribution of **all patents**



Assignee	Number of patent families	% of the total
Microsoft	21	3.8
Amazon Technologies	19	3.4
Google	18	3.2
Apple	13	2.3

Publisher	Number of scientific publications	% of the total
IEEE	87	32.3
Springer	34	12.6
Elsevier	25	9.3

Building Scenarios for the Future

Scenarios for the future of travel, border checks and biometrics in 2040



Aim

- Reframing visions of the future in order to challenge them
- Assessing how alternative futures might influence the evolution of biometrics.



Choice of scenarios

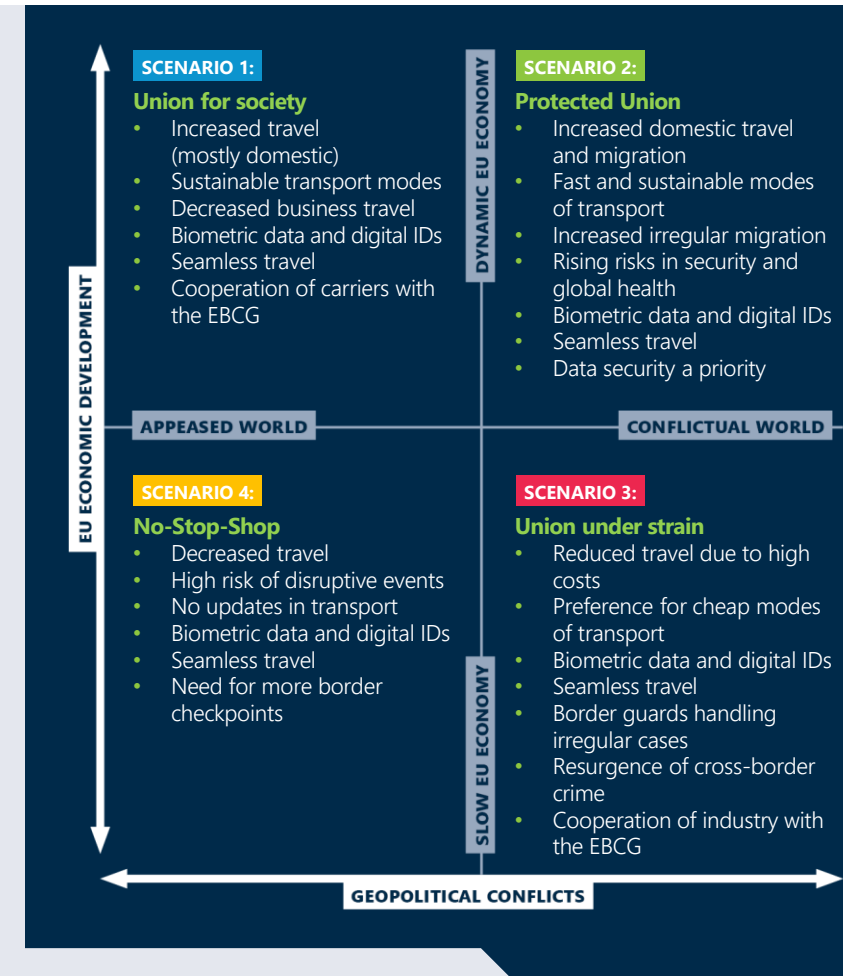
- Based on JRC's study "*The Future of Customs in the EU 2040: A foresight project for EU policy*"^[1]
- Adapted to incorporate aspects relevant to the travel and border check context



Use of scenarios

- Roadmapping
- Mapping capabilities

[1] Ghiran A., Hakami A., Bontoux L., Scapolo, F. *The Future of Customs in the EU 2040: A foresight project for EU policy*, EUR 30463 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-26299-2, doi:10.2760/29195, JRC121859.



