Document Name	**Lantern Technical Options Paper:** **Evaluation of Fingerprint Sensor Technologies**
File Name	**Suppliers' Version** 0.1 DRAFT
Author	Ambika Suman Biometric Technologies Manager

Authorisation	
Signed version held by	

© NPIA (National Policing Improvement Agency) 2008

Table of Contents

Controlling documents

This section contains references to source material used in the preparation of the document.

Description	Document Name and number	Revision
Sensor Technology Review	IDT004-0101-Lantern Sensor Review-V1_0-108-101-LANT-102.doc	1.0 14th June 2007
NPL Biometric Test Guideline reports	ISO Best Practice Guidelines in Biometric Testing Methods	2000
Archived Documents	IDENT1 ITT Benchmark Test Design Strategy – Ambika Suman	September 2002
Archived Documents	IDENT1 ITT Benchmark Test Results Strategy – Ambika Suman	September 2002
Archived Documents	Project Skiddaw Test designs documents and procedures, PSDB (HOSDB)	2005
Publications	Benchmarking Operational Search Accuracy - SPIE Defence and Security Journal, September 2005, Ambika Suman, Geoff Whitaker	2005
Publications	Handbook of Fingerprint Recognition, Springer , 2nd Edition	2004
Workshops	NIST Mobile ID Workshop, FBI presentations, Tom Hopper	Aug 2007

Executive Summary

During the course of the Lantern Project there has been ongoing debate over the benefits of using capacitive sensor based devices in addition to optical based devices for fingerprint capture. To date there is currently no published data that can be used to inform this decision. Recently the NPIA has obtained ownership of Project Roman devices – these are similar to currently deployed Lantern units but capacitive based. Furthermore, the sensors used in them are the only type currently accepted as PIV certified, which is a reduced version of the appendix F compliance standard that is a mandatory requirement for sensors/devices used for searching police fingerprint systems.

The NPIA Biometrics team has been tasked with formulating a set of options for the Lantern project on how to perform an operational evaluation to compare optical and capacitive sensor technologies for police use by exploiting the availability of the optical based Lantern devices and the PIV certified capacitive based Project Roman mobile devices.

It is envisaged that the devices can be deployed operationally for side by side use with the Lantern units. For every individual stopped their fingerprints would be captured on both devices for searching on IDENT1, thereby providing opportunity to compare the search outputs and accuracy for the two technologies.

To evaluate the search performance of fingerprint images from currently deployed capacitive sensor and optical sensor technology it is recommended that the Lantern team perform operational tests during a period of dual operation of the devices for capture. Searching would be performed offline, however, searches on Lantern would continue as normal. In addition to this, a set of controlled tests would also performed with a group of volunteers (NPIA staff or Police officers) to assess the factors that cannot be observed or controlled in operation such as environmental factors, physical robustness of sensors, usability and so forth.

Finally, it is strongly recommended that in addition to testing the devices, a questionnaire or feedback exercise is conducted to note other observations that cannot be tested for. In particular, aspects around Usability such as the finger placement, pressure, sensor position, search time and response cannot be observed independently but are nonetheless important to the findings of the evaluation. The type of user feedback will vary across operational and controlled tests; therefore, feedback from an operational trial would provide the most information that is relevant and reflective of genuine end users' experience.

Introduction

1.1 Document Purpose

This document will be used to report to the Lantern Project Team on the technical issues of evaluating the performance of fingerprints searches from mobile devices that are currently deployed within the police service.

The work will form part of the material disclosed to the Lantern Project Board to provide a set of recommendations for the best way forward to evaluate the performance of remote fingerprint searches on IDENT1.

1.2 Background

1.2.1 Lantern and the debate on options for the choice of Fingerprint Sensor Technology

There has been ongoing debate, both within the Lantern Project team and amongst the vendor community, on the performance of Optical versus Capacitive sensors for capturing fingerprints for searching against large database collections such as IDENT1.

Until recently it has been widely accepted that Optical and mutli-spectral[1] sensors have generally demonstrated better image capture quality (often obtaining prints from subjects with very poor fingerprints), as well as greater robustness to the environmental factors that affect the performance of sensors. Furthermore, capacitive sensors do not meet the requirements for certification of compliance to the FBI Appendix F standard, whereas optical sensors do which has also driven the preference for optical sensors by the police community. The main downside to Optical sensors has been the limitation in size to which these may be reduced to.

