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Non-Contact Multi-Sensor Fingerprint Collection
4/2012 - 8/2012

FINAL REPORT

For:
ManTech International Corp.

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Contents

1. Project Overview

The purpose of this data collection was to obtain data to enable the evaluation of prototype non-contact fingerprint acquisition systems developed by FlashScan3D by comparing to data captured using conventional livescan fingerprint systems, inked rolled prints, and a commercial non-contact fingerprint device. In addition, human factors information was collected from operators performing the data collection to assess the operability of the prototype devices and how the general public interacted with these devices. The target number of participants for this collection was 500. An initial cohort of data was provided after 200 participants were collected, followed by a second cohort of 300. Data collection took place between 4/18 and 8/17/2012, with 500 participants providing data.

The following is a description of the data collection effort, a summary of data collected and participant demographics, and operator feedback from four WVU staff members.

2. Data Collection

Data collection was performed on the WVU Evansdale Campus. The collection utilized livescan and non-contact fingerprint devices provided by ManTech. An indoor laboratory space (164 ESB Addition) was used as the collection area, with all sensors and rolled ink impressions collected in the same space. Data was collected from each device and assembled in a common data repository on a regular basis.

2.1 Fingerprint Devices

Data collection was performed using seven different fingerprint devices (both livescan and non-contact systems), as well as rolled ink impressions. The following is a list of the electronic devices used in this data collection

<u>Livescan Systems:</u>

- Crossmatch Guardian R2
- Crossmatch SEEK II
- i3 DigID Mini
- L1 Touchprint 5300

<u>Non-Contact Systems:</u>

- TBS 3D-Enroll (commercial; Series 11)
- FlashScan3D D1 single-finger device (prototype)
- FlashScan3D D4 four-finger device (prototype)

Images of these devices are shown in Fig. 1.

Figure 1: Fingerprint devices (from top left): Crossmatch Guardian R2, Crossmatch SEEK II, i3 DigID Mini, L1 Touchprint 5300, TBS 3D-Enroll, FlashScan3D D1, FlashScan3D D4.

2.2 Collection Site

Fig. 2 illustrates the arrangement of the equipment in the laboratory used for the data collection.

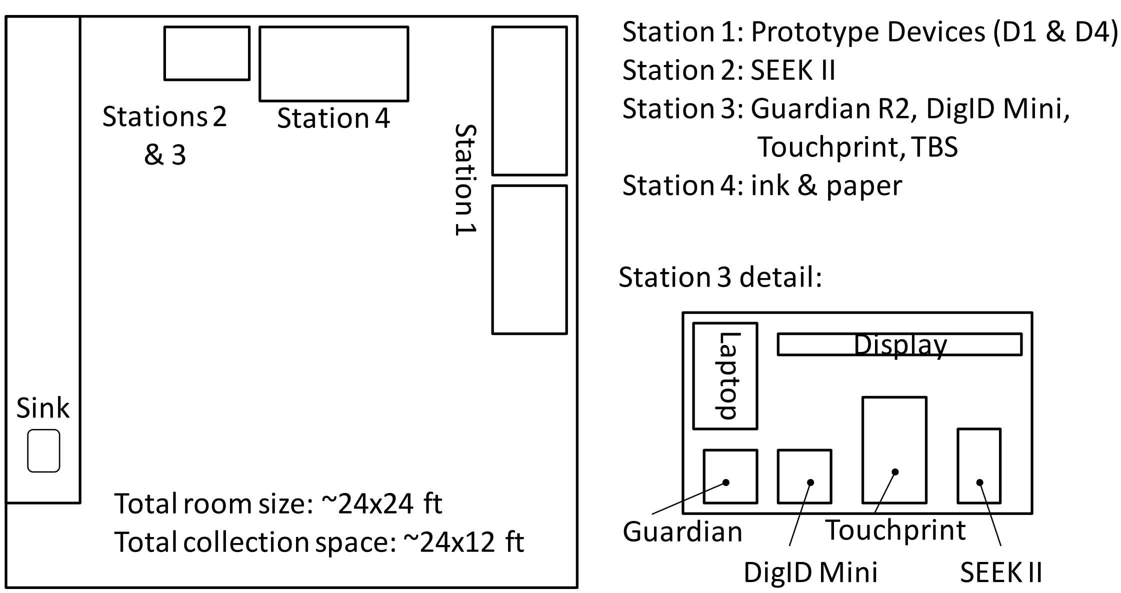

Figure 2: Collection laboratory and station arrangement.

The laboratory space was approximately 24x24ft, with the collection area encompassing ~12x24 ft of this space. Station 1 was spread across two standard laboratory work benches, each accommodating one prototype sensor and the interface PC (D4) or laptop (D1). Stations 2 & 3 were located on an adjustable height table (Workrite Sonoma) to make rolled livescan prints easier to obtain from individuals of varying height. A display was added as well to aid in participant and operator interaction with the devices. Station 4 consisted of an additional standard workbench with a plywood riser with ink plate and card bracket for inked fingerprint impression collection. Butcher paper was applied to the workbench surface to reduce the mess caused by the inking procedure. A sink was available in the room for cleanup, as well as standard ink remover pads. The restrooms were located nearby for additional hand-washing if needed.

2.3 Data Types & Organization

Each participant in the data collection provided two sequential sessions of fingerprints for each sensor. Inked prints were collected once and scanned at 500 and 1000ppi. The following were collected for each sensor device:

Guardian

- two sessions each of: rolled individual fingers on right and left hands, left slap, right slap, and thumb slap

i3 DigID Mini

- two sessions each of: rolled individual fingers on right and left hands, left slap, right slap, and thumb slap

Touchprint

- two sessions each of: rolled individual fingers on right and left hands, left slap, right slap, and thumb slap

SEEK II

- two sessions each of: rolled individual fingers on right and left hands, left index + middle slap and left ring + little slap (to create left slap), right index + middle slap and right ring + little slap (to create right slap), and thumb slap

TBS

- two sessions of each individual finger on right and left hands

FlashScan Single-Finger

- two sessions of each individual finger on right and left hands

FlashScan Four-Finger

- two sessions each of right slap, left slap, and thumb slap

The file structure of the data is as follows:

- ManTech_Fingerprint
  - Date
    - Random ID
      - Fingerprint
        - Crossmatch R2
          - Session 1
            - RandomID_Date_session
              - .bmp files
          - Session 2
            - same as session 1
        - Flashscan 3D
          - Session 1
            - ten folders named as RandomID_date_session_digit
              - .bmp & .byt files
          - Session 2
            - same as session 1
        - Flashscan 3D - D4
          - Session 1
            - vrml folder
            - .bmp & .byt files
          - Session 2
            - same as session 1
        - i3 Digi ID Mini
          - Session 1
            - .png files
          - Session 2
            - same as session 1
        - L1 Touchprint 5300
          - Session 1
            - .png files
          - Session 2
            - same as session 1
        - Seek
          - Session 1
            - .eft file
          - Session 2
            - .eft files
        - TBS
          - Session 1
            - Raw
            - .ini file & .bmp files
          - Session 2
            - Same as session 1

Ten Print Scans
500
.eft file and .bmp files (500ppi scans)
1000
.eft file and .bmp files (1000ppi scans)

Note: All images are saved with format:

"RandomID_Date_Session_additionalinfo.fileextension"

except for those from the FlashScan D4 Device.