3. Filtering Results

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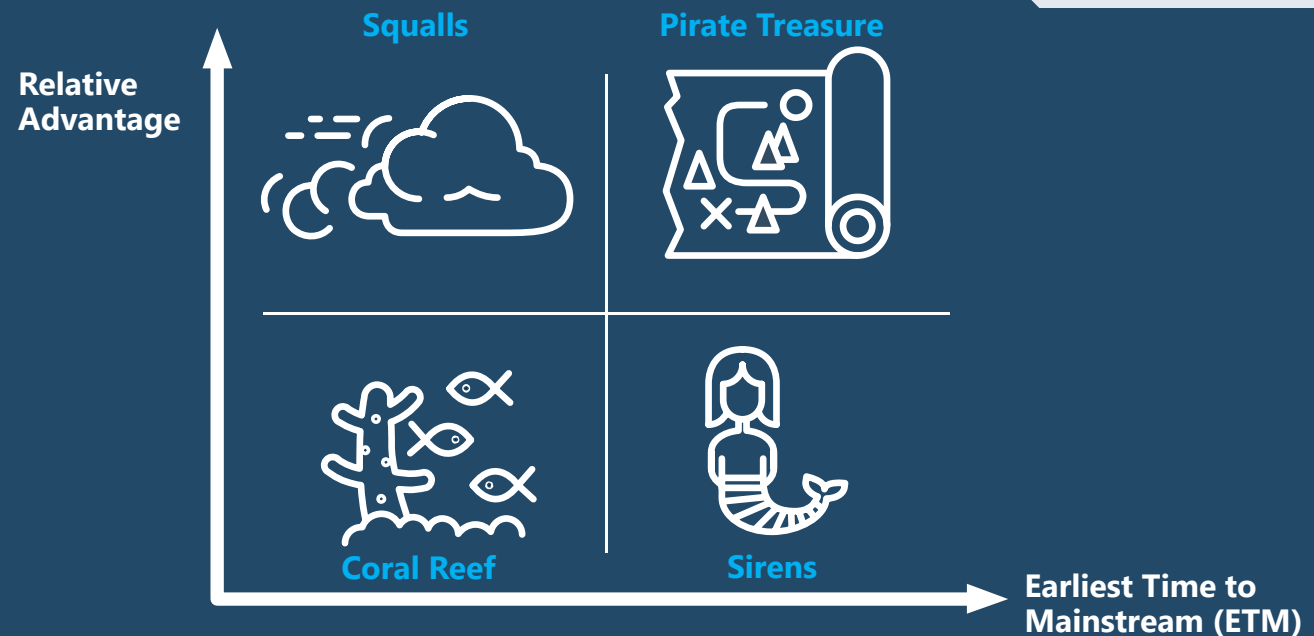
Filtering by Key Strategic Factors

Prioritisation of biometric technologies – The Delphi Survey



Aim

- Select the Key biometric Technological Clusters – KTCs
- Quantitative assessment of the 20 Technological Clusters using 2 metrics: **Relative Advantage** and **Earliest Time to Mainstream** by a **real-time Delphi**
 - Collect experts' opinions
 - Stimulate consensus-oriented structured discussions
 - Exploit collective intelligence, not only statistical distribution of answers



Filtering by Key Strategic Factors

Prioritisation of biometric technologies – The Delphi Survey

#	Technological clusters	Delphi Assessment Composite Metric $p = RA - ETM/2$	Relative Advantage			Earliest Time to Mainstream		
			Average	St Dev	Number of assessments	Average	St Dev	Number of assessments
3.	2D face recognition in the visible spectrum	3.52	5.17	2.27	30.00	3.30	2.50	31.00
2.	2D infrared face recognition	3.45	5.86	1.96	29.00	4.80	2.30	31.00
4.	3D face recognition	3.44	6.81	1.51	32.00	6.70	3.50	32.00
9.	Iris recognition in the near-Infrared spectrum	3.07	6.48	1.79	27.00	6.80	3.40	27.00
8.	Contact-based friction ridge recognition	3.00	4.04	1.99	28.00	2.10	1.50	26.00
10.	Iris recognition in the visible spectrum	1.49	5.18	2.12	28.00	7.40	3.30	27.00
11.	Iris recognition at a distance	1.09	7.11	2.57	27.00	12.00	4.50	28.00
7.	Contactless friction ridge recognition	0.84	5.38	2.19	29.00	9.10	3.30	28.00
16.	Periocular scanning	0.44	5.11	2.15	27.00	9.30	2.60	27.00
5.	Infrared friction ridge recognition	0.41	3.73	1.93	30.00	6.70	3.40	29.00
20.	Speaker recognition	-0.07	3.79	2.18	28.00	7.70	4.10	28.00
13.	Hand vein recognition	-0.41	4.52	2.27	29.00	9.90	4.00	29.00
18.	Gait recognition	-0.56	4.52	1.89	27.00	10.10	3.90	27.00
6.	3D friction ridge recognition	-0.98	4.34	2.28	29.00	10.60	3.60	28.00
15.	Hand geometry recognition	-1.87	2.74	1.84	27.00	9.20	4.20	28.00
12.	Eye vein scanning	-2.34	4.25	2.20	28.00	13.20	3.80	28.00
1.	DNA scanning	-2.56	5.19	3.16	31.00	15.50	3.90	30.00
19.	Handwriting recognition	-2.70	1.63	1.47	27.00	8.70	5.00	27.00
17.	Keystroke dynamics	-4.02	1.00	0.72	27.00	10.00	5.50	27.00
14.	Heart signals recognition	-6.38	1.11	0.77	28.00	15.00	3.40	28.00



Relative Advantage



Earliest Time to Mainstream (ETM)