For many vendors, the use of capacitive sensor has often been the preferred choice. This is mainly driven from a need to minimise costs and make the devices as light and mobile as possible. Recent years have shown that capacitive sensors

---

[1] As with optical, multispectral sensors also use light refraction and absorption to detect a fingerprint pattern from the ridges and ridge valleys. Multispectral technology is more commonly used in ten print sensors such as Livescan.

technology has developed significantly whilst AFIS technology has improved too, such that it may be acceptable to search images from capacitive sensors with modern AFIS technology, and still achieve a desired level of performance for search accuracy.

Whilst evaluation of optical sensors is widely documented there has not been any formal evaluation (or published best practice guidelines) for testing capacitive sensors. More specifically, there is no data on the performance of automated fingerprint recognition technologies that can be used to compare optical and capacitive sensor technologies.

The Lantern project team has been looking to address this debate for several reasons:

- For performance and compliance to Appendix F, the preferred choice for Lantern (the proof of concept study) was to use optical sensor technology. Whilst it is accepted that the model of the Lantern device that is currently rolled out is not the final solution, concern has been raised over its size which does not meet the police service requirements.

- Forces are pushing to minimise the number of devices and items that an officer needs to carry and opt for lightweight, compact and multipurpose solutions. Currently, mobile devices that are designed as such will most likely be based on capacitive sensor technology.

- The cost of capacitive sensors is significantly less than optical sensors in which case capacitive solutions may provide be better value for money in terms of meeting the overall requirements.

- The Lantern Project has received a vast amount of positive publicity both in the media and amongst forces. There is increasing pressure on the NPIA (indeed the Lantern Team) to advise the police service on accepted technologies for use with IDENT1, as a number of forces look to buy mobile fingerprint capture devices. The NPIA is not yet in a position to provide this advice. To do so it must perform formal technical evaluation/benchmark of the technologies on the market assessing search accuracy performance, security and interface requirements, in addition to a number of other factors that would determine the suitability of devices for operational use with IDENT1.

- It is envisaged that NPIA will need to perform an accreditation exercise of devices that would be acceptable for use by the police. This involves

performing benchmark as described above. It will form the basis for establishing framework agreements with the vendor community to both drive the market forward and ensure best value for money, should Lantern as project move towards national roll out of the capability.

- For the purpose of performance (and to avoid being limited to any single vendor) the preferred choice for Lantern is to submit the finger image[2] record as opposed to the finger minutiae[3]. The former is thus a larger file and in order to meet security requirements transmission is limited to SRAS over GPRS. The use of capacitive technology may result in smaller image files as these would be binary, black and white images, as opposed to greyscale images captured from optical sensors. This would suggest that the devices may therefore be used in conjunction with Airwave, which would be a favourable option in terms of using existing police infrastructure and services.[4]

1.2.2 Project Roman

Project Roman is a technology trial involving the roll out of 100 handheld mobile data application devices which replaces traditional bulky forms and eliminates manual paper processes. Designed for local police officers, it enables them to complete any form (such as Stop and Search or Fixed Penalty Notice) on any handheld device, including the O2 XDA. The devices provided by Helimedia allow officers to collect information accurately and efficiently and then link this data electronically to the force's central information and ticket processing systems.

Access to the data on the devices is secured by fingerprint biometric authentication combined with smart card, encryption and Pin number. The devices are fitted with a smart card reader and a UPEK capacitive sensor.

The NPIA now has control (ownership) of these devices and thus provides the Lantern team with the opportunity to perform a side by side comparison of search performance of fingerprint matching for optical and capacitive sensor technology by evaluating the Lantern and Project Roman devices.

Note that whilst the Helimedia, UPEK sensor is only one type of capacitive technology it is not representative of capacitive sensors in general. However, it is

---

[2] ANSI NIST ITL 1A -1997 Type 7 records – Fingerprint Image Data (user defined)

[3] ANSI NIST ITL 1A -1997 Type 9 records – Minutiae Data

[4] Airwave – Police Digital Radio Communication devices currently based on Tetra technology. Bandwidth restrictions mean that images from Lantern are too large to be transmitted over Airwave.

currently the only model of capacitive sensor that meets the FBI PIV standard for single fingerprint scanners (a diluted version of appendix F compliance); thereby it is the only type of capacitive sensor that can be used by the police with AFIS. Therefore, evaluating Optical sensor technology used by Lantern with sensor technology on the project Roman devices is valid way forward to address this issue.