Due to operator error and sensor malfunction, some data may be missing or corrupted. A list of errors and missing data was provided as an addendum to the dataset upon delivery to ManTech. In instances where a particular sensor was malfunctioning or away for repair (such as the FlashScan D4 scanner), collection was continued and this data will be missing from the subject's data record.

2.4 Collection Procedure

The following is a description of the collection procedure the participant experiences from consent to remuneration. It is written as an instructional document describing to staff members the standard operating procedure of each data collection station. Total time through the collection was 45 minutes to 1 hour.

2.4.1 Consent

Greet the participant and provide the consent form. Explain each section of the consent form, including all locations on the form that need to be initialed, dated, or signed. Ensure that your explanation includes the following:

- The purpose of the study is to collect data for biometrics research funded by ManTech International and the National institute of Justice.
- Data collection consists of fingerprints captured by multiple electronic fingerprint devices and on paper with ink.
- Participation is strictly voluntary; they may opt out of the process at any time.
- Inform the participant that they will be receiving gift cards upon completion of data collection and that if they choose to not complete the study they will not receive the gift cards.

Once the participant has read and completed the consent form, ask if they have any further questions and direct them to the Enrollment workstation.

2.4.2 Enrollment

Once the participant has arrived at the Enrollment Workstation, ask them for a photo ID to verify their identity. Participants may already be in the Enrollment database from another study, so ask if they have participated before. If they have participated before they will already have an RID number, if not they will need a new RID generated in the system. Using the Enrollment interface, search the database to see if the basic information (name, date of birth, etc.) exists in the database. Searching the database can be completed by using the participant's first or last name, date of birth, or all three. Typically it is most efficient to search by last name and identify the correct person based on the date of birth that appears after searching. If the participant already has an RID in the system, make a note of the RID for use while completing the enrollment process. If the participant is not in the system proceed to enter new data for the participant. Once you have completed the enrollment form, print the barcode and save the information. Instruct the participant to proceed to the fingerprint collection laboratory.

<u>2.4.3 Station 1: Prototype Devices</u>

The prototype devices were typically initialized at the beginning of each collection day based on the standard procedures supplied by FlashScan3D and ManTech, and operated continuously until all appointments scheduled for that day were completed.

2.4.3a - FlashScan3D D4

1. Create a sub-folder named according to the participant's 7-digit RID number in the folder 'ManTechFingerprint' located on the desktop. Use the barcode scanner to scan the RID number when naming the folder.
2. Inside the 7-digit RID folder, create two additional folders named '1' and '2.'
3. In the 'mat5_debug' folder, add a new folder named 'vrml.'
4. Click on 'fscan.exe,' located on the desktop, to begin data collection with the D4 device. The interface shown in Fig 3 will initialize.

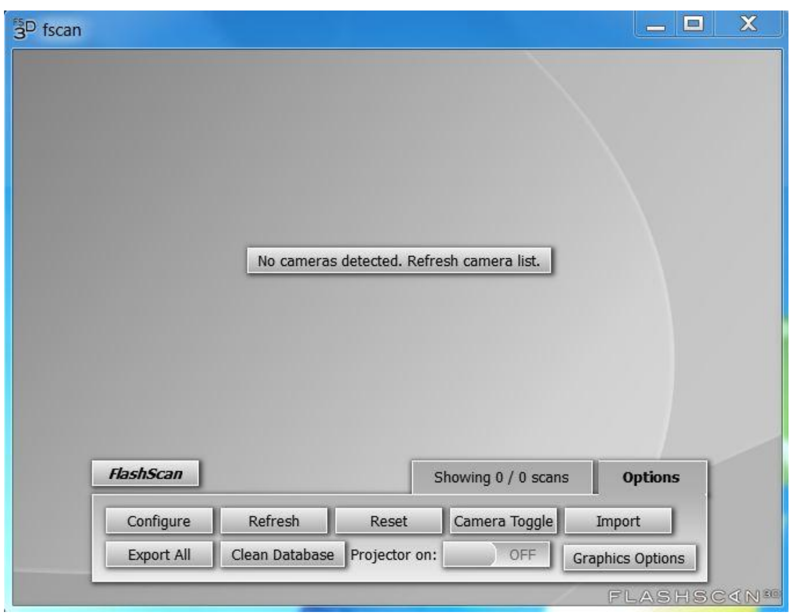

Figure 3: Collection interface for the FlashScan3D D4 device.

<u>NOTE:</u> An issue causing the collection interface software to crash may occur at any given time while the FlashScan software is running. The issue causes a window to open stating "Error In Function BiCirWaitDoneFrame. Timed out while waiting for circular acquisition." To resolve this issue: exit the FlashScan software; unplug the camera, cooling fan, and projector power supply cables from the device; unplug the framegrabber sync-cable from the

computer; and shut down the computer. Make sure the projector VGA connector and both CableLink cables (Red and Blue) are properly connected then follow the setup guidelines as shown in the manual provided by FlashScan and ManTech.

5. Ask the participant to place their right four fingers under the protective, cover as shown in Fig. 4.

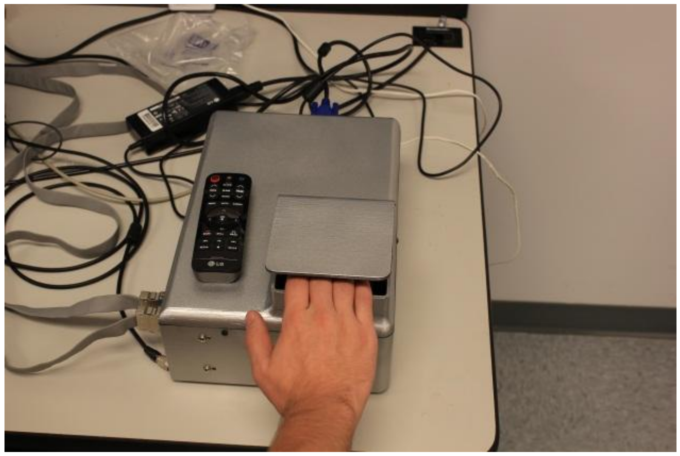

Figure 4: Finger placement for D4 slap capture.

6. After the fingers are placed as shown, click the ‘FlashScan’ button in the user interface to initiate capture. *Note:* Due to improper finger placement, motion, or skin tone, the scan may fail. If so, repeat until a successful scan has been completed.
7. A successful capture will place 21 files into the ‘mat5_debug’ folder at this point.
8. Repeat steps 5 & 6 for the left hand
9. A successful capture will place 21 additional files into the ‘mat5_debug’ folder, giving a total of 41 files in the folder at this point.
10. Repeat steps 5 & 6 for both thumbs, as shown in Fig. 5.