Filtering by Other Relevant Factors

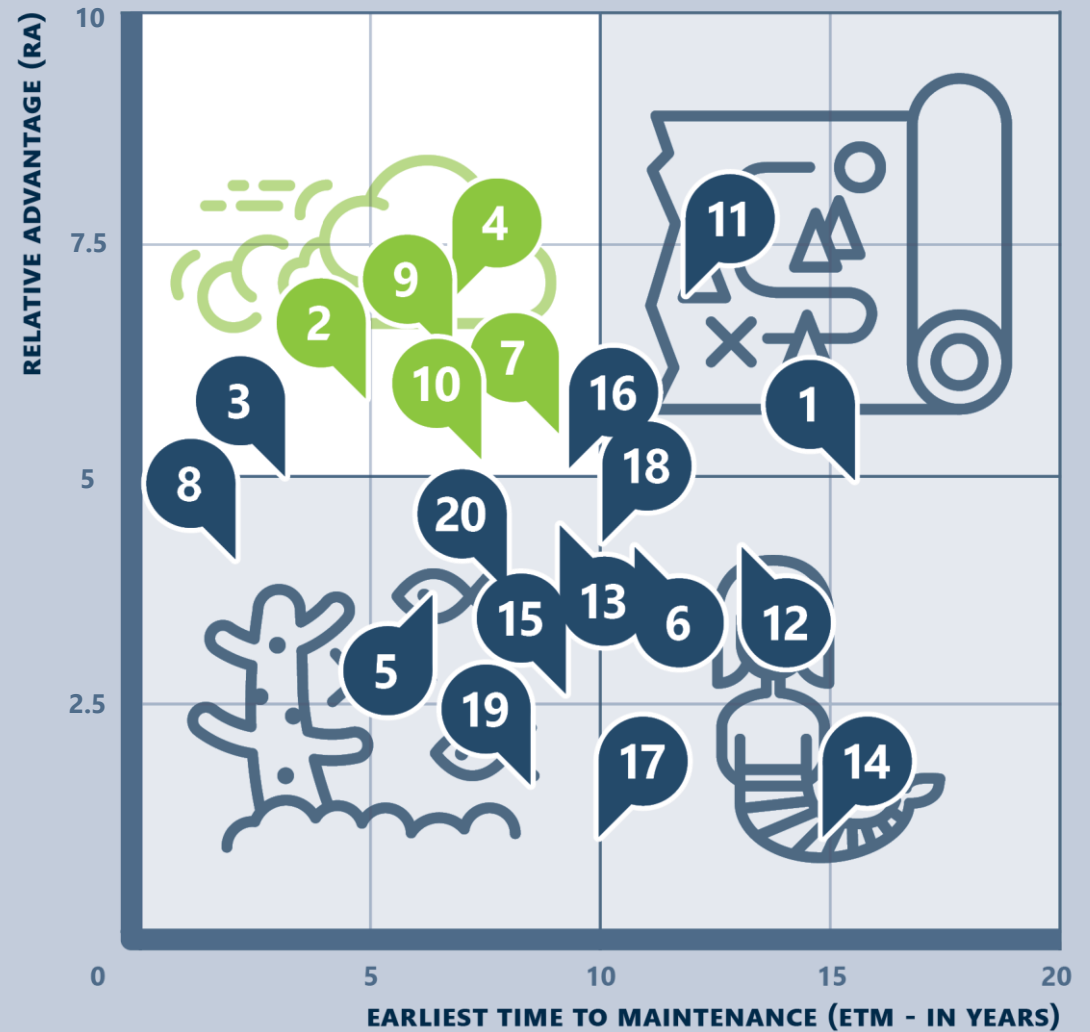


ADDITIONAL CHECKS FOR

- ✓ redundancy
- ✓ vulnerability to adversary attacks
- ✓ "must-haves" from the needs analysis

FINAL SELECTION OF 5 KTC

2.  Infrared face recognition
4.  3D face recognition
7.  Contactless friction ridge recognition
9.  Iris recognition in the NIR spectrum
10.  Iris recognition in the visible spectrum



4. Deep Analysis

Project Overview

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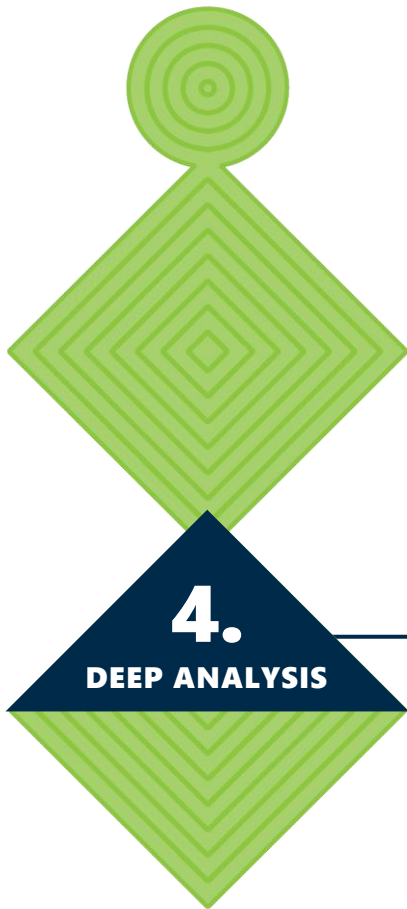
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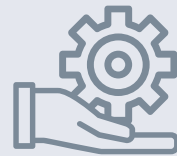