1.3   Other Fingerprint Sensor Technologies

In addition to capacitive and optical sensors there are numerous other fingerprint sensor technologies such as finger swipe, thermal, sub-dermal multispectral (including contactless capture sensors which are still at an R&D stage).

This report excludes any detail description on fingerprint sensor technology as this is widely documented both in published journals and in the Lantern Report "IDT004-0101-Lantern Sensor Review-V1_0-108-101-LANT-102.doc, June 2007" which documents a review of fingerprint sensor technologies.

1.4   The Task for the NPIA Biometrics team

The NPIA Biometrics team has been tasked with formulating a set of options for the Lantern project on how to perform an operational evaluation to compare optical and capacitive sensor technologies by exploiting the availability of the Lantern and Project Roman mobile devices.

It is envisaged that the devices can be deployed operationally for side by side use with the Lantern units. For every individual stopped their fingerprints would be captured on both devices for searching on IDENT1, thereby providing opportunity to compare the two technologies.

No decision has yet been made on whether the images from the Project Roman device should be searched in real time or offline. It is assumed that the preference is to perform an operational test on live subjects; however, certain factors may only be determined by testing in a controlled environment.

The following sections of the report explore the issues to consider in comparing these factors followed by options for performing live operational tests, operational capture with offline searching and controlled testing.

2 Evaluation of Optical Vs Capacitive Sensors

2.1 Test Purpose and Scope

The scope and purpose of this evaluation **is limited to:**

- a comparison of the search accuracy performance of fingerprints from optical and capacitive sensors used on currently deployed technology - that is, the Lantern and Project Roman devices.

The scope and purpose of this evaluation **will NOT include:**

- an exhaustive benchmark of fingerprint capture methods, fingerprint sensors or vendors
- an evaluation of any other functionality enabled on the devices.

2.2 Test Factors to Consider

Listed below are factors that affect search accuracy performance and thus should be considered in the design of the test. For each of these factors one must decide if they fall within a "white" or "black" box. Factors that must be controlled will be referred to as "White box" factors. Those that are considered to be operational variables, thus not controlled in the test, are referred to as "black box" factors.

Certain factors within the white box will not be controllable in an operational test yet have to be accounted for in order to draw valid conclusions from the evaluation. In these cases controlled tests may be required too.

Black Box Factors	Examples
These factors are not assessed as part of the test as they are operational variables that cannot or need not be controlled	Live Enrolment Type of Subjects Usability – Finger Placement, Pressure, Positioning
These factors vary with operation yet it is important to understand the affect that these have on performance. However, these can only be assessed under controlled conditions. Therefore, for operational testing these are within the Black box. For controlled tests these are white box factors.	Environmental Factors – heat, humidity, sunlight, debris Physical Robustness of sensor – prolonged use, scratches, battery life etc
These factors are out of scope of the operational tests but can be assessed by post processing of the results after the tests.	Spurious Minutiae, Size and Weight, Use of NFIQ, Number of Capture Attempts, Sensor Area, File Size, HCI feedback and other user interface features and Cost.
White Box Factors	**Examples**

These are factors that need to be observed and assessed and can be controlled without compromising the operational integrity of the tests and results obtained.	Same subjects enrolled for each device
	Number of subjects, Habituation of use, Fingerprint Image quality

2.2.1 Live / Physical Test Subjects:

The fingerprint images from the mobile devices will require capture from live subjects. The subject's fingerprints will have to be captured on each device in order to draw direct comparison of the searches between the two.

For an operational trial the devices will have to be deployed together and for each person stopped they will have to capture their fingerprints on both the Lantern and Project Roman devices.

2.2.2 Number of Subjects:

Albeit an operational trial, or a controlled test there is a limitation to the number of subjects that data can be obtained from. The number of subjects will either impact on, or be limited to, the duration of the operational trial. An estimated 1000 searches are submitted over Lantern per month. A reasonable test sample size is usually 10% of the population, or in this case 100 candidates to compare the searches from the two technologies. However, there are a number of other factors that require observation, thus a large set is required to ensure a sufficient number of instances for each factor can be observed in order to draw statistically valid conclusions. Therefore, it is recommended that a target of 500 subjects should be set as test sample data size.