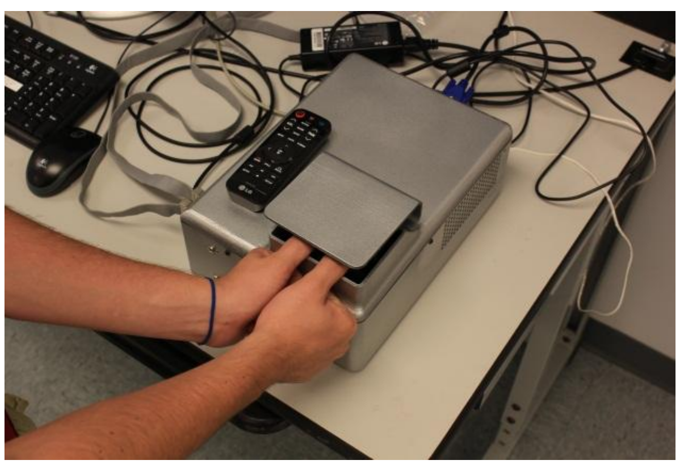

Figure 5: Finger placement for D4 thumb slap capture.

11. After the thumb slap capture is completed, there should be a total of 81 files in the debug folder.

12. Move All 81 of these files (including the vrml folder) into the folder named “1” in the ‘ManTechFingerprint’ folder located on the Desktop.
13. In the now empty ‘mat5_debug’ folder create a new empty folder named ‘vrml’.
14. Repeat steps 5-11.
15. Move all 81 files (including the vrml folder) in the ‘mat5_debug’ folder to the file named “2” in the ‘ManTech Fingerprint’ folder located on the Desktop. Collection is now complete for this device.

2.4.3b - FlashScan3D D1

1. Create a sub-folder named according to the participant’s 7-digit RID number in the folder ‘ManTechData’ located on the desktop. Use the barcode scanner to scan the RID number when naming the folder.
2. Inside the 7-digit RID folder, create two additional folders named ‘1’ and ‘2.’
3. Click on ‘fscan.exe,’ located on the desktop, to begin data collection with the D1 device. An interface similar to the D4 device (shown in Fig. 4) will initialize.
4. Ask the participant to insert their right thumb face down under the protective cover. General finger placement is demonstrated in Fig. 6.

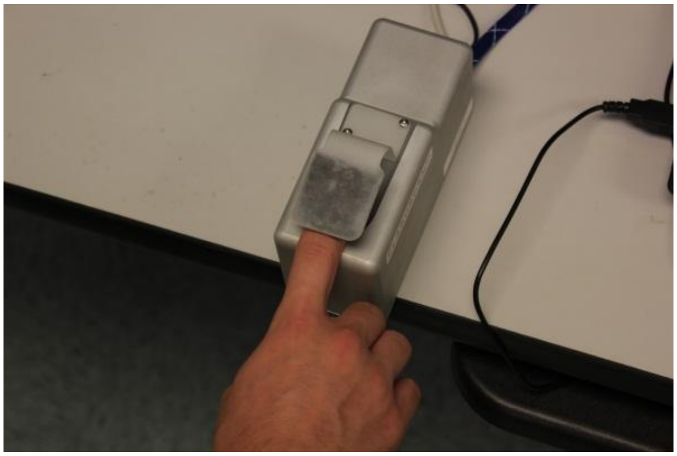

Figure 6: Finger placement for D1 scanner

5. Click the ‘FlashScan’ button in the user interface to initiate capture. Data is saved in the ‘FS3D_Database’ folder, located on the desktop. *Note:* Due to improper finger placement, motion, or skin tone, the scan may fail. If so, repeat until a successful scan has been completed.
6. Instruct the participant to proceed to the index finger, and repeat steps 4 and 5.
7. After the right hand is completed, instruct the participant to repeat the procedure, starting with the left thumb. Repeat steps 4 and 5 for all fingers on the left hand.
8. 10 images should now be saved in the ‘FS3D_Database’ folder. Move these images to folder ‘1’ located in the participant’s RID folder in the ‘ManTechData’ folder.
9. Repeat steps 4-7 for a second set of prints.
10. Move the 10 images saved in the ‘FS3D_Database’ folder to folder ‘2’ located in the participant’s RID folder created in the ‘ManTechData’ folder. Collection is now complete for this device.

2.4.4 Station 2: Crossmatch SEEK II

1. On the SEEK II mobile computer desktop, select 'MOBS'
2. From within the 'MOBS' program, select Enrollment.
3. Select the 'CAR' folder.
4. Select 'Enrollment.'
5. Select 'Fingerprints.'
6. Select 'Capture,' as shown in Fig. 7.

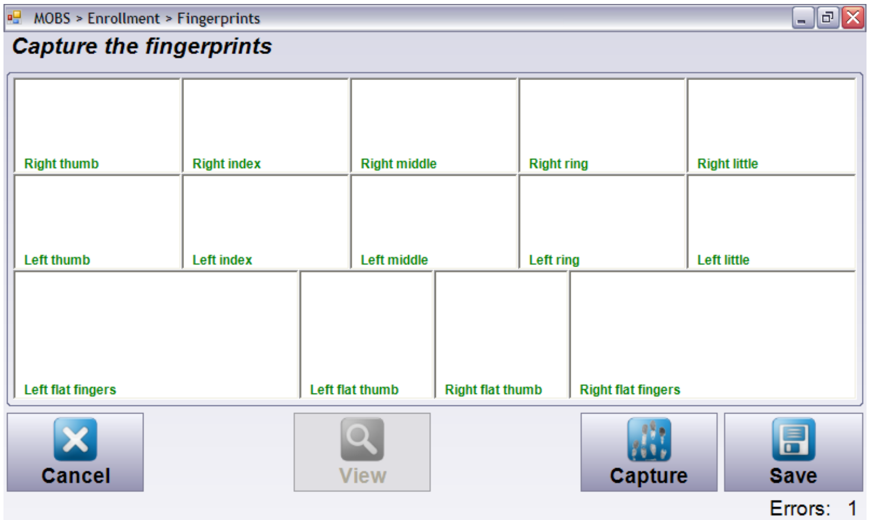

Figure 7: MOBS fingerprint capture interface.

7. The participant will place right index and right middle fingers on the platen to capture the slaps.
8. The participant will then place right ring and right little fingers on the platen to capture the slaps.
9. The participant will then place right and left thumb on the screen to capture the slaps.
10. The participant will then place the right thumb flat on the platen. The staff member will roll the thumb from nail to nail to capture the rolled fingerprint image.
11. Repeat step 10 for all four fingers on the right hand.
12. Repeat steps 7-11 for the left hand.
13. If, at any time, partial or low quality prints are captured, you may go back and recollect a new image. If print quality has been assured, select 'Save' as shown in Fig. 8.