Roadmaps of key biometric technological clusters



Aim

- In-depth analysis of the key technological clusters
- Envisage potential future developments in terms of:
 - Applications
 - Functions
 - Products and systems



Outcomes (for each KTC)

- Visual technology roadmap chart
- List of expected key opportunities and challenges in the today-2040 timeframe
- Comparative analysis to study how the of the hypothetical scenarios might influence the developments envisaged in the roadmaps

Roadmaps of key biometric technological clusters

Visual technology roadmap charts – 3D face recognition

EXAMPLE DEVELOPMENTS

2028 – 2040

Seamless border checks using 2D and 3D face recognition (after check-in, biometric data is acquired and stored; it is removed after the passenger leaves the airport/BCP)

2026 – 2040

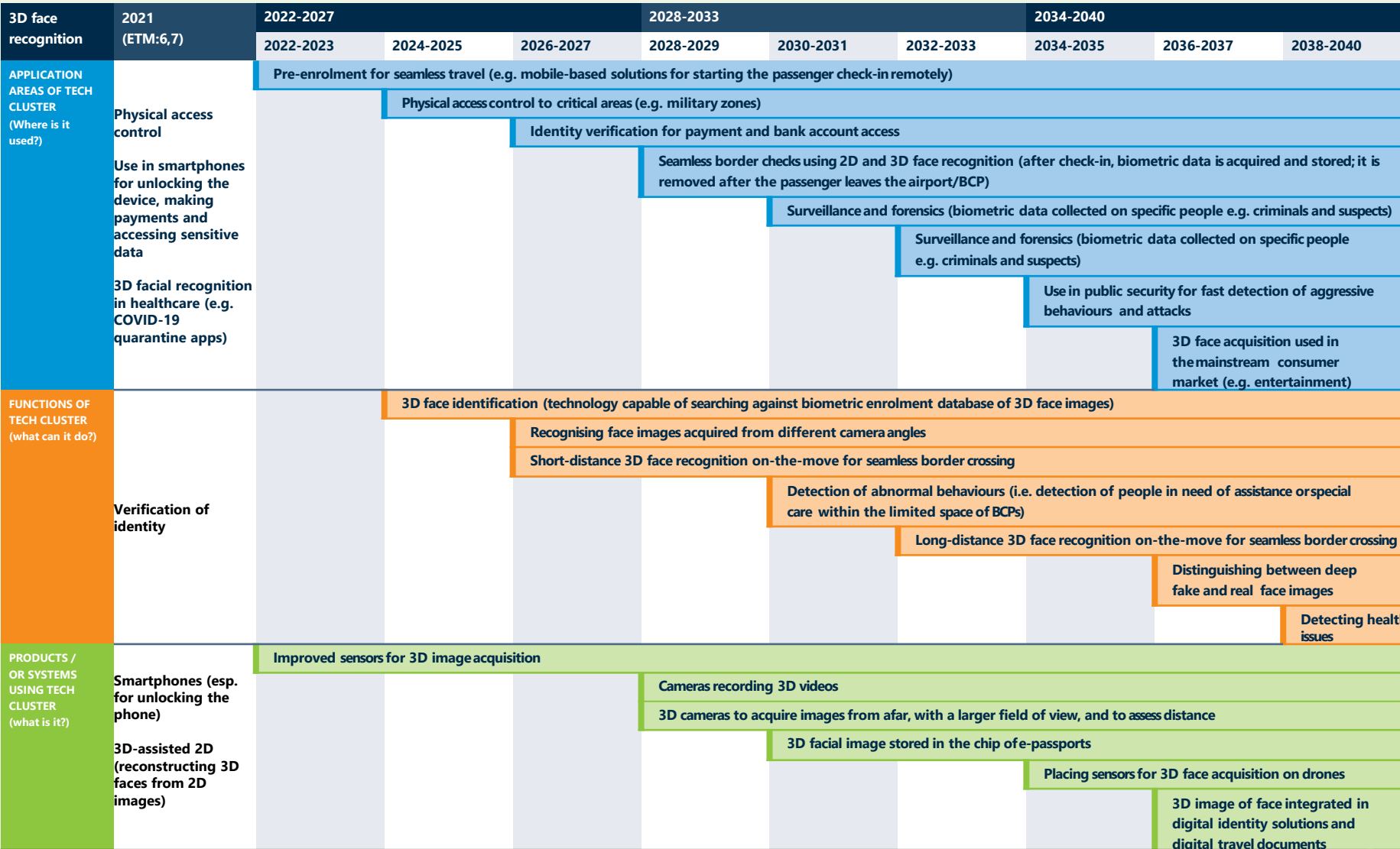
Short-distance 3D face recognition on-the-move for seamless border crossing