2.2.3 Habituation of Use – Order of Capture on Device:

Having used a fingerprint sensor once, it is generally easier to provide a fingerprint image with each additional attempt. The quality of the image provided is likely to be better as a result of habituation of the user. For example, the positioning of the finger, the pressure applied on the sensor, etc. will affect the quality of the image captured by the sensor. Therefore, the order in which the devices are used should be controlled. Half of the subjects should have enrolled on the Project Roman unit first and the Lantern second. The remaining subjects should be enrolled in the reverse order.

2.2.4 Environmental Factors:

The conditions of the operational environment may affect the capacitive sensor. Factors such as temperature from the battery/charger heat, humidity, sunlight, dirt on the platen, are known to affect both optical and capacitive sensors - the latter are thought to be more vulnerable to these factors.

One can argue that they are part of the black box as they are operational factors but the impact on accuracy that these have may be significant and thus should be tested for. This may form part of a separate test performed in controlled conditions.

2.2.5 Physical Robustness:

Over the course of time both optical and capacitive sensors will be affected by wear and tear. Scratches or build up of residue on the platen surface, prolonged or continual use, dropping the device and continual recharging are some of the factors that will affect the performance of both the device overall as well as the sensors.

Once again with environmental factors these too are operational factors and cannot be individually accounted for in an operational trial. Testing for these factors is well documented for optical sensors but not so for capacitive sensors; therefore, some investigation into the factors that result from wear and tear should be performed. As many of these factors are unknown for capacitive sensors they can be observed and noted during an operational trial and replicated for subsequent assessment under controlled conditions.

2.2.6 Usability:

Usability impacts both operational performance and the choice of device. However, the sensor is just one aspect of usability that must be accounted for. The scope of these assessments are limited to the sensor and fingerprint capture and thus the factors listed below are a subset of a much larger group of usability issues that ideally would be considered in an assessment of such devices:

- Finger Pressure – The degree of pressure required when placing one's finger on the sensor. -

According to the best practice guidelines from the NIST Mobile Data Group, a key requirement for the FBI is for the device to be usable and held with one hand, to ensure the other is free. Having to apply significant pressure to the device to obtain a fingerprint image is not only unacceptable operationally but it may also result in the officer having to support the device using both hands.

- Capture time and number of attempts required–

There is often a delay between the placement of one's finger on the platen and the sensor reading, the display of the fingerprint and instruction for the next finger to be placed. This often results in one lifting their finger off the sensor too early or applying pressure at the wrong time. Inevitably this will affect the number of attempts required to capture a usable fingerprint which in turn may frustrate the users.

- The Position of the sensor on the device –

Whilst this is a design consideration, the position of the sensor on the device affects the placement of the finger and in turn the quality of the image. It is worth noting any observation on this to inform best practice on using the devices.

- Size and weight of the device –

Size, shape and weight are linked with other factors such as the amount of pressure applied on the device, whether it can be supported by one hand etc. However, in this test the size of each device is fixed. Nonetheless, observations on user preference are worth noting.

- Sensor Area –

Capacitive sensors generally have a smaller sensor area than optical sensors. Whilst this helps keeps the device compact it is also a current limitation in the design of capacitive sensors which have an upper limit in size. The UPEK sensor has a large area in comparison to others in its genre. The sensor size is an important factor as it affects how users position their finger on the platen which in turn significantly affects search performance.

A large sensor area allows for more ridge detail to be captured (or multiple fingers for optical)[5] but it also introduces variation in the positioning and orientation. Smaller sensor areas confine the position of the fingerprint but may result in a lot of detail not being captured in the peripheral areas. If the subject's fingerprints are larger than the sensor region then a significant amount of data is not captured and thus affects the search accuracy.

Optical sensor region
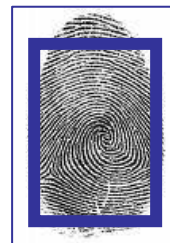
Smaller capacitive sensor, crops fingerprint image

---

[5] Optical sensors can support multiple (sequential) fingerprint capture which is beneficial as it avoids errors the wrong finger being captured and so forth. The design of capacitive sensors is limited to single finger but this is likely to change as the market evolves.

The sensor size for each device is a fixed. Therefore, it is a black box factor for the scope of this test. However, this can be assessed offline by storing and retrieving the captured images for analysis by experts at a later point in time.