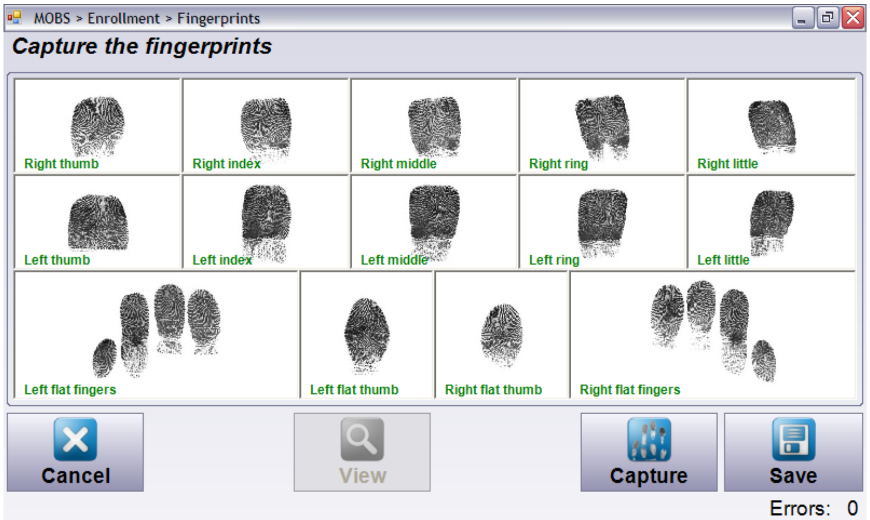

Figure 8: Completed MOBS fingerprint capture. The ‘Save’ option is located in the lower right.

14. Select ‘Save’ again on the next screen.
15. From there, a new notification will pop up. Select ‘Later.’
16. Navigate back to the SEEK II Desktop.
17. Select ‘Computer.’
18. Select ‘My Computer.’
19. Select ‘C Drive.’
20. Select ‘Documents and Settings.’
21. Select ‘All Users.’
22. Select ‘Application Data.’
23. Select ‘Cross Match Technologies.’
24. Select ‘MOBS.’
25. Select ‘Pendings.’
26. Rename the most recent file with the format ‘RID_DATE_SESSIONNUMBER.eft.’ Since the random ID is manually entered, double check the number to ensure no errors are made in file naming.
27. Repeat steps 2-26 for session number 2. Collection with this device is now completed. If necessary, clean the platen of the device using lift tape.

<u>2.4.5 Station 3: Laptop</u>

Four different devices: Crossmatch Guardian R2, i3 DigID Mini, L1 Touchprint 5300, and the TBS 3D-Enroll, were connected to a laptop so that data could be saved in a common repository. The Guardian and TBS devices were operated through a sample collection interface provided by the device manufacturer. The i3 and L1 devices were integrated into a common collection interface. The following is a description of fingerprint collection in each of these platforms.

2.4.5a - Crossmatch Guardian R2

1. Select the ‘ManTechData’ folder on the Desktop.
2. Create a folder labeled ‘CrossmatchR2’ inside the participant’s RID folder. Use the barcode scanner to scan the RID number when naming the folder.
3. Inside the ‘CrossmatchR2’ folder, create two separate folders labeled ‘1’ and ‘2.’

4. Start the Crossmatch software by clicking on the Crossmatch L-SCAN Essentials icon on the computer desktop.
5. Select the 'Save Images' radio button shown on the left side of Fig. 9.

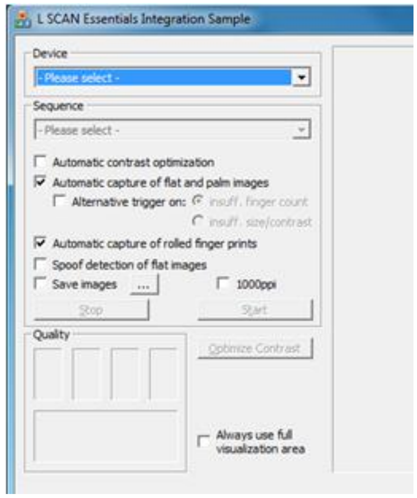

Figure 9: Guardian fingerprint collection interface.

6. Select the Save images radio button, and then select the '…' box, shown in Fig. 9.
7. Select the folder '1' that you created in step 4.
8. Select the 'Always use full visualization area' radio button, shown at the bottom of Fig. 9.
9. The participant places both thumbs on the platen to capture the thumb slap (Fig 10(a)).
10. The participant places the right four fingers on the platen to capture the right slap (Fig 10(b)).
11. The participant then places the left four fingers on the platen to capture the left slap (Fig 10(c)).
12. Place the participant's right thumb on the platen and roll the thumb, nail to nail, to capture the rolled fingerprint. A general demonstration of this is shown in Fig 10(d).

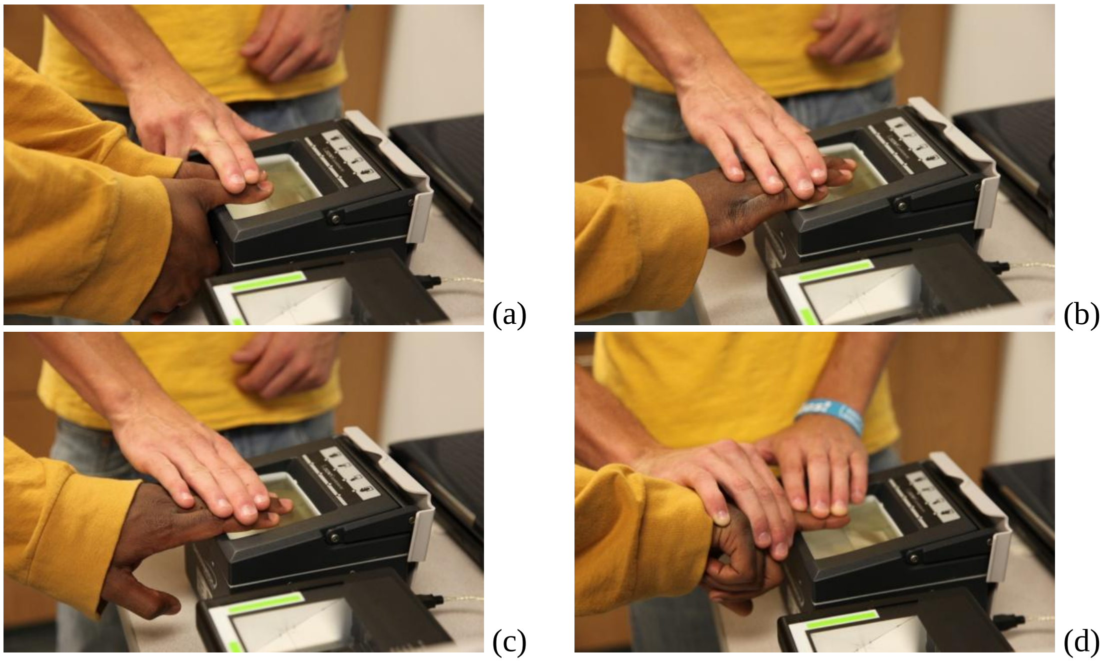

Figure 10: Fingerprint collection using Crossmatch Guardian R2: (a) thumb slap, (b) right slap, (c) left slap, and (d) rolled prints.