2032 – 2040

Long-distance 3D face recognition on-the-move for seamless border crossing

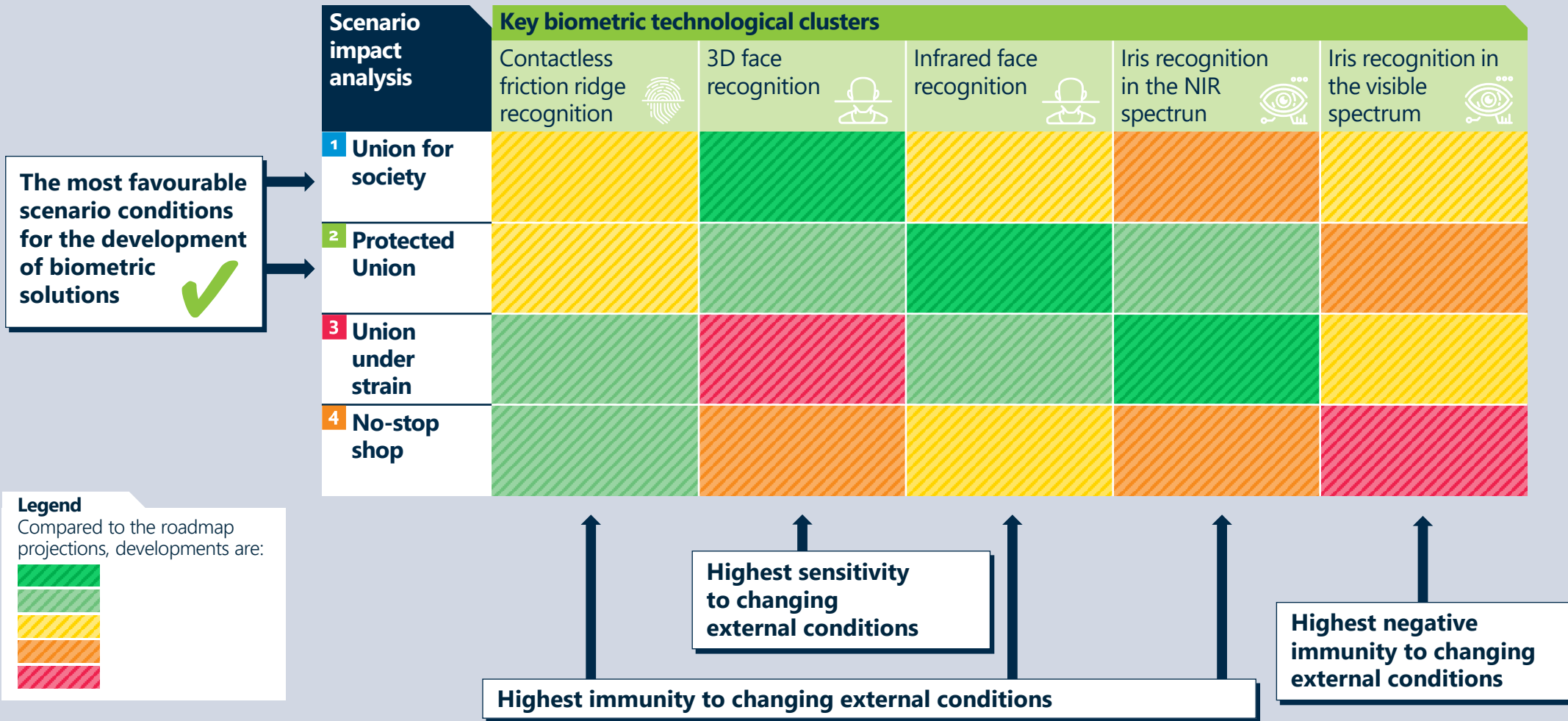
2030 – 2040

3D facial image stored in the chip of e-passports



Roadmaps of key biometric technological clusters

Cross-cluster comparison of scenario impact – 3D face recognition



5. Mapping Capabilities

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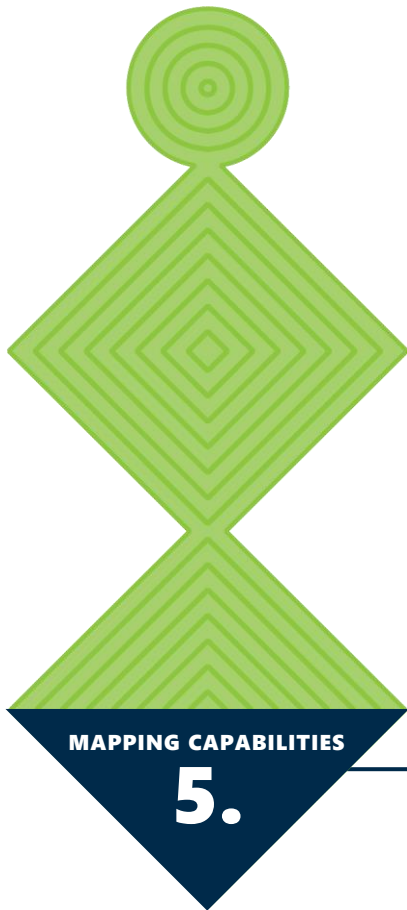
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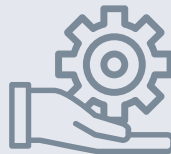