2.2.7 Measuring Fingerprint Image Quality and its Variation Between Devices -

Fingerprint image quality will vary between the devices and individuals. Image Quality is crucial to the performance of the search and thus must be scrutinized closely in comparing the images from the UPEK capacitive sensor and the optical sensor. Where a trade off for cost and size is to be made against image quality then one must ascertain the difference in fingerprint quality that is obtained from the two sensor types. To measure this factor a sufficient number of fingerprints from subjects must be captured to ensure a good range of varying qualities are obtained such that it is reflective of the operational population. In addition, a method of measuring image quality between the two devices is required too. The NIST Fingerprint Image Quality Score[6] should therefore be used as a quality indicator for measuring and comparing the images from each device.

2.2.8 Use of NFIQ to Aid/Inform the Capture and Search Algorithm

The Lantern devices are currently designed to return a (NFIQ) quality measure to provide feedback to the operator on the quality of the subjects fingerprint captured. This quality indicator is used by the operator to decide on whether or not to recapture the subject's fingerprints.

In order to perform a fair and level comparison between two technologies the process should be duplicated for the project Roman devices too, thereby ensuring repeatability and operational integrity.

Where this is not possible, an alternative approach would be to capture (3 per device) multiple images using the capacitive sensor and save them for offline searching. NFIQ can be applied to the images offline and for each subject the first image with an acceptable image quality score (or the highest score for subjects who do not provide sufficiently good fingerprint images) would be used for the search. This requires a quality acceptance threshold to be determined as part of

---

[6] NFIQ – NIST Fingerprint Image Quality Score – this is a standardised quality scoring system developed by the National Institute of Standards and Technology for measuring the quality of a fingerprint image.

the test. Having captured the fingerprint images these must be saved together with a subject identifier, the order of their capture (capture attempt number).

Alternatively, the test can be repeated with a second group of subjects in a controlled environment where only a single attempt to capture the fingerprint image is permitted for each device.

Note if the test is performed within a real environment for operational reasons it would be not be acceptable to limit the number attempts to capture fingerprints on the Lantern devices. This can only be done under controlled conditions.

2.2.9 Number of Minutiae & Spurious Minutiae[7]

The number of minutiae detected and visible within the image is an important factor in terms of the sensor performance and as a measure of image quality. However, the minutia count alone is not enough as some of these may be spurious minutia resulting from the capture method, the encoding of the image and artefacts on the sensor. The presence of spurious minutia will adversely affect search performance and thus should be considered as a factor for comparison between the sensor technologies.

In order to assess this factor it must be possible to retrieve the captured images either from the devices or from IDENT1 such that they can be viewed and analysed offline by fingerprint experts. Inevitably this implies a resource and cost overhead on the suppliers involved and the availability of fingerprint experts to assist on the tests.

2.2.10 File size

Fingerprint image files from capacitive sensors are binary B/W images and thus their file sizes could potentially be much smaller in comparison to optical sensors which output greyscale images. This may be better for transmission times, the throughput of searches and the amount of data that can be transmitted. It may also suggest that data would be transferrable by means other than GPRS – i.e. Airwave could also be considered as an option. The file sizes should also be recorded and compared between the devices.

---

[7] Spurious minutiae – false minutiae points picked up in the fingerprint image as a result of digital artefacts introduced by the sensor method, state of the sensor platen, the physical state of the donor's finger that is scanned, and the other operational factors that affect the image that is captured and observed.

2.2.11 Out of Scope of the Test

Cost – the cost is not a technical factor of the test but may be used by the team as an evaluative factor between the two sensor types.

SRAS of GPRS connectivity – both the devices would operate over SRAS and GPRS. This is an operational or implementation factor and thus part of the black box.

2.2.12 Other Factors to Consider in evaluation but not testable

Weight and size –

This is fixed and notable.

Battery Life –

This can be observed but it is a black box or operational factor. The battery life of the device is attributable to the overall functionality of the device as opposed to the sensor alone.

User Interface and other HCI Factors of the devices –

The design of the user interface, toolsets, look and feel and the general design of the device fall under Usability. Whilst these factors can be observed and taken into consideration they attributable to the specific device functionality which is not within the scope of the evaluation. It would be advisable nonetheless to use this opportunity to obtain feedback to see whether any design features have an effect on search performance. A Feedback questionnaire would be an appropriate method of capturing this information from operators.