13. Repeat step 11 for all fingers on the right hand, beginning with index and ending with little.
14. Repeat step 11 for all fingers on the left hand, starting with the thumb and ending with little.
15. Once the rolled left little capture is completed, repeat step 6 to change the folder to ‘2’ created in step 4.
28. Repeat steps 7-15 for collection session 2. Collection with this device is now completed. If necessary, clean the platen of the device using lift tape.

2.4.5b - i3 DigID Mini

1. Click on ‘Fingerprint Capture’ on the Desktop.
2. Select the “i3 digID Mini” radio button in the user interface, shown in Fig 11.

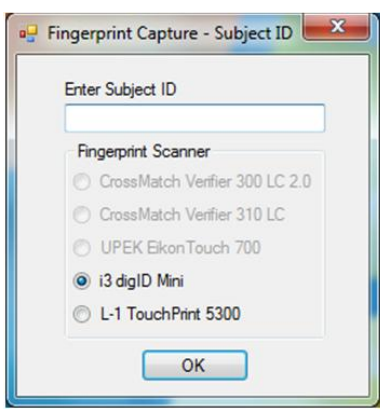

Figure 11: Sensor interface for i3 and L1 fingerprint devices.

3. Place the cursor in the field labeled “Enter Subject ID” and scan the RID using the barcode scanner.
4. Click ‘OK’ to initialize the capture interface.
5. Place the participant’s right thumb in the middle of the platen, similar to the Crossmatch Guardian sample shown in Figure 10. Roll the thumb from nail to nail to complete fingerprint capture.
6. Proceed to the right index finger, and roll as described in step 5 for the remaining fingers on the right hand.
7. Repeat steps 5 & 6 for the left hand.
8. Once each individual fingerprint is captured, the participant places both thumbs on the machine to capture the thumb slap.
9. The participant then places the right four fingers on the machine to capture the right slap.
10. The participant repeats step 9 with the left four fingers to capture the left slap.
11. Once all fingerprints are captured, the operator performs any necessary re-captures and clicks ‘Save.’
12. Repeat this process for the second session of fingerprints. Collection with this device is now completed. If necessary, clean the platen of the device using spray cleaner and a lint-free cloth.

2.4.5c - L1 Touchprint

1. Click on ‘Fingerprint Capture’ on the Desktop.
2. Select the “L-1 TouchPrint 5300” radio button in the user interface, shown in Fig. 11.
3. Place the cursor in the field labeled “Enter Subject ID” and scan the RID using the barcode scanner.
4. Click ‘OK’ to initialize the capture interface.
5. Place the participant’s right thumb in the middle of the platen, similar to the Crossmatch Guardian sample shown in Figure 10. Roll the thumb from nail to nail to complete fingerprint capture.
6. Proceed to the right index finger, and roll as described in step 5 for the remaining fingers on the right hand
7. Repeat steps 5 & 6 for the left hand
8. Once each individual fingerprint is captured, the participant places both thumbs on the machine to capture the thumb slap.
9. The participant then places the right four fingers on the machine to capture the right slap.
10. The participant repeats step 9 with the left four fingers to capture the left slap.
11. Once all fingerprints are captured, the operator performs any necessary re-captures and clicks ‘Save.’
13. The process is repeated for the second session of fingerprints. Collection with this device is now completed. If necessary, clean the platen of the device using spray cleaner and a lint-free cloth.

2.4.5d - TBS 3D-Enroll

1. Select ‘TBS 3D Capture Suite’ on the Desktop to initialize the collection interface shown in Fig. 12.

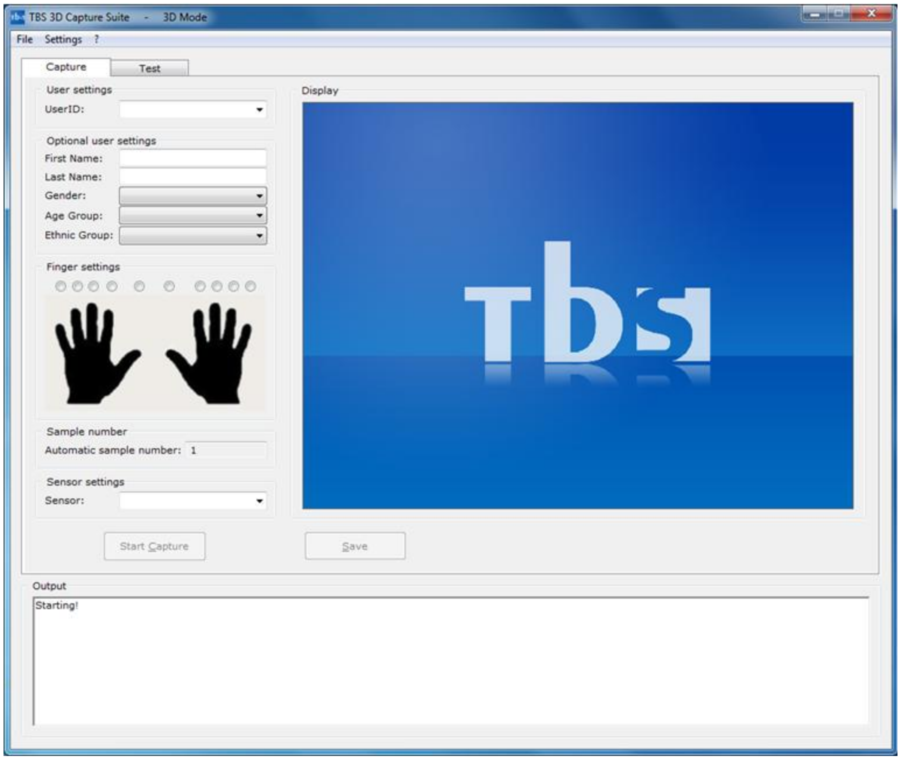

Figure 12: TBS fingerprint capture interface.

2. Place the cursor in the field labeled 'User ID' and scan the barcode to enter the RID number.
3. Select the radio button corresponding to the right thumb in the TBS interface.
4. Instruct the participant to insert their right thumb into the device. General finger placement is shown in Fig. 13. Ensure that the tip of the finger touches the guiding dot and aligns with the guiding line, both indicated on the interface.

Figure 13: Participant interaction with the TBS fingerprint device.

5. A green check mark will indicate when fingerprint capture is complete.
6. Select ‘Save.’
7. Repeat steps 3-6 for the remaining fingers on the right hand and all fingers on the left hand.
8. Select the shortcut to the TBS file storage location on the Desktop.
9. Select ‘Samples’ inside the folder identified in Step 8.
10. Select the folder corresponding to the RID number of current participant. This folder was automatically created in step 2.
11. Create a folder labeled ‘1’ inside of the RID folder.
12. Move all data in the root folder into folder ‘1.’
13. Repeat steps 3-12 using folder ‘2.’

<u>2.4.6 Station 4: Collecting Fingerprints on Ten-Print Cards</u>

This station should be completed last to prevent the fingerprint ink from interfering with the operation of the other livescan devices.

1. Label the ten-print card as shown in Fig 14, with the participant’s RID number written in the ‘Signature’ box and the date written in the box labeled ‘Leave Blank’.

