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Biometrics at the Border

International Joint Conference on Biometrics (IJCB) 2017

3rd October, 2017

Denver, CO, US

Keynote speaker:
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The work has been supported by the FastPass and PROTECT projects. The research leading to these results has received funding from the European Union Seventh Framework and H2020 Programmes under grant agreements n° 312583 and n° 700259 respectively. This publication only reflects the author's view and the European Union is not liable for any use that may be made of the information contained therein. *The content contained therein cannot be copied, reproduced or modified in the whole or in the part for any purpose without written permission from the author.*

Overview of Talk

- **Biometrics at the Border**
  - Status, challenges, vision
- **FastPass**
  - Overview of goals, main achievements, biometric innovations
  - Biometrics recommendations for future ABC installations
- **PROTECT**
  - Concept and scenarios, technical solutions, multimodal database
- **PETS** (Performance Evaluation of Tracking and Surveillance)
  - History, border security, standards
- **Summary**

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Biometrics - ePassport Gates - Benefits

- Increased security (forgery, imposter detection)
- Improved efficiency (1 border officer per up to 10 gates)
- Relatively quick and easy to use
- Good passenger feedback

Heathrow T5

- Border Force (UK) operating ePassport gates since 2008
- 3 generations of eGates have processed 125m passengers
- 242 ePassport gates installed across 32 locations
- Border strategy is all low-risk passengers use eGates
- 2017: 50% increase on 2016 usage of eGates (target: 60m by 2018)

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Biometrics - ePassport Gates - Challenges

- Permissable user groups
- Transaction times
- Limited space in arrivals halls
- Cost of installing and using technology
- Usability
- Increasing passenger numbers

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Border Security Vision

- Expectation is that **biometrics** and related technology will facilitate crossing of EU external frontiers by non-EU citizens, especially frequent travellers
- At the same time optimise security, effectiveness and the integrity of immigration control
- Speed up transaction times
- Reduce amount of space required to process passengers and integrate with other functions (e.g. customs)
- Advance data capture and risk analysis

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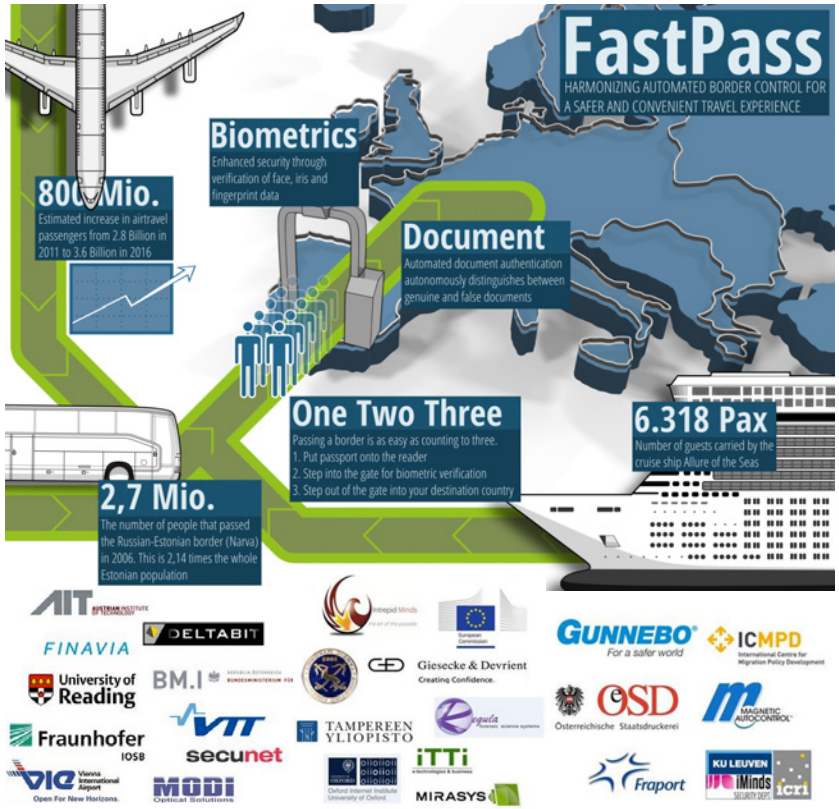
FastPass – The Project



Goal

- Harmonised, modular reference system for ABC
- User-centric approach

Details

- EU FP7 Security
- Jan 2013 – Mar 2017
- 27 Partners, led by AIT

Challenges

- Security (Spoofing, Attacks)
- Acceptability
- Harmonization

Further Info

- www.fastpass-project.eu

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FastPass Objectives

Supporting Innovative Border Crossing Concepts

- **Airborder:** Comparison of classical method with kiosk biometric token
- **Landborder:** Process with registration
- **Cruise ship:** Enhance nominal list with biometric information

Architecture Based on Innovative Technologies

- Reference Architecture with open interfaces
- Advanced Technology Modules (Passport, Identifcation, Video Surveillance)
- Security evaluation

Integration with EES and RTP

- Extend usability to TCN
- Evaluate the value of RTP for EU citizens

Harmonized ABC Systems

- Use of passport scanners
- Use of kiosks
- Instaneous „Go Through“
- Process harmoni-zation

European cooperation

- Liason with commission, EP, Frontex, eu-LISA, FRA
- Liason with other European Research Projects
- Liason with industry
- Liason with BG authorities

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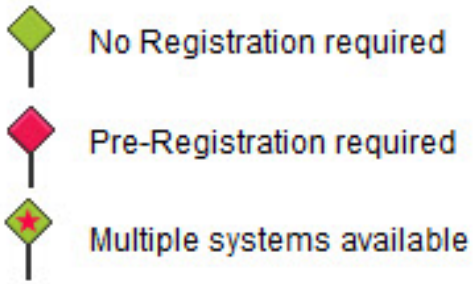
Automated Border Controls in Europe

As of 2013, 288 operating ABC gates installed in over 13 EU Member States (FRONTEX)



(IATA, 2014)

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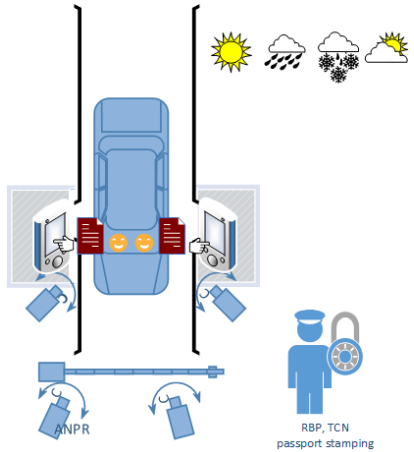
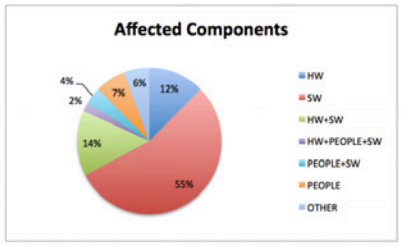
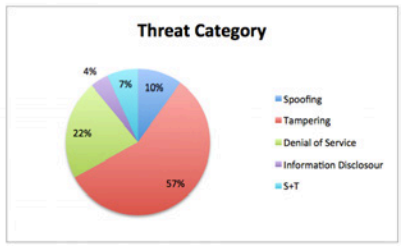
FastPass - Main achievements

- **Next-generation sensor development and novel frameworks, software and algorithms**
  - On-the-move biometric identification; improved speed, quality; reduced intrusiveness, counter spoofing
- **Innovative scenarios based on harmonized architectures**
  - Several air border scenarios, cruise-ship scenario, land border scenario with travellers remaining in vehicles
- **Methodology for a holistic risk and security assessment**
  - List of threats, with type, impact, exploitability and mitigation strategy
- **Recommendations for future ABC**
  - http://www.vtt.fi/inf/pdf/technology/2017/T303.pdf







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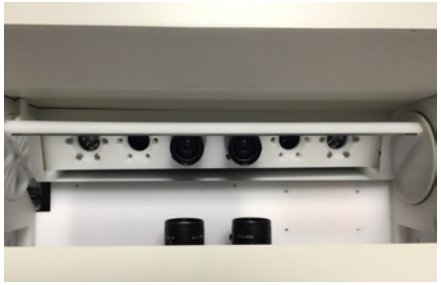
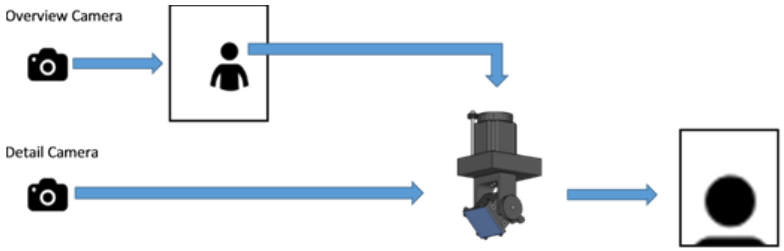
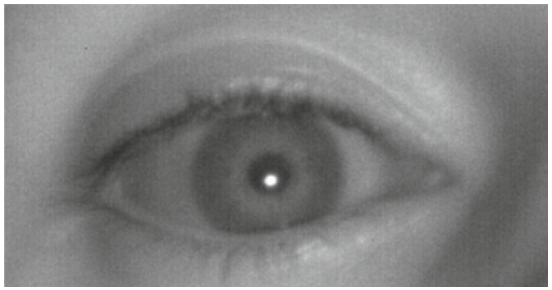
On-the-move face identification unit