2.3   Other Issues to Consider in the Test Design and Execution

2.3.1   Results Data and Analysis Strategy –

Based on the test factors as detailed in section 2.2 a number of observations will be made on factors that may affect the search performance. The factors that will be observed and measured, together with data that is required from the tests to observe these factors must be defined in a Results Data Strategy Document. This document should also define how the format of any data output from IDENT1 or the devices themselves.

2.3.2   Matcher Scores

Unlike most fingerprint searches on IDENT1, only the top most position is regarded as a hit. In order to compare the quality of the matches returned at position 1 the (matcher scores and NFIQ scores) are required for both the returned match at position 1 and the next two/three respondents. Good separation between the match scores has a positive effect on accuracy and scales as the search and database capacity increases.

2.3.3 Fingerprint expert intervention to analyse images –

Earlier in section 2.2 a number of factors such as Spurious Minutiae were highlighted a number of factors that require analysis. However, to do so requires both access to the images already captured and the resource of fingerprint experts to view and analyse images.

2.3.4 FAR and FRR – Determine Ground Truth

The nature of mobile fingerprint searching means that there is trade off in accuracy expected. There is a genuine risk that returned information on the Lantern and Project Roman devices may not always agree. Lantern currently operates at False Accept Rate and False Reject Rate as defined by the business. Where matches are found on Lantern they are verified by a full ten print check via Livescan in custody. Therefore, not all the searches submitted via Lantern will have a match in the database or can be guaranteed to be true. A Ground Truth has to be established in order to compare the searches from the two devices.

This is where offline searching and/or controlled testing would be a preferred option.

2.4 Test Options

The following is a list of options for performing the tests. Two operational options are given in addition to a controlled option as an alternative.

2.4.1 Option 1: Operational Tests – Live Capture and Search

This option involves an end to end operational test where the two devices are deployed together. For each subject whose fingerprints are searched their prints will be captured on both the Lantern and the Project Roman device. The searches are both launched on IDENT1 and returned and compared.

For this option an interface for both devices will be required on IDENT1.

The results will have to be stored for offline analysis in addition to other test data that must be captured.

There is a risk that the results returned to each device may not agree. Operationally this is unacceptable for the police user who must act on the basis of these results. Furthermore, where results conflict often then users will lose confidence in using the devices. As an alternative results of the searches should be returned to one device only – i.e. Lantern.

2.4.2 Option 2: Operational Tests – Live Capture and Offline Search

As in Option 1, this also involves performing an operational test where the two devices are deployed together. For each subject whose fingerprints are searched their prints will be captured on both the Lantern and the Project Roman device. The searches are both launched on IDENT1 but operational information will only be returned to one device. Alternatively, only Lantern is used as an operational search and the data from both Lantern and Project Roman are stored for offline search and analysis.

For this option one would have to keep both the images and search details for prolonged period of time. Therefore, one must check whether this is enabled under the current legislative clauses for use and acquisition of the data.

Sufficient number of subjects – the trial can continue until a sufficient number of (verified) known matches are found through Lantern.

Only Lantern would be used operationally which avoids the issue around conflicting search results from each device.

2.4.3 Additional Option 1: Controlled Test Environment – repeated live dual capture and search

Ideally for this trial in order to ascertain a best estimate for the expected accuracy of using capacitive sensor over optical technology, an operational trial would be the best option. However, there are certain factors that cannot be accounted for through operational testing but are fundamental to understand. Some of these factors can be controls placed on the operational trial but for many factors the only way to evaluate them accurately is by controlled testing.

This would involve gathering a group of volunteers from whom fingerprint images on both devices would be captured, repeatedly and under controlled conditions. Factors such as environment, sensor condition, usability as described in section "2.3   Test Factors to Consider" can only be evaluated in this way.

3 Summary of Options

The following table is summary of options and a check list of factors that can be explored under each of them