Capability Readiness Analysis



Aim

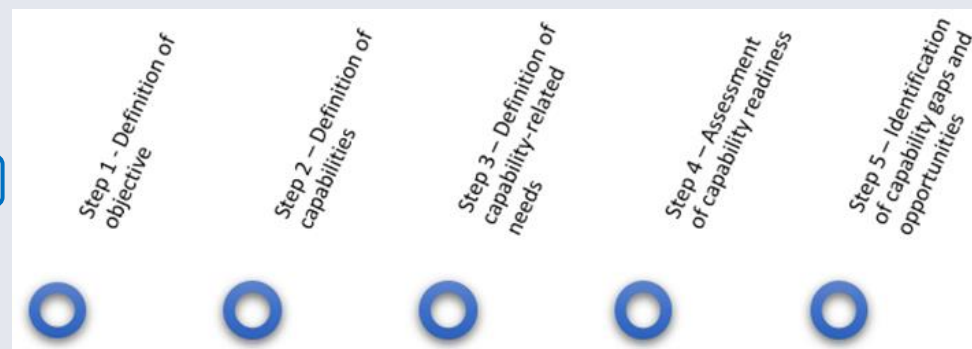
- Explore existing EU capability landscape
- Identify capability gaps and opportunities across the various timeframes and scenarios



Outcomes (for each KTC)