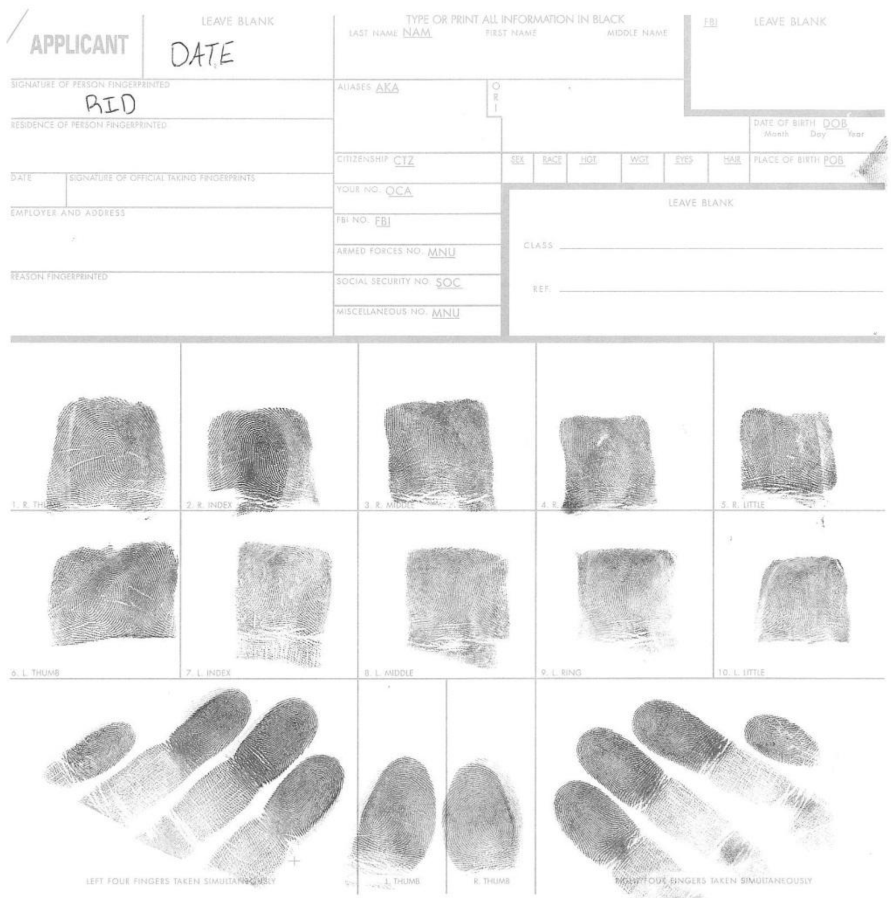

Figure 14: Sample 10-print card.

2. Beginning with the right thumb, roll the finger in the ink, going nail to nail.

3. Position the participant next to the ten-print card.
4. Place the side of the thumb in the specified box, and roll from nail to nail.
5. Repeat steps 2-4 with the remaining fingers on the right hand and all fingers on the left hand.
6. Check the amount of ink remaining on the right fingers and re-ink if needed. Applying even pressure, capture the left slap impression in the designated box.
7. Repeat step 6 for the right hand.
8. Check the amount of ink remaining on the thumbs and re-ink if needed. Applying even pressure, place the left and right thumb on the designated to capture the thumb slap impression.
9. If any mistakes are made in the inking of the fingerprints, place a white 're-tab' sticker over the bad print block then retake that impression.
10. Once satisfied with the completion of the ten-print card, give the participant an ink remover wipe and ask them to remove all residue from the fingers.
11. Write the participant's RID number on the top right-hand corner of an empty manila envelope.
12. Place the ten-print card in the manila folder, along with the print-out of the subject RID number with bar code.

2.4.7 Collection Completion

After the participant has provided fingerprints at all of the stations, provide directions to the bathroom (or lab sink) in case they wish to wash their hand more thoroughly, and instruct them to proceed to the remuneration office to receive their gift cards.

2.4.8 Post Processing

The data collected was stored in four different locations: 1) the laptop that served as the interface tot eh FlashScan D1 device, 2) the PC that served as the interface for the FlashScan D4 device, 3) the SEEK II device, and 4) the laptop that served as the interface to the Guardian, DigID Mini, Touchprint, and TBS devices. Each of these location provided adequate storage for day-to-day collection activities, but a backup of all data was performed on a weekly basis.

Data was delivered to ManTech in two releases. One took place after the collection of data from the first 200 participants, and the second after the final total of 500 was achieved. Prior to each of these data releases, the data was evaluated and a list of quality issues or missing data was compiled and supplied along with the release.

The ten-print cards could not be delivered due to IRB restrictions on data transfer. Because of this, ManTech supplied the WVU team with an FBI-certified flat-bed scanner (Epson Perfection V700) and Aware AccuScan card scanning software to create electronic records of the ten-print cards. Cards were scanned at both 500 and 100ppi, and a .eft record and individual .bmp images were created for each participant at both resolutions. Card scanning was performed on a daily basis using a computer located in guest office on the same floor as the collection lab. The card scanning procedure is as follows:

1. Open 'CSScanDemoEFT.exe' located on the computer's Desktop.

2. Once the GUI is loaded, the designated scanner should be changed to ‘Epson Perfection V700’ in the drop down selection list.
3. The layout file then needs to be chosen by following the following steps in the Windows 7 OS:
    a. Browse
    b. select C drive
    c. Choose ‘program files(x86’
    d. Choose ‘Aware’
    e. Choose ‘AccuScan’
    f. Choose ‘Samples’
    g. Choose ‘Samples’
    h. Choose ‘acuscan_fbi_criminal_alt2.xml’
4. Place ten print card in scanner.
5. Click ‘Scan’ in the scanning software interface (Fig.15). Note that the default resolution is 500ppi.

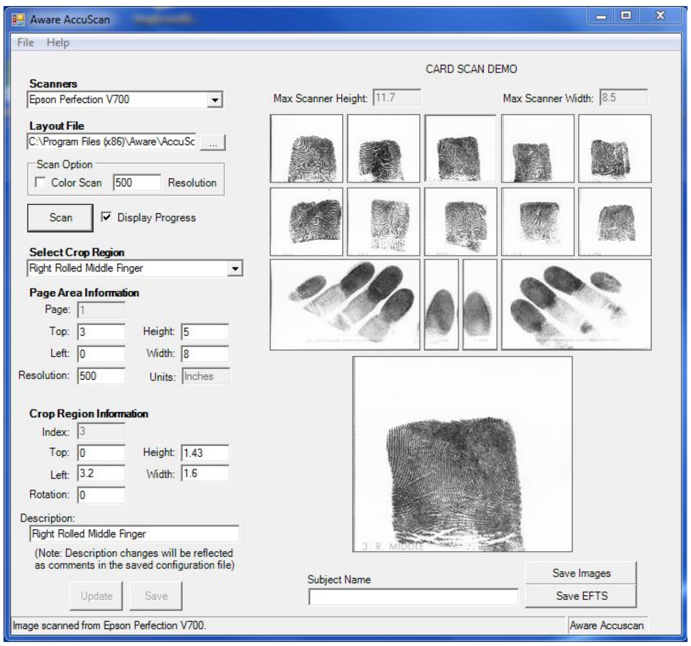

Figure 14: AccuScan scanning interface.