Test Factors to Consider		Operational Tests			Controlled Tests		Importance
		Prison	Public Event/Location	Period of dual operation	Police Volunteers	NPIA Staff volunteers	HML
Subjects	Can we capture fingerprints from live subjects or volunteers?	Yes	Yes	Yes	Yes	Yes	H
	How many subjects would be have their fingerprints captured on the devices?	cc 100 per day	cc 200-300 per day/ event	If only use a couple of units ~ 200 per month If use all units ~ 1000 searches per month	50 per day	10 - 20 per day	H
	How many of these subjects are likely to have a record on IDENT1?	All	Unknown,	Unknown	All	None	H
Ground Truth	Will there be a ground truth?	Yes	No	No	Yes	Only if they are enrolled	H
	How many ground truth pairs are required for comparing the accuracy alone?	min 100 + 50 as contingency	min 100 + 50 as contingency	min 100 + 50 as contingency	200 + 50 as contingency	100 including a contingency	H
	Can we guarantee to get enough throughput to determine a ground thruth for comparing accuracy?	Yes	No	No	Yes	? - but we can send out a request for interest	H
Habituation of Use	Can we control the order of capture on the devices?	Yes	Yes	Yes	Yes	Yes	H

Environmental Factors	Can we assess the effects of Prolonged Sunlight?	No	No	No	No	Yes	H
	Can we assess the effects of Humidity?	No	No	No	Yes	Yes	M
	Can we assess the effects of Dirt on the Platen?	No	No	No	Yes	Yes	H
	Can we assess the effects of Rain/wet conditions?	No	No	No	Yes	Yes	H
	Can we assess the effects of Prolongued use?	No	No	No	Yes	Yes	H
	Can we assess the effects of Prolongued Battery Use?	No	No	No	Yes	Yes	H
	Can we assess the effects of Temperature?	No	No	No	Yes	Yes	H
Physical Robustness?	Can we assess the effects of sensor wear - scratches etc?	?- we can degrade the sensors in certain ways before subjects fingerprints are captured	No	No	Yes	Yes	H
	Can we assess the effects of handling the device	Yes	No	No	Yes	Yes	H
Image Quality	Can we assess the variation in image quality from each device such that it is operationally reflective of the user population?	Yes	Yes	Yes	No	No	H
NFIQ	Can we control the number attempts required to capture a image of a desired level of NFIQ quality?	? Must be able to save images and put in place a process rules around searching that allows for this to be measured fairly.	? Must be able to save images and put in place a process rules around searching that allows for this to be measured fairly.	? Must be able to save images and put in place a process rules around searching that allows for this to be measured fairly.	Yes	Yes	H
Access to Images	Can we retain the captured images for offline analysis?	?	?	?	Yes	Yes	H

		? Only if we have access to the images	? Only if we have access to the images	? Only if we have access to the images			
Spurrious Minutiae	Can we measure the spurrious minutiae count?				Yes	Yes	H
Usability	Can we observe the number of attempt required by the user for their fingerprints are captured correctly - capture delay, timeout etc	Yes	Yes	Yes	Yes	Yes	H
	Finger Pressure	No	No	No	Yes	Yes	M
	Finger Positioning	No	No	No	Yes	Yes	M
	Sensor Area	Yes	Yes	Yes	Yes	Yes	H
	Single Hand Support	Yes	?	?	Yes	Yes	H
File size	Can we measure the affects of the file size and transmission times?	Yes	Yes	Yes	Yes	Yes	M
HCI Look and feel	Can we get operational feedback on usability?	Yes	Yes	Yes	No	No	H
Expert intervention Operational End User Feedback	Can we get experts to assess the images?	Yes	Yes	Yes	Yes	Yes	H
	Will the general feedback from end users be sufficiently reflective of operational end users?	Yes	Yes	Yes	No	No	H

4 Recommended Option

To evaluate the search performance of fingerprint images from currently deployed capacitive sensor and optical sensor technology it is recommended that the Lantern team choose Option 2: Operational Tests with Live Capture and Offline Searching.

Ideally searches on Lantern would continue as normal. For the period of the trial, data on both devices will be stored and the searches would be replicated or performed offline.

In addition to this, a set of controlled tests would also be performed with a group of volunteers to assess the factors that cannot be observed or controlled in operational testing such as environmental factors, physical robustness of sensors, usability and so forth.

Finally, it is strongly recommended that in addition to testing the devices, a questionnaire of feedback exercise is conducted to note other observations that cannot be tested for. In particular, aspects around Usability such as the finger placement, pressure, sensor position, search time and response cannot be independently observed but are nonetheless important to the findings of the evaluation.

The type of user feedback will vary across operational and controlled tests; therefore, feedback from an operational trial would provide the most information that is relevant and reflective of genuine end users' experience.

5   Control page

Distribution list

Recipient	Title	Location

Change control

Version	Date	Authority	Evidence of approval	Record of change

6 Appendix –

NOT PROTECTIVELY MARKED