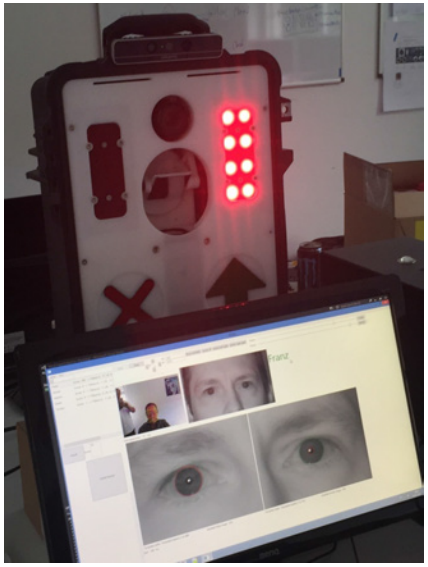


Scientific value	Scientific quality
Fast moving mirror technology to enable • Fast person face localisation • Long-distance detailed high-resolution face capture • On-the-move face capture	• Compared with exiting eGate, the technology allows face verification **from distance** and **on-the-move** • Allows people localisation with **different heights** quickly, **without standing off close and still** • Allows high throughput **>700 per hour** instead of 150 per hour • **Indoor** and **outdoor** (air, sea and land)
Robust face identification at kiosk • Colour camera for 1:1 face match • Combining new enrolment of face and iris under NIR • Illumination in different wavelengths • 3D counter-spoofing algorithm	• Compared with traditional face matching in gate, kiosk enrolment **minimizes the FRR by 30%**



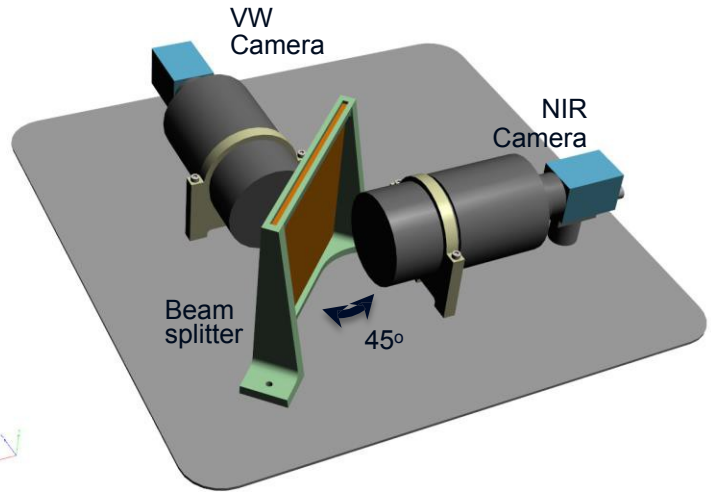
Long-distance iris acquisition sensor prototype

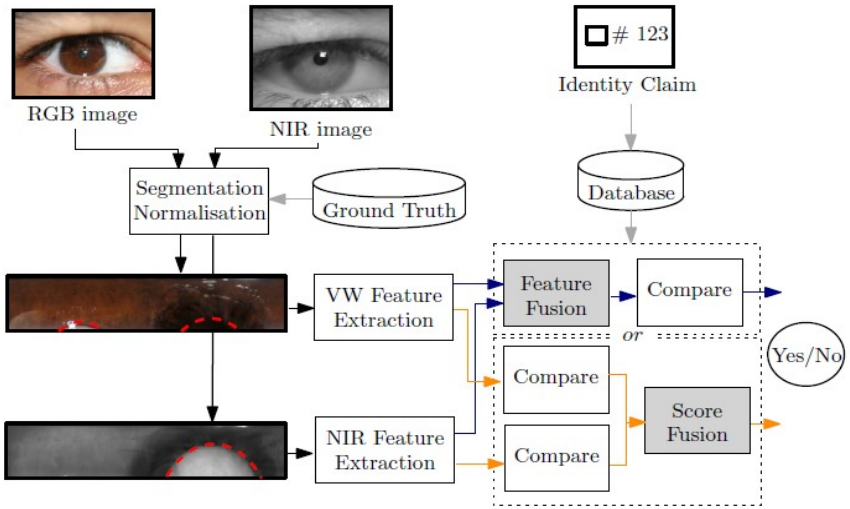




Scientific value
Innovative iris camera with fast moving mirror technology: •Allows long-distance, different-height iris capture: 1.5m x 2m •Novel iris capture sensor
Scientific quality
Robust face identification at kiosk •Minimum user cooperation, user-friendly, less intrusive •Allows kiosk iris enrolment •Much lower cost for producing the sensor: around €5K •Portable unit, easy integration

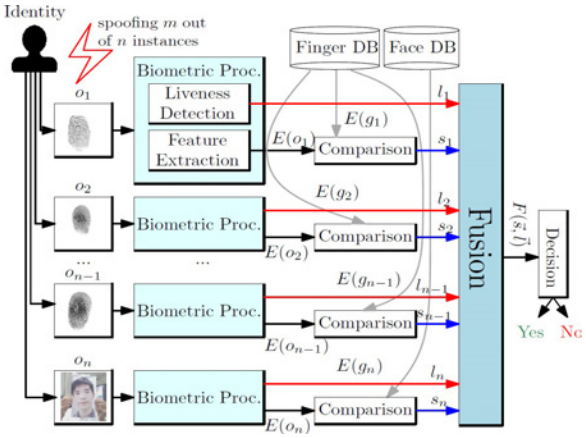
Multispectral iris/periocular sensor

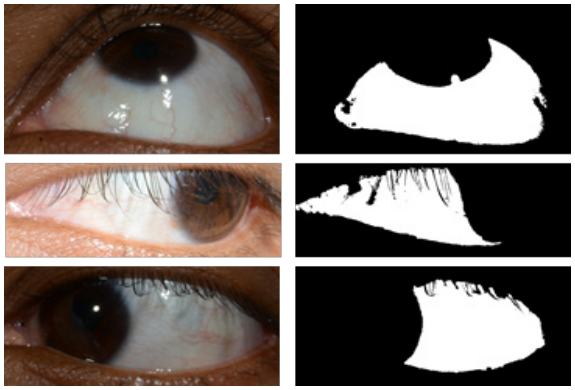


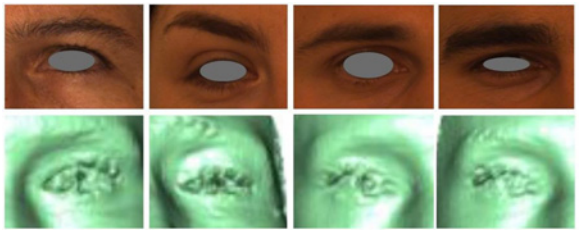


Scientific value	Scientific quality
• Multispectral: near infrared + visible spectrum • Synchronous data acquisition for the two spectra	Why multispectral? • In ABC typically the passport image is acquired in visible spectrum • Face recognition achieves highest accuracies in near infrared • Iris texture reveals different information in various wavelengths Iris acquisition from distance: • High resolution iris capture at a distance (~2 m) • Under normal lighting condition

Selected scientific research output on biometric recognition







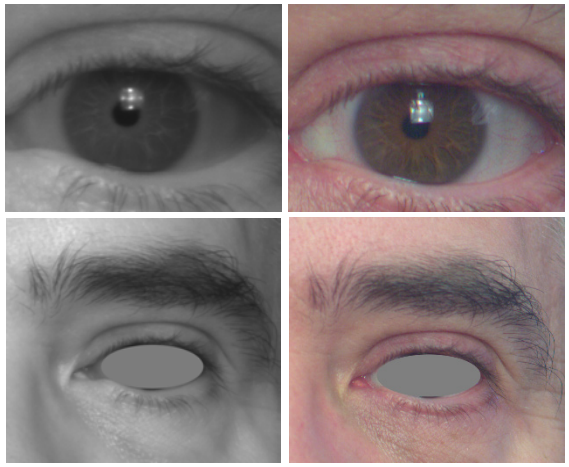
Scientific value	Scientific quality
Biometric fusion algorithms: •Spoofing-resistant multimodal fac… fingerprint fusi… •Multi-spectra … recognition (NI… •Neural networ… biometric fusio… •Sum-rule mod… fusion	• Novel 1-Median filtering method to detect outliers …alities based on …le under …ccuracy …nt
Sclera segment… •Using two-stag… learning based…	…2015 …Segmentation …tition" …llumination and
3D+2D periocul… recognition •First work on f… texture + 3D sh…	• Evaluation under less constrained …ession, head …l face or iris recognition performance

Wild, P., Radu, P. and Ferryman, J. Robust multimodal face and fingerprint fusion in the presence of spoofing attacks, Pattern Recognition, 10.1016/j.patcog.2015.08.007, 2016.

Radu, P., Ferryman, J. and Wild,P. A robust sclera segmentation algorithm, BTAS2015, 10.1109/BTAS.2015.7358746, 2015.