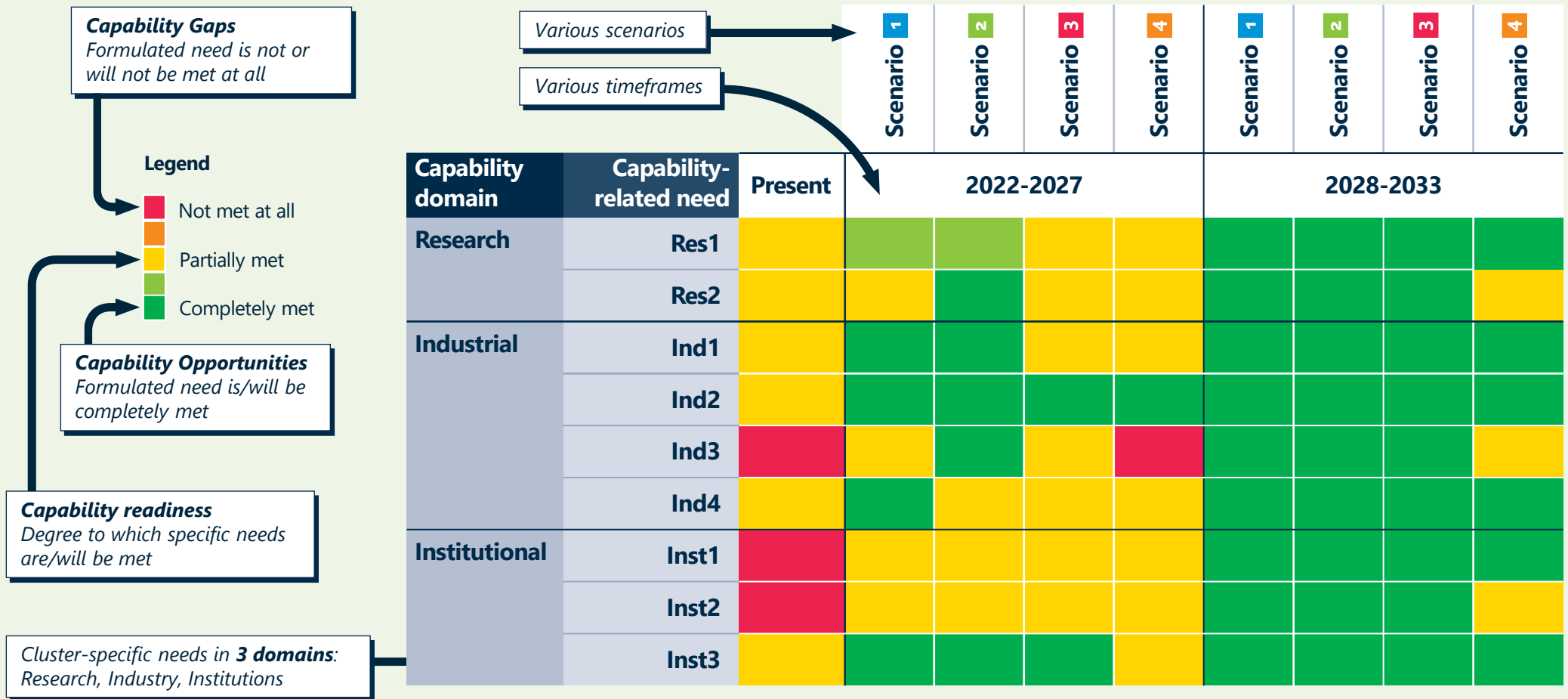
- Capability readiness heatmaps

METHODOLOGY



Capability Readiness Analysis

Heatmaps – 3D face recognition



Conclusions

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Main Outcomes

Each of the phases of this complex Research Study produced its own set of future-oriented insights with the intention of supporting the EBCG community in decision-making processes that:



exploit opportunities

mitigate associated threats



result in the implementation of new biometrics-enabled technological solutions

5 Key Technological Clusters



Infrared Face Recognition



3D Face Recognition



Contactless Friction Ridge Recognition



Iris Recognition in the NIR Spectrum



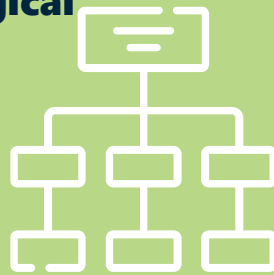
Iris Recognition in the Visible Spectrum

Main Outcomes

Technology Foresight Manual describing the TF Process, the Methods and the Tools



Taxonomy of Biometric Technologies and Biometrics-Enabled Technological Systems



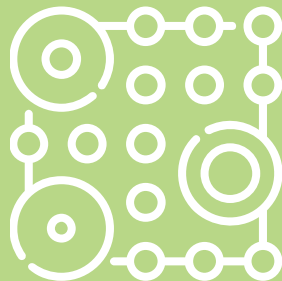
Analyses conducted over the patents, scientific literature and EU-funded projects



Set of scenarios for the future of travel and border checks



Prioritisation Matrix of biometric technological clusters



Set of roadmaps developed for the key biometric technological clusters



Heatmaps reflecting capability readiness for the key biometric technological clusters



Project Newsletters

APPLICATION

Technology Foresight on Biometrics for the Future of Travel

Objective

In October 2020, Frontex Research and Innovation funded an open procurement process for the provision of a Technology Foresight Research Study on Biometrics for the Future of Travel. The main objective of this research is to explore the future of biometrics for the border control system from the perspective of the European Border and Coast Guard (EBCC) over the next 10 years, medium to long term (10-15 years) and to identify the key challenges and opportunities for the system.

Purpose

The overall objective of the project is to identify the key challenges and opportunities for the system and to provide a strategic vision for the future of biometrics for the border control system.

Deliverables

The general objective of this research will be achieved by producing a research study that includes the identification and description of emerging biometric technologies with the strongest potential to address the strategic objectives of the European Border Management and the key challenges and opportunities for the system.

Service provider

The overall objective of this research will be achieved by producing a research study that includes the identification and description of emerging biometric technologies with the strongest potential to address the strategic objectives of the European Border Management and the key challenges and opportunities for the system.

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Key technology identification

The main objective is to prepare a list of critical biometric technologies that should be considered for future research and development. This requires the identification of key technologies and the analysis of their capabilities.

Patent analysis

Recent literature, consisting of published official documents covering various areas of research, will be used to identify key technologies and their capabilities.

Delphi method

The Delphi method was originally developed in the 1950s and is a structured communication technique that involves multiple rounds of questionnaires to reach a consensus on a topic.

NEWSLETTER #1 - METHODOLOGY

TECH FORESIGHT ON BIOMETRICS

PHASE 1: DEFINING THE METHODOLOGY AND SETTING THE CONTEXT

The project

In October 2020, Frontex Research and Innovation funded an open procurement process for the provision of a Technology Foresight Research Study on Biometrics for the Future of Travel. The main objective of this research is to explore the future of biometrics for the border control system from the perspective of the European Border and Coast Guard (EBCC) over the next 10 years, medium to long term (10-15 years) and to identify the key challenges and opportunities for the system.

The means

The first project newsletter aims to shed some light on the tools and methods that will be used in this project and to provide a strategic vision for the future of biometrics for the border control system.

Foresight: Strategic insights from the future

Foresight is a strategic tool that allows organisations to anticipate future events and trends. It is a process of identifying and analysing potential future scenarios and their implications for the organisation.

Project phases

The project is divided into several phases, including the identification of key technologies, the analysis of their capabilities, and the identification of key challenges and opportunities for the system.

Tools & methods

The project will use a variety of tools and methods, including the Delphi method, patent analysis, and key technology identification.