6. Click ‘Save Images.’
7. Save in ‘ManTech Ten Print Data’ in a folder named according to participant’s RID number located in the date collected. Use the barcode scanner to scan the barcode in the envelope along with the ten print card to avoid number entry errors.
8. Save files using the naming convention ‘RID_DATE_500.bmp.’ Again, the barcode scanner can be used to retrieve the RID and date.
9. In the same naming convention from step 8, put the file name in the Subject name area, click ‘Save EFTs,’ and save the data in the same folder as above.
10. Change the scanner resolution to 1000ppi in the ‘Scan Option’ field.
11. Under ‘Page Area Information,’ change the resolution to 1000.
12. Click ‘Update’ near the bottom of the window.

13. Repeat steps 5-8.
14. Save files the naming convention 'RID_DATE_1000.bmp.' Again, the barcode scanner can be used to retrieve the RID and date.
15. Repeat step 9 using the naming convention from step 14.

3. Collection Demographics

Figures 15-19 provide information on cumulative participation in the data collection and a breakdown of ethnicity, age and gender. Fig. 15 indicates that participation peaked after marketing events in mid May and late June. Collection activities were suspended twice during the project period due to DOJ review of the IRB documentation. The first suspension was in place from 5/24 to 5/30/2012 and the second was in place from 6/6 to 6/28/2012. Despite these suspensions, participation remained surprisingly high during the summer months. This is mainly due to non-student participation from the Morgantown community. The long suspension period in June is represented in the cumulative growth chart shown in Fig. 16, indicating otherwise steady participation. Fig. 17 indicates that Caucasians make up over half of the participants at 57%, followed by African Americans (11%) and Asian Indians (9%). This ethnicity distribution shows higher than normal African American participation, most likely due to higher participation from the community rather than student population. This shift in normal academic year demographics is seen in the age distribution in Fig. 18 as well, indicating that the majority of participants were in the 20-29 age range, making up 53% of the total, with the next highest groups in the 30-39 (16%) and 40-49 & 50-59 (both 11%) age ranges. Fig. 19 shows that male participation was greater than or equal to female for most ethnicities, with the exception of Caucasians and Asians, where female participation was greater than male.

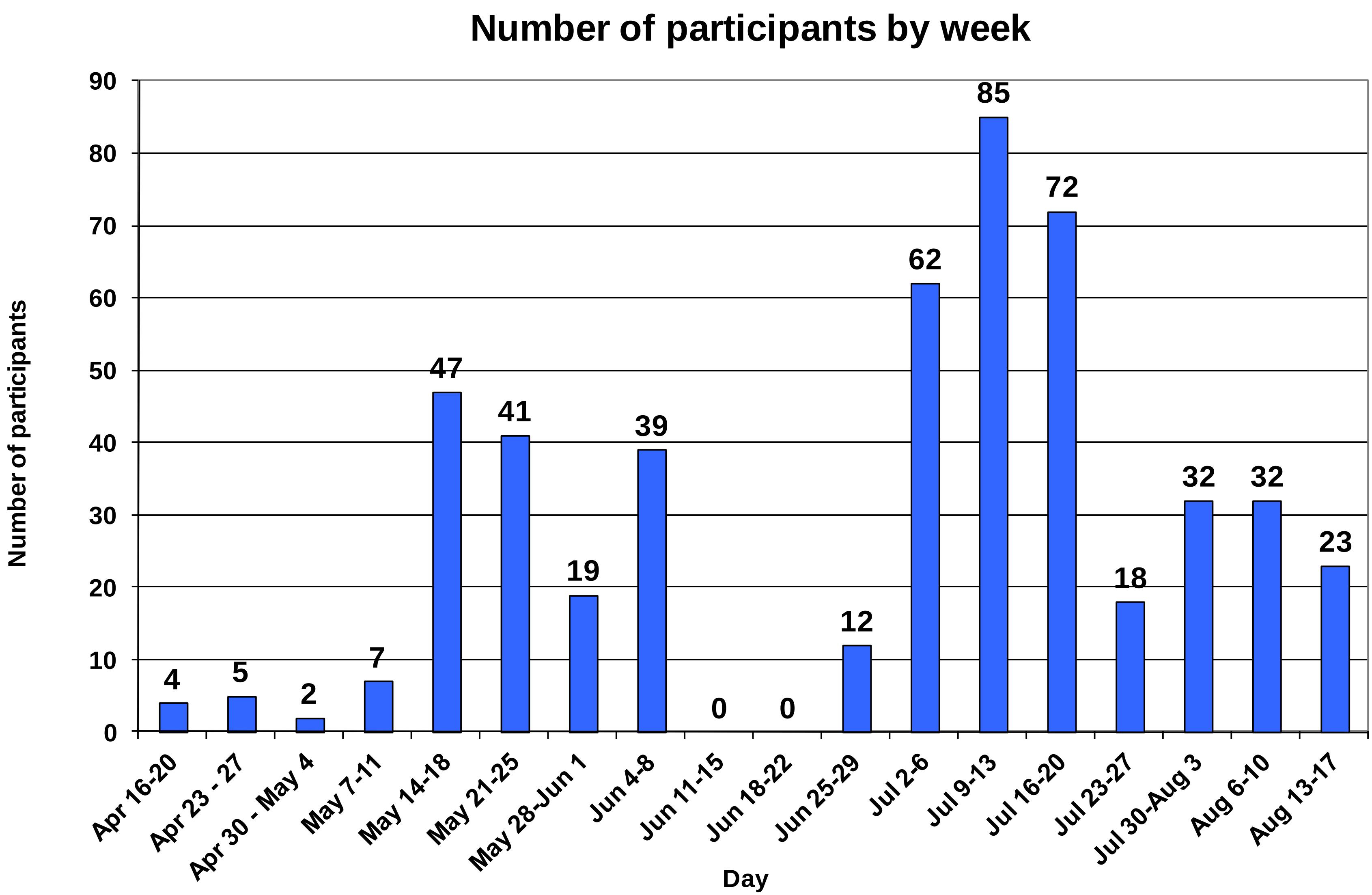

Figure 15: Number of participants by week.