Chen, L. and Ferryman, J. Combining 3D and 2D for less constrained periocular recognition, BTAS2015, 10.1109/BTAS.2015.7358753, 2015.

CrossEyed competitions on multi-spectrum iris/periocular recognition

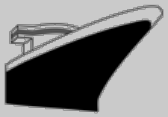


Results of the 5 methods submitted (error rate in %)

Team	Rank	GFRR@GFAR =0.001%
HH1	1	0.87
NTNU	2	11.76
HH2	3	21.37
HH3	4	25.83
Bmscians	5	100
Aurora	/	/

Scientific value	Scientific quality
Benchmark dual-spectrum eye dataset •High quality, high resolution dataset •Wide range on age, ethnicity, eye colour, eye shape, challenging conditions (partial occlusions, light reflection, eye glasses)	• Available to public research communities • Realistic environment, normal indoor lighting condition • First synchronised eye dataset between NIR and VW • Nearly 200 enrolled users • Contribution to standardisation in biometric recognition
CrossEyed competition (1st and 2nd editions) •BTAS 2016 •IJCB 2017 – more participants •Website: www.crosseyed.eu	• First competition organised on cross-spectral iris and periocular recognition • First competition organised on periocular recognition • The evaluation adapts ISO/IEC 19795-1:2006 standards for biometric performance testing and reporting • Received a wide range of feedback, interest from research community

Demonstrations / Pilots

			
Demo Schedule	August – October 2016	November 2016 – January 2017	Juni 2015 – December 2016
Demo participants	~ 1000	~ 150	~ 10000
Biometrics used	Face	Face	Face + Finger
Process	Kiosk / Gate with Face as token	Kiosk / Gate with license plate / passport as token	Comparison of - Mantrap - Kiosk/Gate with passport token - Kiosk/Gate with face token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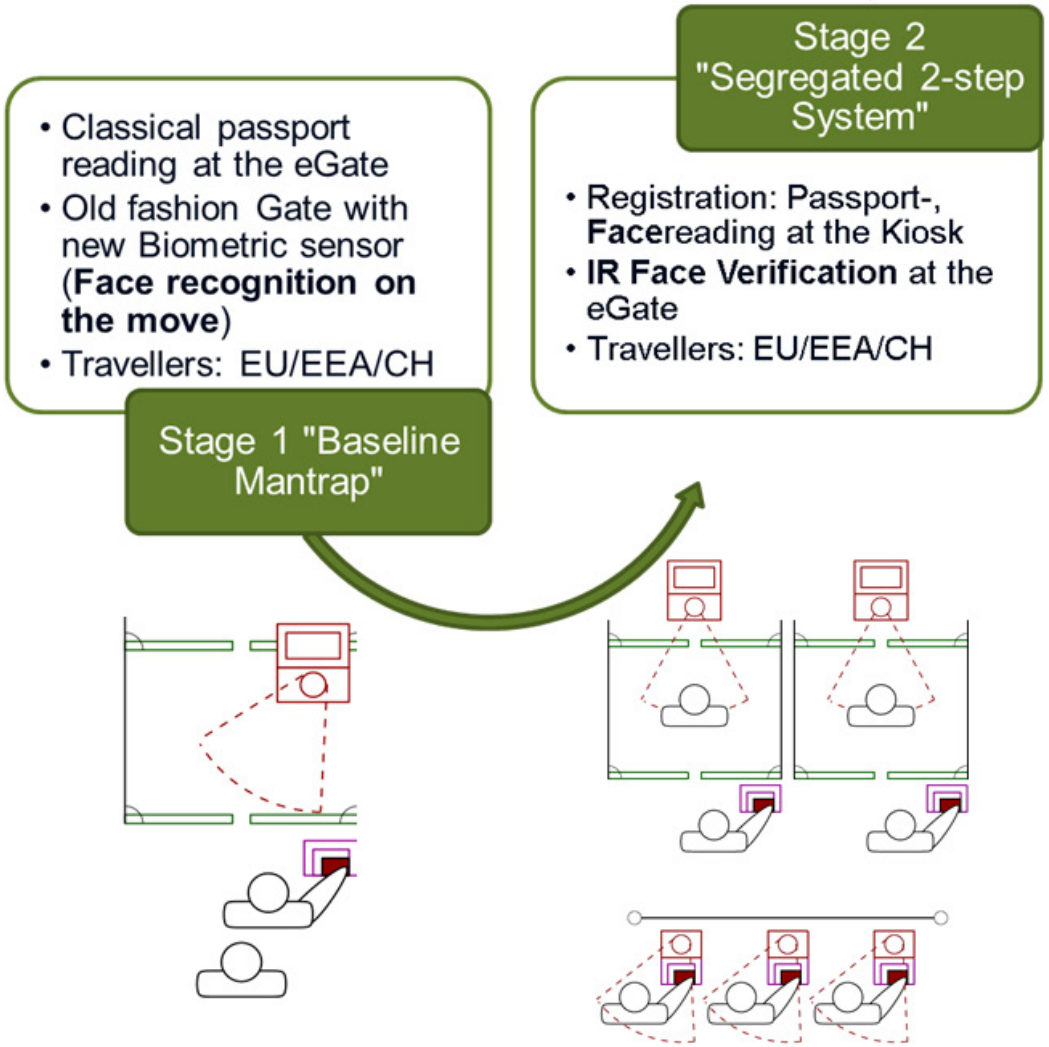
Air border concept



- Demonstration at Vienna airport
- Face as token – further increase of throughput

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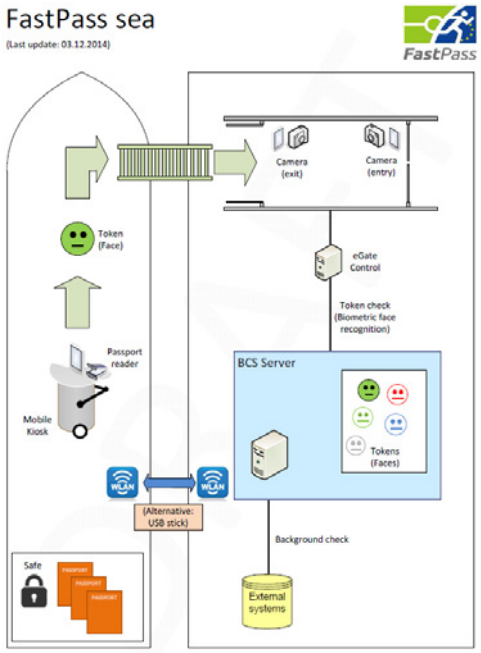
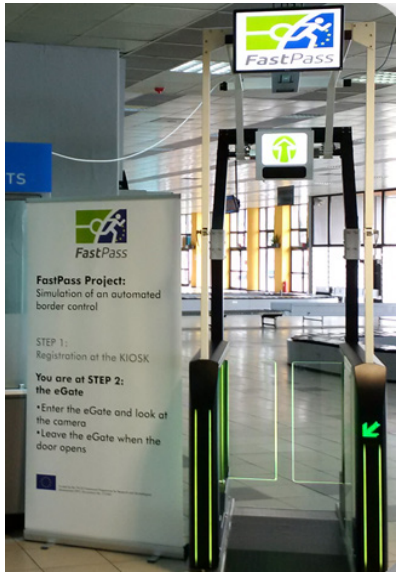
Cruise ship concept

- Demonstration at Port of Piraeus
- Document Authentication
- Passenger Authentication and Identification (1:n)
- Documents: ePassports
- Travellers: EU/EEA/CH, TCNVH, TCNVE
- Biometrics:
  - Face (+ Iris as laboratory test)
- RTP simulated





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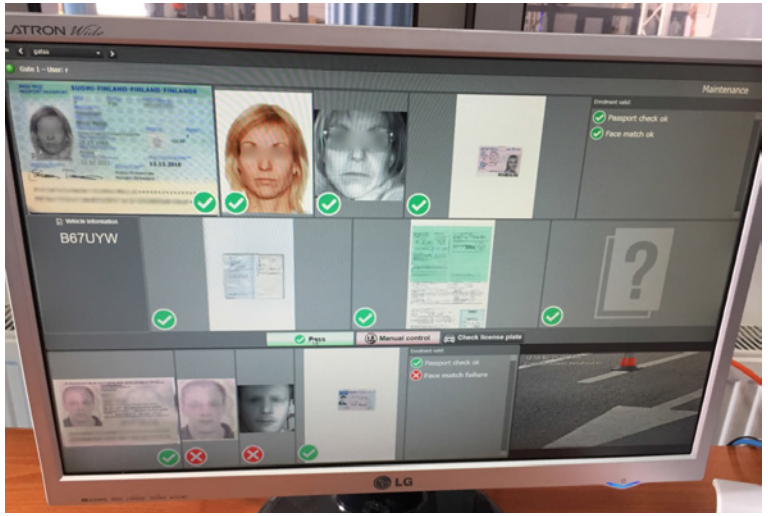
Land border concept

- Demonstration at Moravita
- Exit control for frequent traveller
- Enrolment of
  - ID documents
  - Vehicle documents
  - Driving license
- Movable terminals
- ANPR to detect vehicle
- Driver and Co-driver check
- Customs check, occupancy check, stamping is done manually