Key technology identification

The main objective is to prepare a list of critical biometric technologies that should be considered for future research and development. This requires the identification of key technologies and the analysis of their capabilities.

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Delphi method

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NEWSLETTER #2 - SCENARIO ANALYSIS

TECH FORESIGHT ON BIOMETRICS

Scenario analysis

Scenario analysis is a strategic tool that allows organisations to anticipate future events and trends. It is a process of identifying and analysing potential future scenarios and their implications for the organisation.

Scenarios for the year 2040

For the purpose of this scenario analysis, we have identified four scenarios for the year 2040, based on the current trends and the potential future developments in the field of biometrics for the border control system.

Scenario 1: Union for society

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 2: Protected Union

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 3: Union under strain

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 4: No-Stop-Shop

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Geopolitical conflicts

The scenarios are based on different geopolitical configurations, including the presence of conflicts and the impact of global events on the EU.

Scenario 1: Union for society

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 2: Protected Union

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 3: Union under strain

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 4: No-Stop-Shop

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

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NEWSLETTER #3 - SCENARIO ADAPTATION

TECH FORESIGHT ON BIOMETRICS

Scenario analysis workshop

The scenario analysis workshop was held in October 2020, with the aim of identifying and analysing potential future scenarios and their implications for the organisation.

Scenario 1: Union for society

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 2: Protected Union

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 3: Union under strain

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Scenario 4: No-Stop-Shop

In 2040, the EU is prospering economically and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced. The EU is a high standard of living for its citizens and the digital transformation is well advanced.

Geopolitical conflicts

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NEWSLETTER #4 - TAXONOMY

TECH FORESIGHT ON BIOMETRICS

Taxonomy of biometric technologies

The taxonomy of biometric technologies is a classification system that categorises biometric technologies based on their underlying principles and their applications.

1. BIOMOLECULAR BIOMETRICS

- 1.1 DNA biometrics
- 1.2 Other biomolecular biometrics

2. MORPHOLOGICAL BIOMETRICS

- 2.1 Face recognition
- 2.2 Iris recognition
- 2.3 Physiological signals biometrics
- 2.4 Friction ridge recognition
- 2.5 Vascular pattern recognition
- 2.6 Hand geometry biometrics
- 2.7 Other morphological biometrics

3. BEHAVIOURAL BIOMETRICS

- 3.1 Keystroke dynamics
- 3.2 Gait analysis
- 3.3 Voice recognition
- 3.4 Facial expression recognition
- 3.5 Heart rate variability
- 3.6 Brain activity
- 3.7 Other behavioural biometrics

4. ENVIRONMENTAL BIOMETRICS

- 4.1 Environmental biometrics
- 4.2 Environmental biometrics
- 4.3 Environmental biometrics
- 4.4 Environmental biometrics
- 4.5 Environmental biometrics
- 4.6 Environmental biometrics
- 4.7 Environmental biometrics
- 4.8 Environmental biometrics
- 4.9 Environmental biometrics
- 4.10 Environmental biometrics

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NEWSLETTER #5 - 4CF MATRIX

TECH FORESIGHT ON BIOMETRICS

Technological clusters in the long

The 4CF matrix is a tool used to identify and analyse technological clusters in the long term. It is based on the identification of key technologies and their relationships.

Relative Advantage (RA)

Relative Advantage (RA) is a measure of the advantage that a technology has over its competitors. It is based on the identification of key technologies and their relationships.

Earliest Time to Mainstream (ETM)

Earliest Time to Mainstream (ETM) is a measure of the time it takes for a technology to become mainstream. It is based on the identification of key technologies and their relationships.

A matrix of Biometrics technological clusters

The matrix of Biometrics technological clusters is a tool used to identify and analyse technological clusters in the long term. It is based on the identification of key technologies and their relationships.

Delphi survey results

The Delphi survey results are a set of data that provide insights into the future of biometrics for the border control system. It is based on the identification of key technologies and their relationships.

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NEWSLETTER #6 - RESEARCH STUDY

TECH FORESIGHT ON BIOMETRICS

Research Study

The research study is a comprehensive analysis of the current state of biometrics for the border control system and the potential future developments in the field.

Key biometric technological clusters

- 1. Infrared face recognition
- 2. 3D face recognition
- 3. Contactless friction ridge recognition
- 4. Iris recognition in the NIR spectrum
- 5. Iris recognition in the visible spectrum

Main outputs

The research study generated several key outputs, including the identification of key technologies and their relationships, and the identification of key challenges and opportunities for the system.

Key biometric technological clusters

- 1. Infrared face recognition
- 2. 3D face recognition
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Main outputs

The research study generated several key outputs, including the identification of key technologies and their relationships, and the identification of key challenges and opportunities for the system.

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**Thank you
for your attention!**

If you have any questions regarding
this research study please contact
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