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FastPass – the system/technology, that

- **…is secure**
  - Resistent
    - to latest attacks on document scanner,
    - to biometric spoofing
  - Risk Assessment, Security Assessed by dedicated methodology
- **…is liked**
  - UI developed with extensive feedback from different European border guards
  - Process and procedures developed with extensive evaluation from traveller groups
  - Respects privacy and data protection (Data protection impact assessment – DPIA)
- **…is harmonized – and shows new processes and scenarios**
  - ONE reference architecture serving many processes
  - First European solution for cars at land border with ABC
  - First solution for cruise ships
  - Real comparison of different approaches on an airborder crossing point

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Technical recommendations for biometrics

- **Environmental:**
  - Performance tests should be performed when external temperature represents lowest local annual temperatures to ensure that ABC travellers are identified reliably during cold weather.
  - Additional correction on uncontrolled external light influences should be applied to ensure robust and high quality face capture
- **User engagement:**
  - Additional audio(visual) signals should be deployed to attract attention from users to ensure that they engage with camera(s)
- **Spoofing:**
  - Face spoofing detection against 3D masks is challenging while the person is on-the-move especially when the user is less cooperative. Thus, faster detection is necessary for on-the-move scenarios

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PROTECT

University of Reading

It would be ideal if new [biometric] technologies could be developed to enable free-flowing border control systems, reducing the need for physical border lines/eGates

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PROTECT

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Vision: contactless, free-flowing border control systems using advanced but appropriate technology

- Contactless biometric recognition on-the-move
- Multimodal biometrics (fusion)
- Counter spoofing
- Exploitation of travellers' mobile devices
- Future electronic machine readable documents

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PROTECT

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PROTECT (**P**ervasive and Use**R** F**O**cused Biome**T**rics Bord**E**r Proje**CT**)

- 3 year (2016-2019), 10 partner EC project
- 5M€ funding

Academic research

University of Reading

UNIVERSITÄT SALZBURG

UNIVERSITÉ DE NAMUR

WAT

Applied research

EURECOM

Sophia Antipolis

Industry

VERIDOS

IDENTITY SOLUTIONS

by Giesecke & Devrient and Bundesdruckerei

Consultancy

iTTi

e-technologie i biznes

Intrepid Minds

The art of the possible

End users

Home Office

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Scenario 1 – Biometric corridor

Concept

A sensor network configuration that spans a corridor performing reliable person identification while the travellers are ‘on the move’

- Lightly supervised multi-modal contactless biometric sensor network
- Research and development of emerging contactless biometrics
- Enable non-intrusive, non-stop robust and rapid passing through
- CCTV-based tracking of travellers to limit number of biometric templates to match against

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Scenario 2 – Mobile devices

Concept

Utilisation of traveller's mobile devices to perform biometric template storage and transmission to enable fluent identification process and analysis of potential for usage of mobile device sensors for biometric data acquisition

- Modernise travel experience utilising rapid innovation and adoption of smartphone technologies
- Use Bluetooth/NFC to alert a biometric system
- Use smartphones to capture data (biometric/document)
- Passenger position in the corridor (e.g. iBeacon)

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Scenario 3 – ePassports/eSecurity

Concept

Greater exploitation of data held within next-generation future travel documents, to enable storage and access of other/ enhanced biometrics in the ePassport chip

- Research new ways of providing biographic and biometric data to the verification system
- Research in new access and transmission modes to electronic passports to increase efficiency
- Research new technologies to enhance storage capabilities
- Enforce data security and privacy while enabling data transmission over greater distances by using Wi-Fi or Bluetooth Low Energy

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Dorohusk and Terespol site visits (February 2017)

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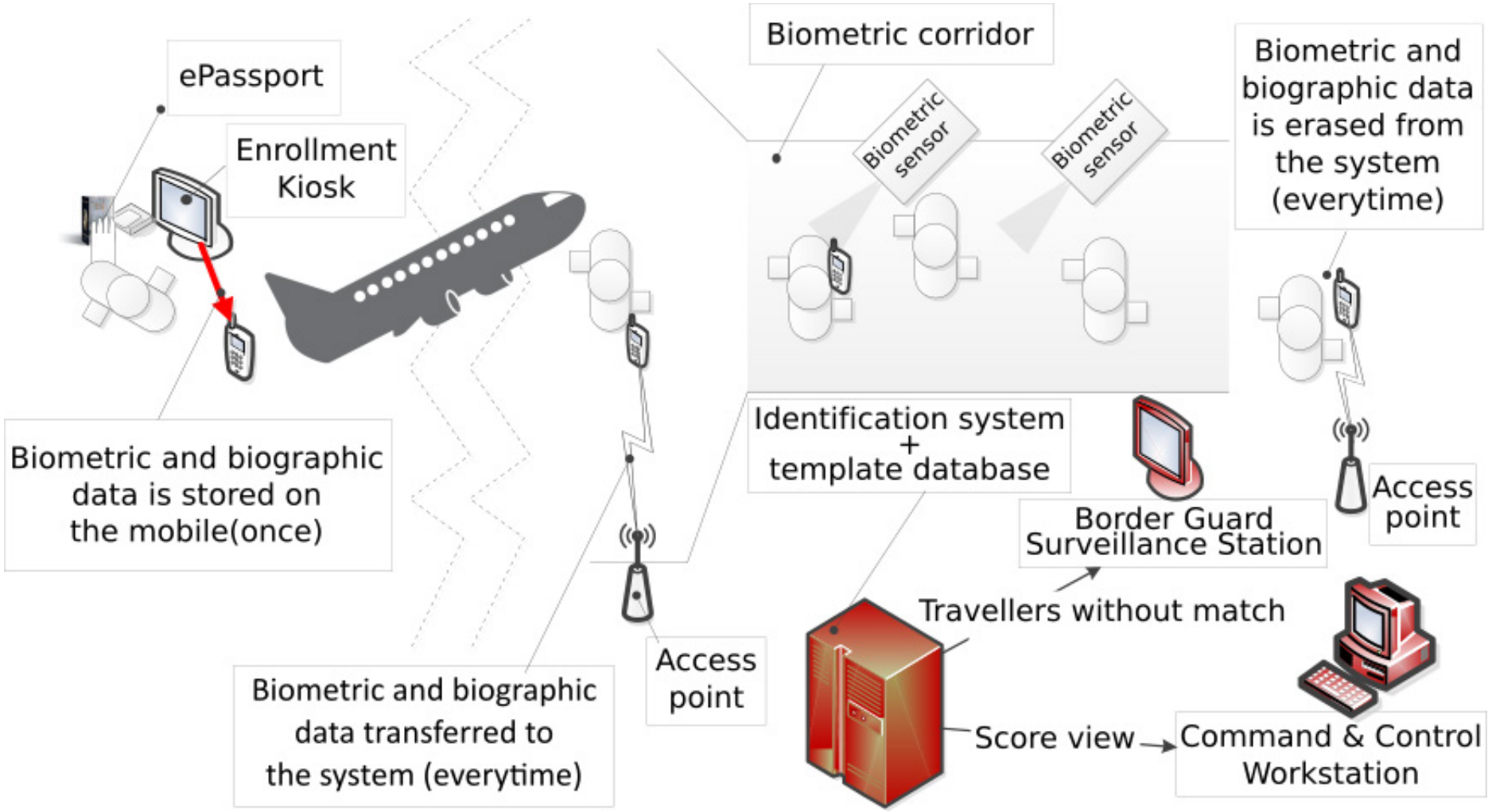
Technical solution – air border



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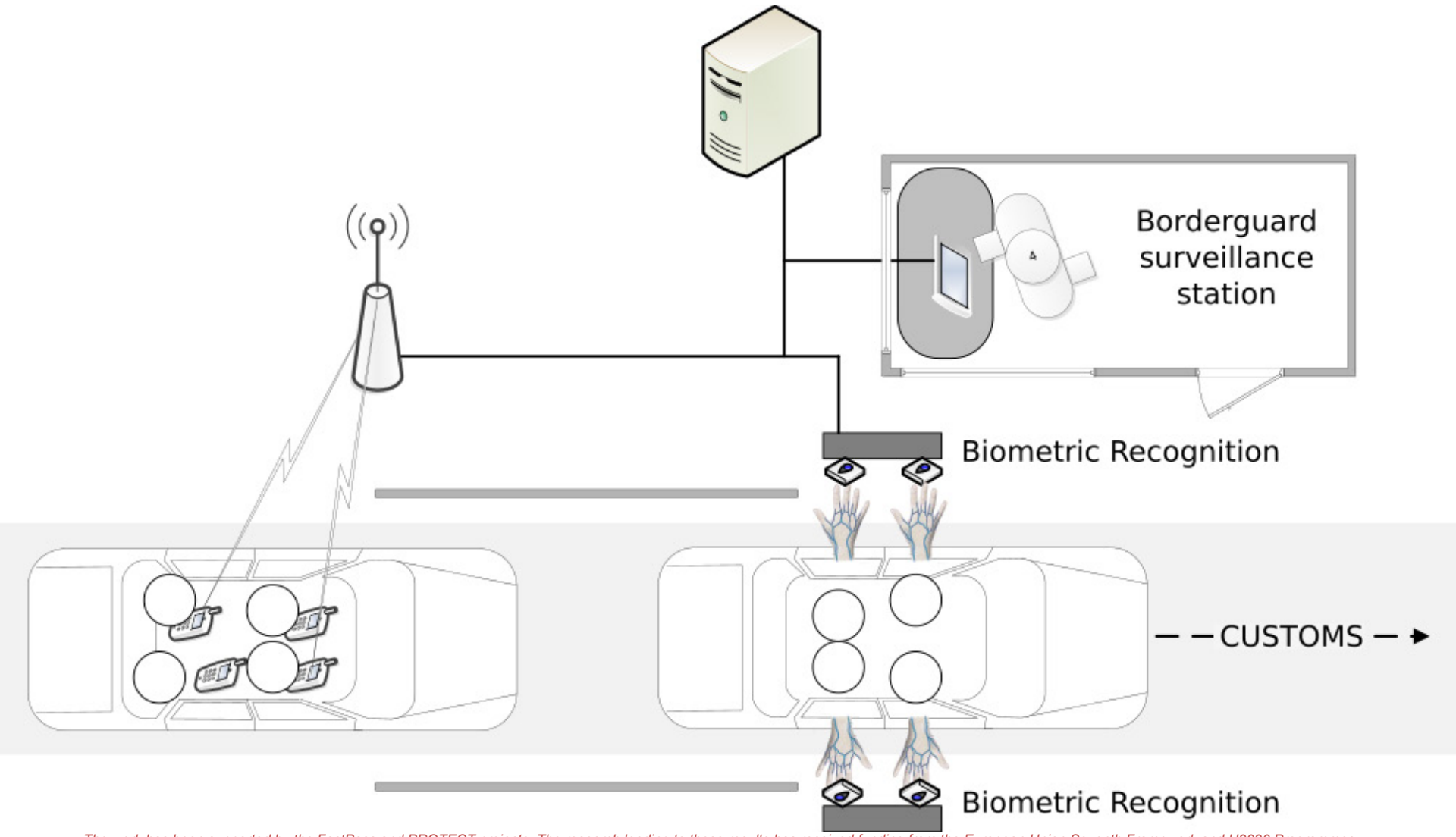
Technical solution – land border



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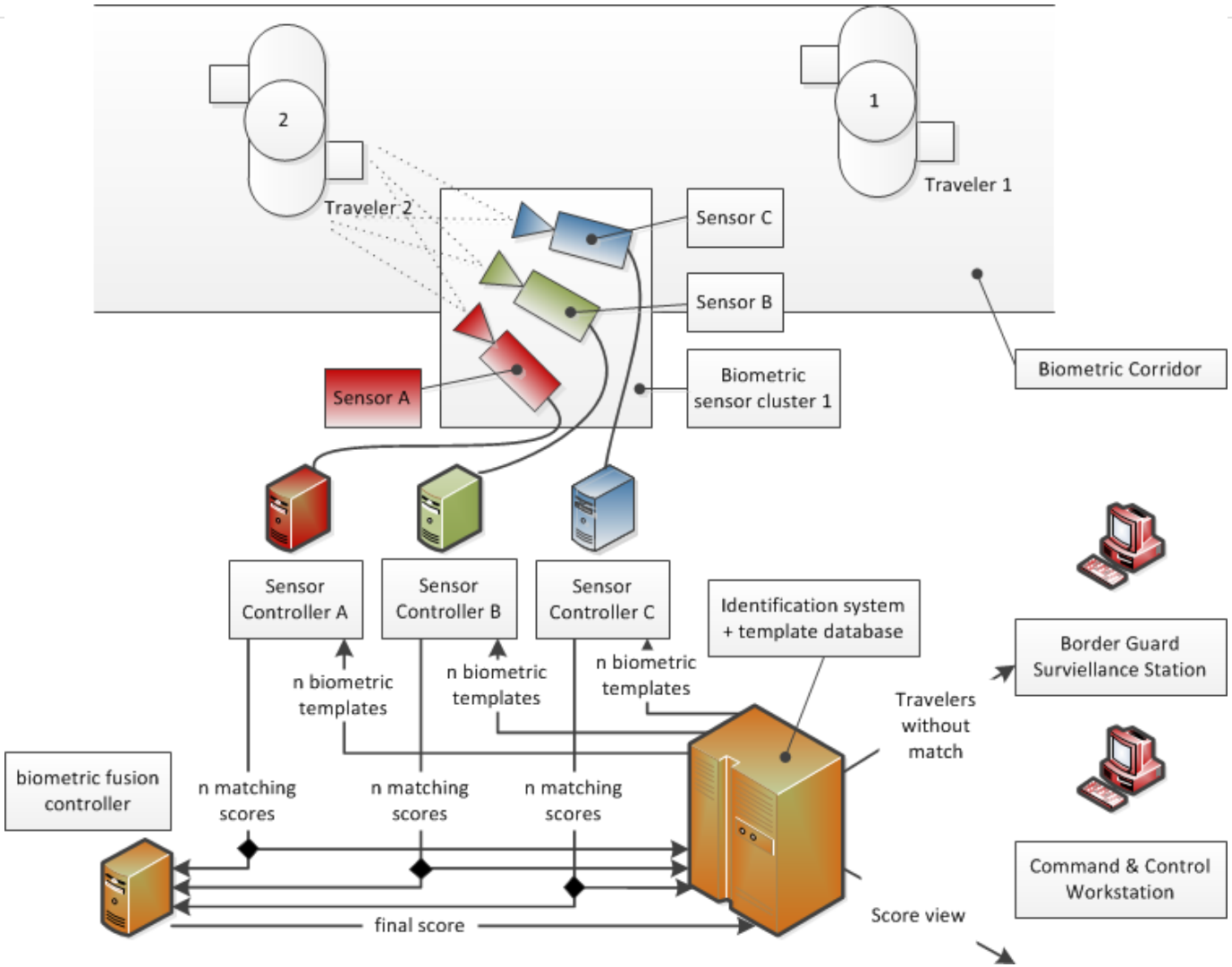
Multimodal biometric fusion



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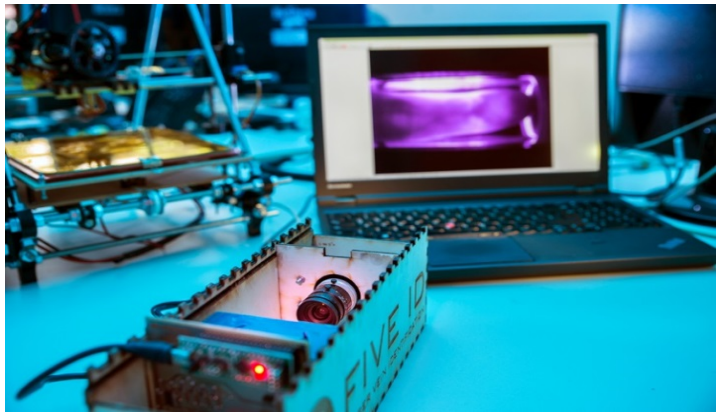
Example biometric innovation

- Hand vein (custom build FiveID sensor)



- Technical Data:
  - Acquisition type: can be made contactless to an extent
- Camera:
  - IDS Imaging UI-1240ML-NIR sensor
  - 9mm wide-angle lens
  - Max resolution of 1280x1024 pixels
  - 8-bit grey scale images
- Illumination:
  - Type: trans-illumination
  - LED: 8x NIR LED 860nm
  - Laser: 6x NIR laser diodes 808nm

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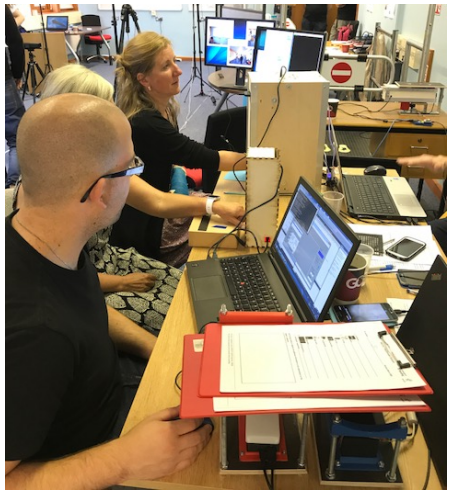
Multimodal data collection

Multimodal data collection

- Took place between 26th-29th June 2017
- Partners participated: UREAD, PLUS, ITTI, EURECOM, WAT, Veridos, IRM



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Multimodal data collection

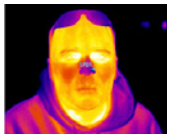

2D Face VIS

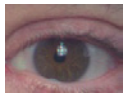
2D Face NIR


2D Periocular VIS


2D Periocular NIR

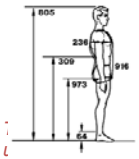

3D Face


Thermal Face


Iris


Finger/hand vein


Voice


Anthropometrics

- Dataset specification:
  - Total: 47 subjects
  - Age: 21 ~ 76
  - Gender: 57% (male), 43% (female)
  - Biometrics: 2D, 3D and thermal face, finger vein, hand vein, iris, and anthropometrics
  - A subset of 20 subjects have been initially released to community

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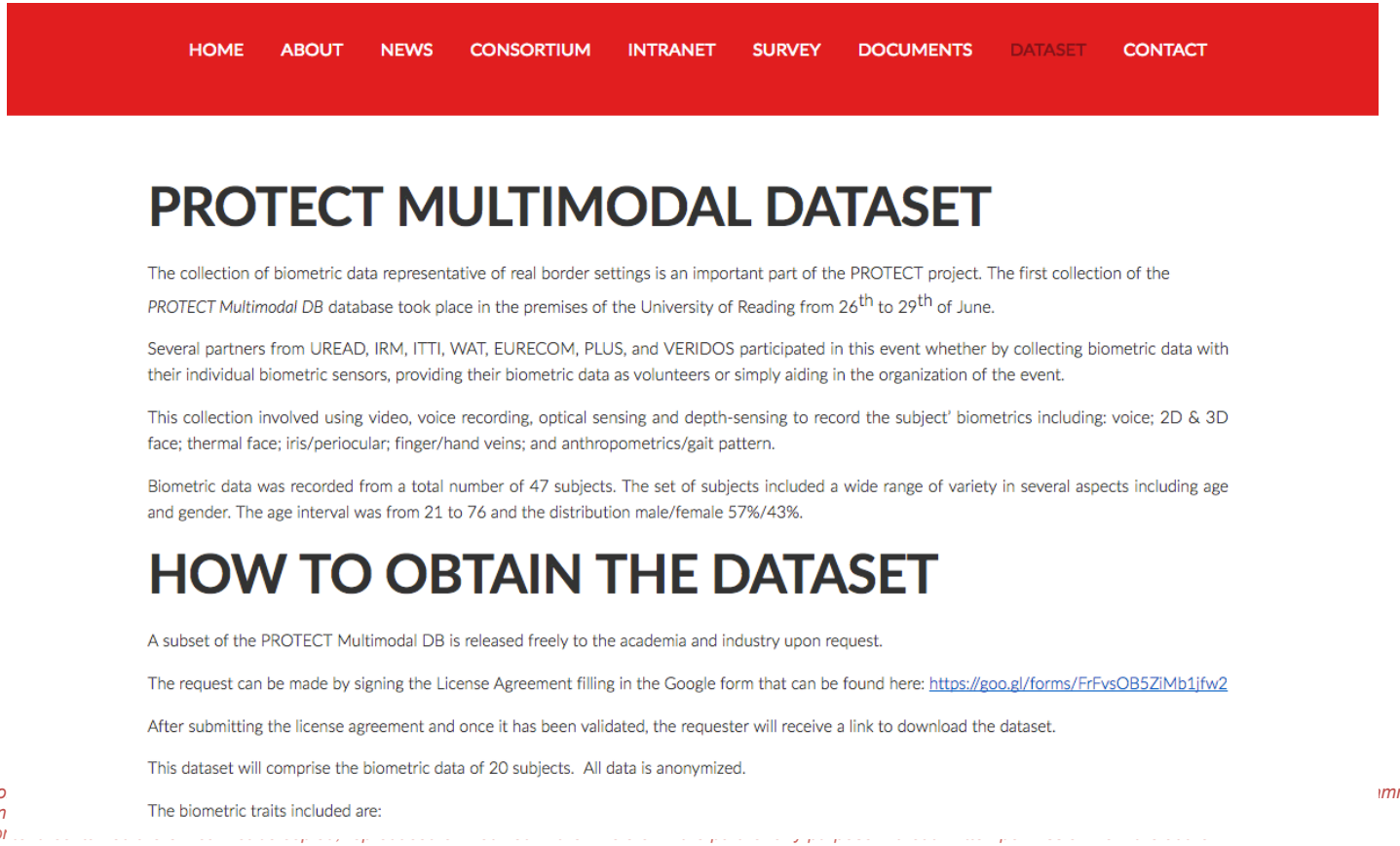
Public multimodal dataset

- Dataset publicly available at www.projectprotect.eu
- Request to access the dataset can be made by signing the License Agreement



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Legal obj. 1: Impact of EU Smart Borders on PROTECT solutions

- In April 2016, the EC decided to :
  - revise its 2013' EES proposal accompanied by a draft amendment of the Schengen Code necessary for its implementation;
  - withdraw its 2013' RTP

Current work is investigating the impact of these new regulatory proposals on the technical solutions developed within PROTECT

Legal obj. 2: Apply GDPR principles to sensors

- Consequences of the General Data Protection Regulation (GDPR) and impacts on sensors, data processing and system architecture.
  - Biometric data is considered as sensitive data.
  - Is it possible to base the legitimacy of the PROTECT biometric processing activities on the consent of travelers for the purpose of "facilitating their lives" (convenience) at borders?
  - Which kind of set of measures could be the best guarantees for privacy-friendly multi-modal biometric solutions?

Many grey areas which are currently under investigation.

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We are not alone

May 2017

A world first: Australia's plan for advanced biometric airport checks

At the start of this year, Australia's border authorities announced an ambitious plan to roll out biometric identification across all their international airports by 2020. In a "world first", international travellers entering the country will be processed via a completely unmanned system that uses fingerprints, iris and facial recognition.

Government of Dubai to develop world's first gate-less border using biometrics and Blockchain

The technology will enable passengers alighting from aircraft to walk straight through to baggage collection without stopping at passport control.

June 2017

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PETS (Performance Evaluation of Tracking and Surveillance)

- 19 (IEEE) sponsored workshops with major conferences since 2000
- Scenario-based
  - published [to academia and industry] benchmark dataset and metrics
  - paper submission with accompanying results
  - submitted results evaluated and published at workshop

PETS 2015 Keynote
AVSS Sep 2015, Karlsruhe, Germany

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- 19 (IEEE) sponsored workshops with major conferences since 2000
- Scenario-based (published dataset, paper submission with accompanying results, submitted results evaluated and published)

- Ref: “Performance evaluation of crowd image analysis using the PETS2009 dataset”. PRL. 2014. DOI: 10.1016/j.patrec.2014.01.005

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PETS 2015

Sensor locations and their FOVs

ID	Model	Resolution (pxl)	Frame Rate
VS_1	Basler BIP2-1300c-dn	1280 x 960	25
VS_2	Basler BIP2-1300c-dn	1280 x 960	15
VS_3	Basler BIP2-1300c-dn	1280 x 960	25
TH_1	FLIR SC655	640x480	25
TH_2	FLIR SC655	640x480	12.5
TH_3	FLIR SC655	640x480	25
TH_4	FLIR A65	640x512	30

Sensor properties: VS: Visual; TH: Thermal

- multimodal multi-sensor dataset addressing the application of multi sensor surveillance to protect critical infrastructure

Scenario type	ID	Description	Challenges
Normal	N1_P5	A vehicle driving across the scene	Scale change; pose change; speed change; clutter
Warning	W1_P5	A group of 6 people walking across the scene	Occlusion; scale change; clutter; speed change
Alarm	A1_P5	An abandoned bag is picked up suspiciously	Scale change; pose change; clutter; speed change

VS_1 VS_2 VS_3

TH_1 TH_2 TH_3 TH_4

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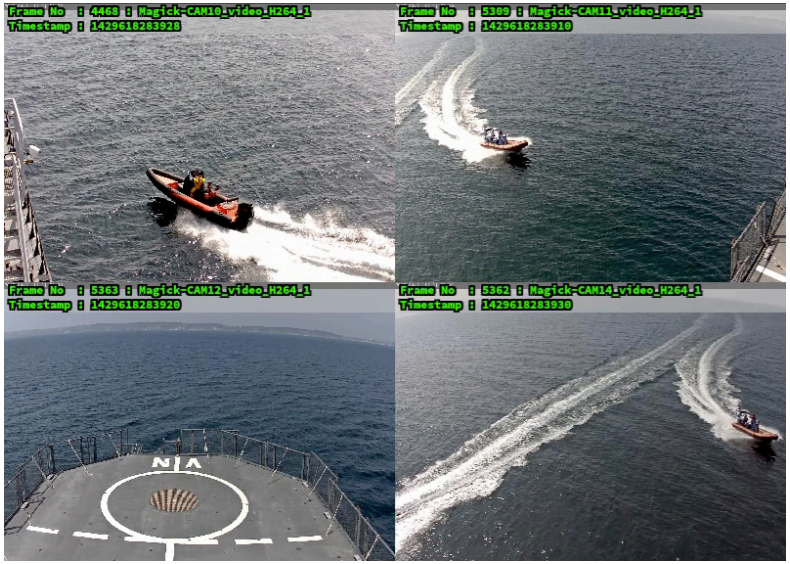
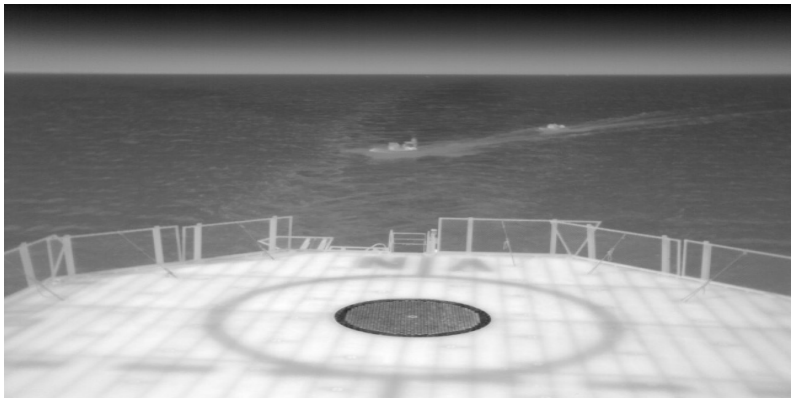
BMTT-PETS 2017

- Includes maritime surveillance dataset with ground-truth annotations (IPATCH project)
- 17 sensors, 59 sequences (TBs of data!)





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Evaluation Landscape

- Many new initiatives since 2000
  - New datasets and annotation means (e.g. Amazon Mechanical Turk)
  - New performance evaluation methodology (including metrics)*
  - Trend towards online evaluation (incl. submission of code)

- VOTS (Visual Object Tracking Challenge) (www.votchallenge.net)
  - Evaluates short term trackers (currently single view)
  - Next workshop in conjunction with ICCV'17 (October)

- Benchmarking Multi-Target Tracking (www.motchallenge.net)
  - Most recent event in collaboration with PETS at CVPR2017
    - BMTT-PETS

*e.g. see: Nawaz, T., Ellis, A. and Ferryman, J. (2017), A method for performance diagnosis and evaluation of video trackers, SIVP. DOI: 10.1007/s11760-017-1086-7

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PETS – Biometrics – Border Security

- Border security is not just biometrics, also includes video surveillance [1].
- 'Tracking' of travellers can be used to reduce complexity of biometric matching from 1:m to 1:few.
  - Also 'identity-aware tracking' where e.g. detected faces are assigned to recovered trajectories of pedestrians [2].
- Also need to consider other evaluation measures, e.g. usability, cost, level of non-intrusiveness, speed, reliability, ... in addition to biometric accuracy and video surveillance (detection, re-id, etc.) performance metrics.

[1] Weissenfeld at el., Security Components in a One-Stop-Shop Border Control System, Proc. IEEE Joint Intelligence and Security Informatics Conference (JISIC), DOI: 10.1109/JISIC.2014.42, 2014.

[2] S-I. Yu, D. Meng, W. Zho, A. Hauptmann, The Solution Path Algorithm for Identity-Aware Multi-Object Tracking, CVPR 2016.

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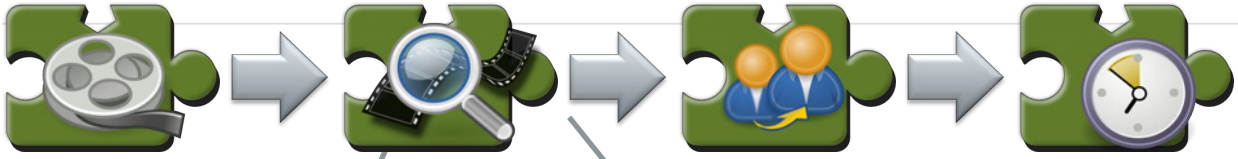
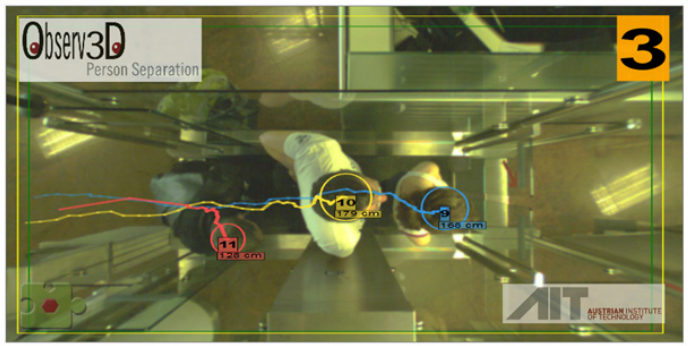
Advanced video surveillance modules



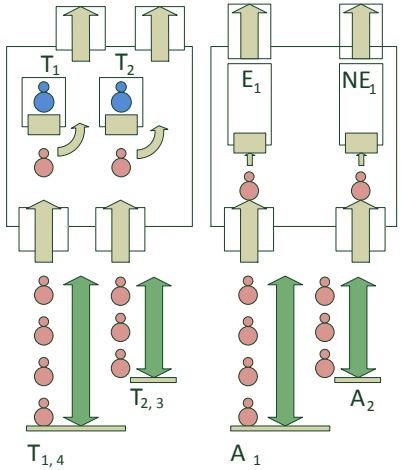
AIT Connected Vision – distributed video surveillance concept/SDK

Module:
- self-descriptive
- independent

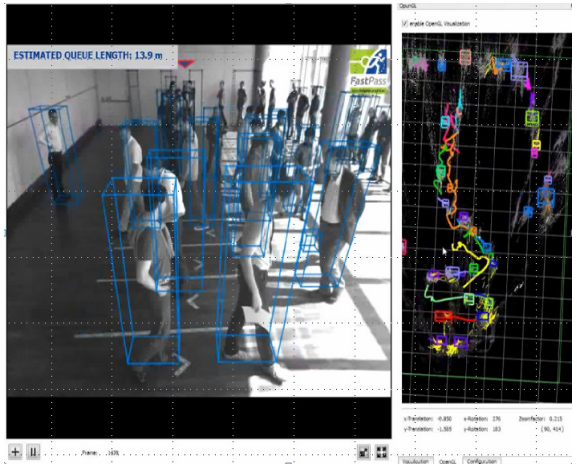
Interface:
- RESTful interface
- JSON encoded



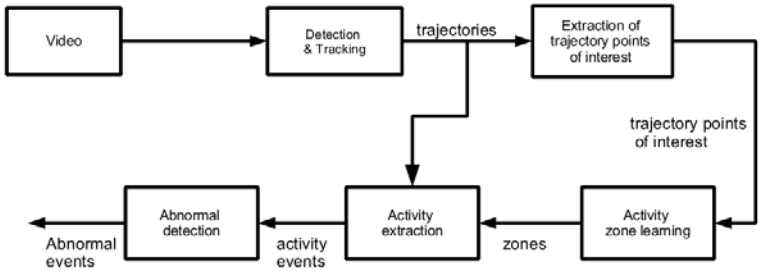
Person separation



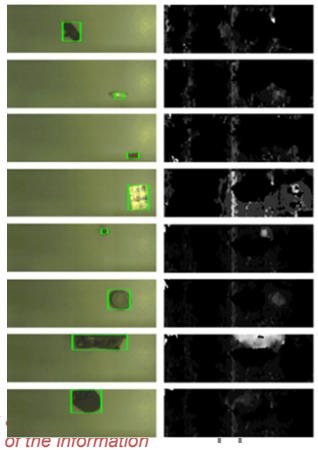
Dynamic queue optimisation



Queue analysis (length, dynamics) to get waiting time



Abnormal behaviour detection



Left luggage detection

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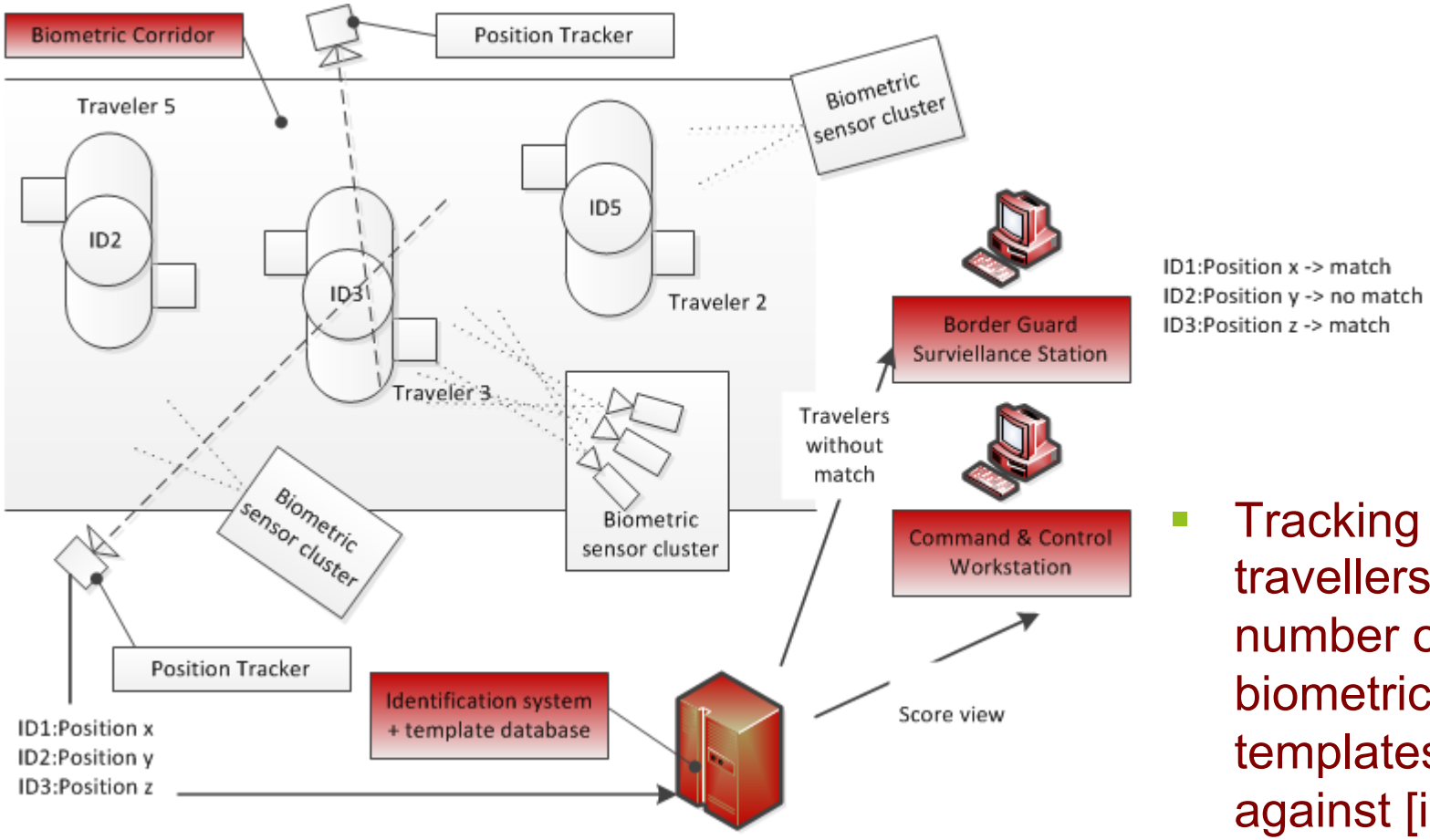
Person tracking



- Tracking of travellers to limit number of biometric templates to match against [in biometric corridor]

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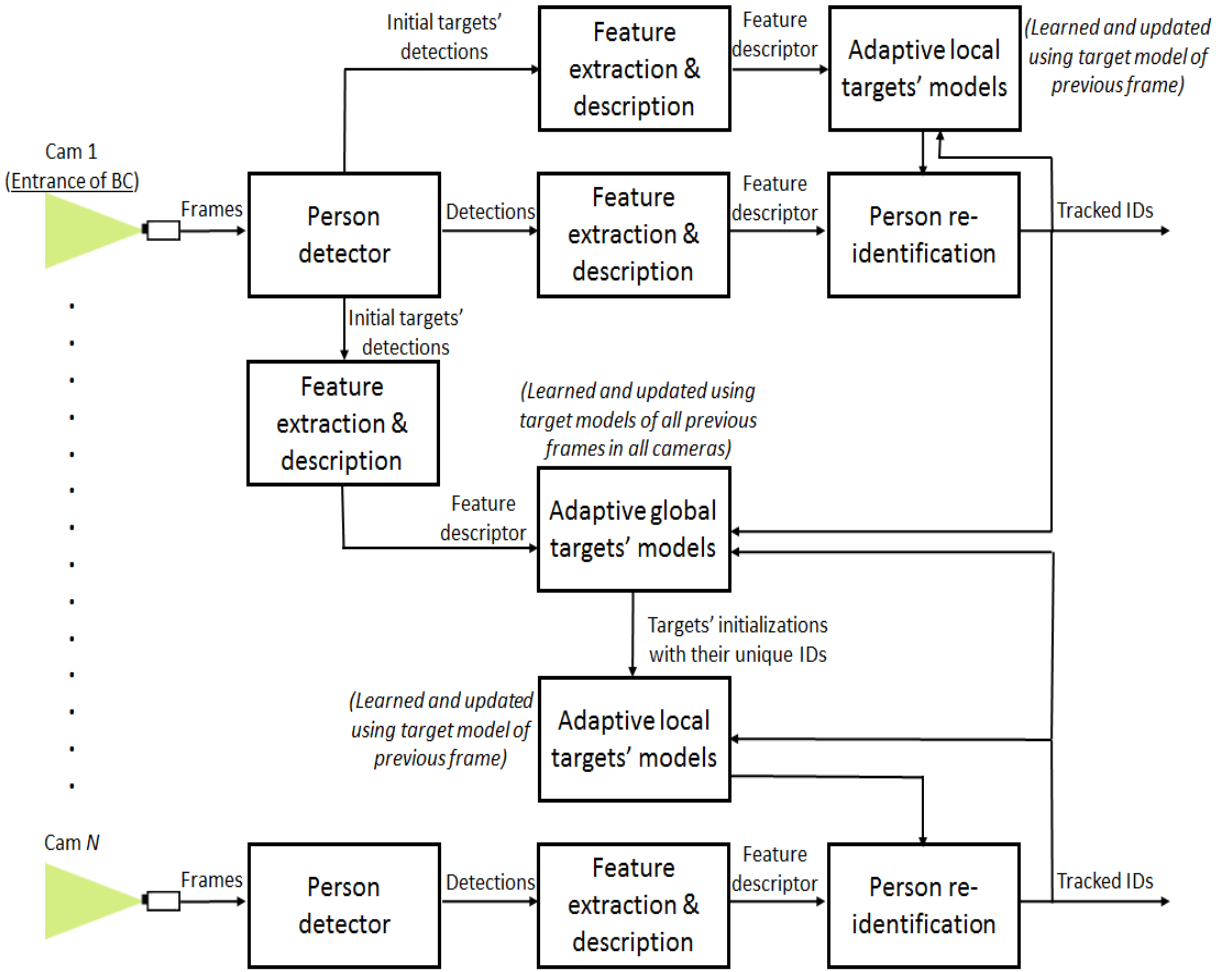
Person tracking via person detection + re-id



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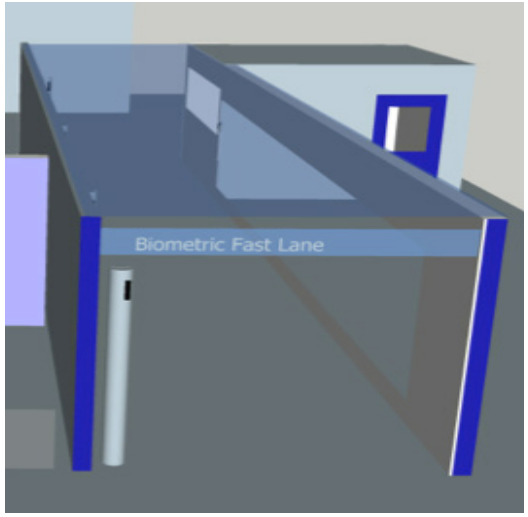

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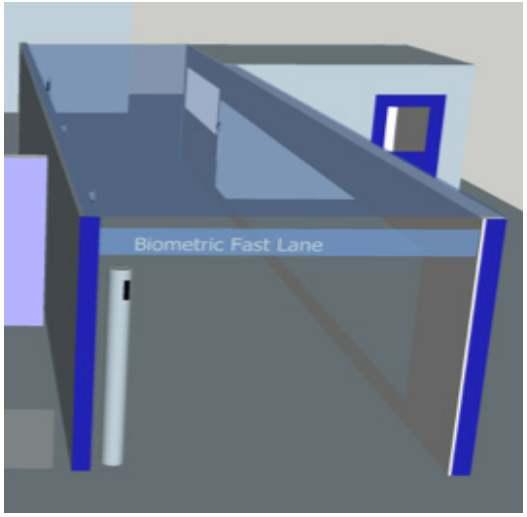
Person re-identification

Tracking of travellers to limit number of biometric templates to match against [in biometric corridor]



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PETS and standards

- Most working groups and developing standards [related to video surveillance] address interoperability of equipment and networks and not performance evaluation measures of analytic software

- Existing efforts towards standards in video analytics (detection, tracking, event detection, behaviour analysis, ...) are still fragmented.

- New efforts are required to specify best practise, specify evaluation methodology for video analytics for specific applications (e.g. border security)

- See: Ferryman, J., Video surveillance standardisation activities, process and roadmap, EC Science Hub, 2017 DOI: 10.2788/92267

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Summary

- FastPass has realized a harmonized set of [biometric] processes for ABC e-gates applicable to land, sea and air borders
- PROTECT is pushing the boundaries of identity confirmation at borders with a contactless biometric on-the-move proposition, incorporating mobile devices/ePassports
  - Minimally cooperative
  - Multimodal with counter spoofing
  - Privacy and security issues
- Evaluation and standardization
  - Biometrics and video surveillance
  - Evaluation measures go beyond recognition
  - Ultimately a harmonized approach to biometrics on-the-move ABC.

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Acknowledgements

- Ana Sequeira
- Lulu Chen
- Tahir Nawaz
- Luis Patino
- Jonathan Boyle

- Peter Wild
- Petru Radu
- Lulu Chen
- Luis Patino

PETS

- Luis Patino
- Longzhen Li
- Anna Ellis
- Tahir Nawaz
- Tom Cane

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Thank you

www.fastpass-project.eu
www.projectprotect.eu

james@computer.org

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