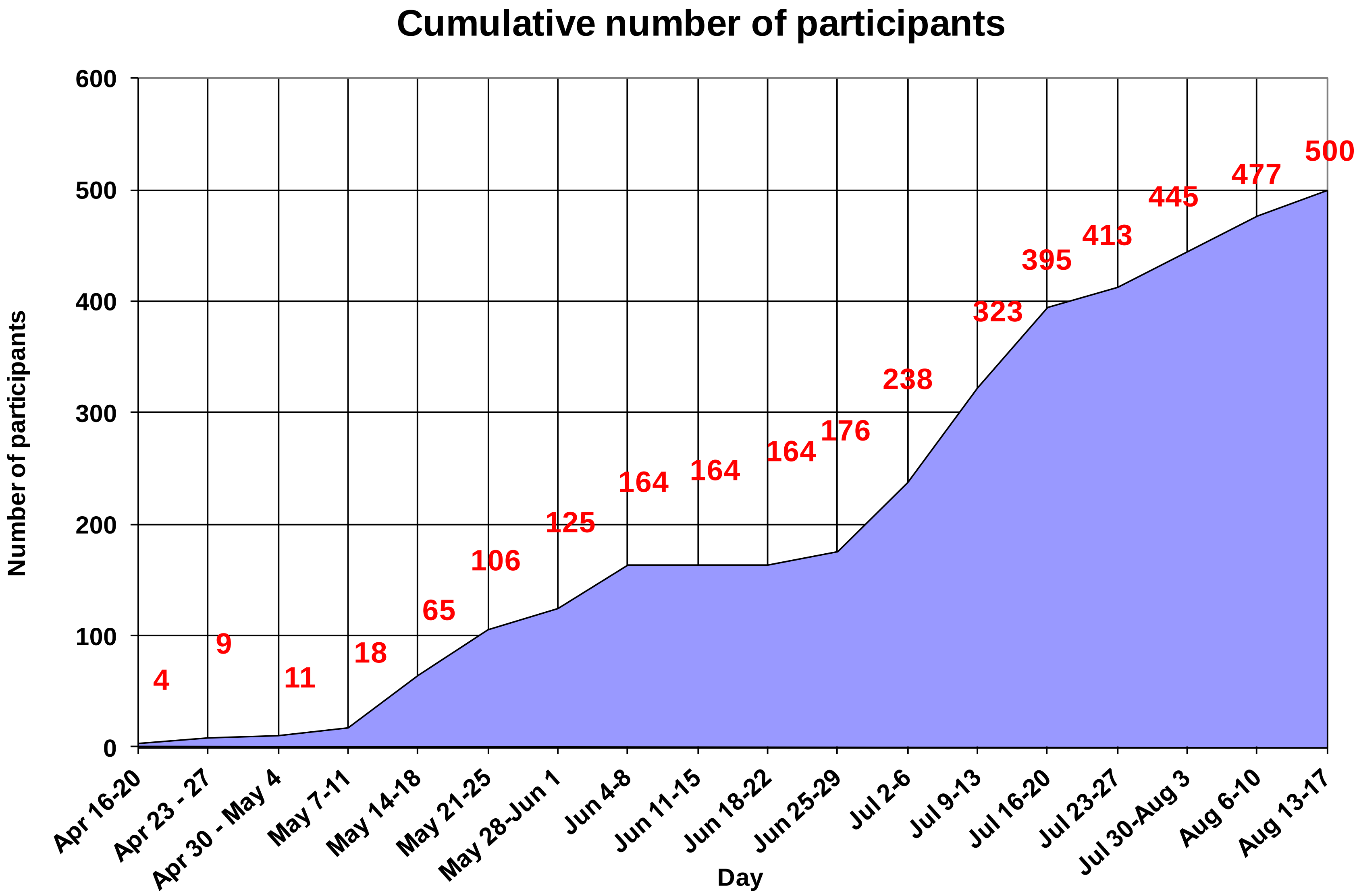

Figure16: Cumulative participation.

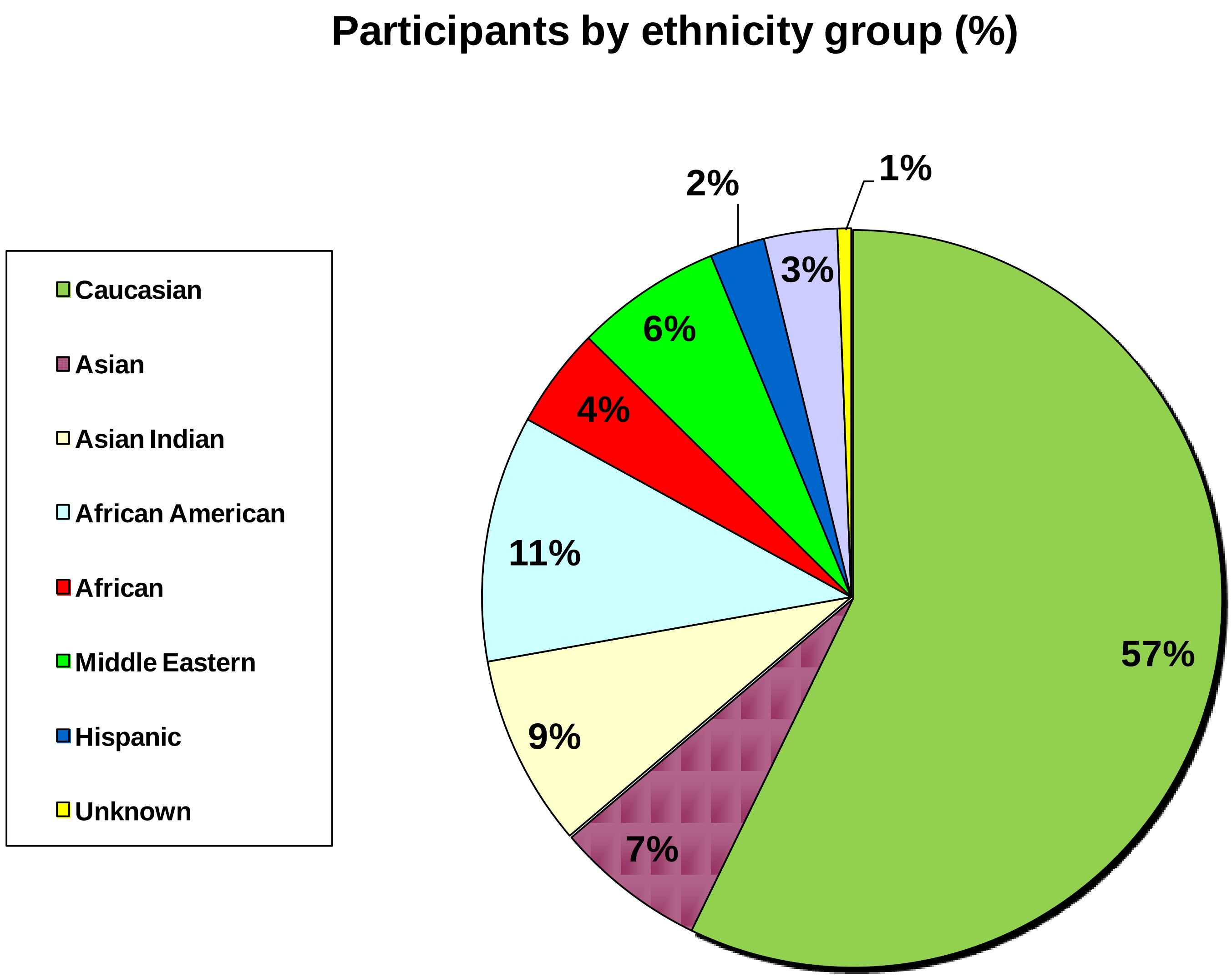

Figure 17: Participant ethnicity.

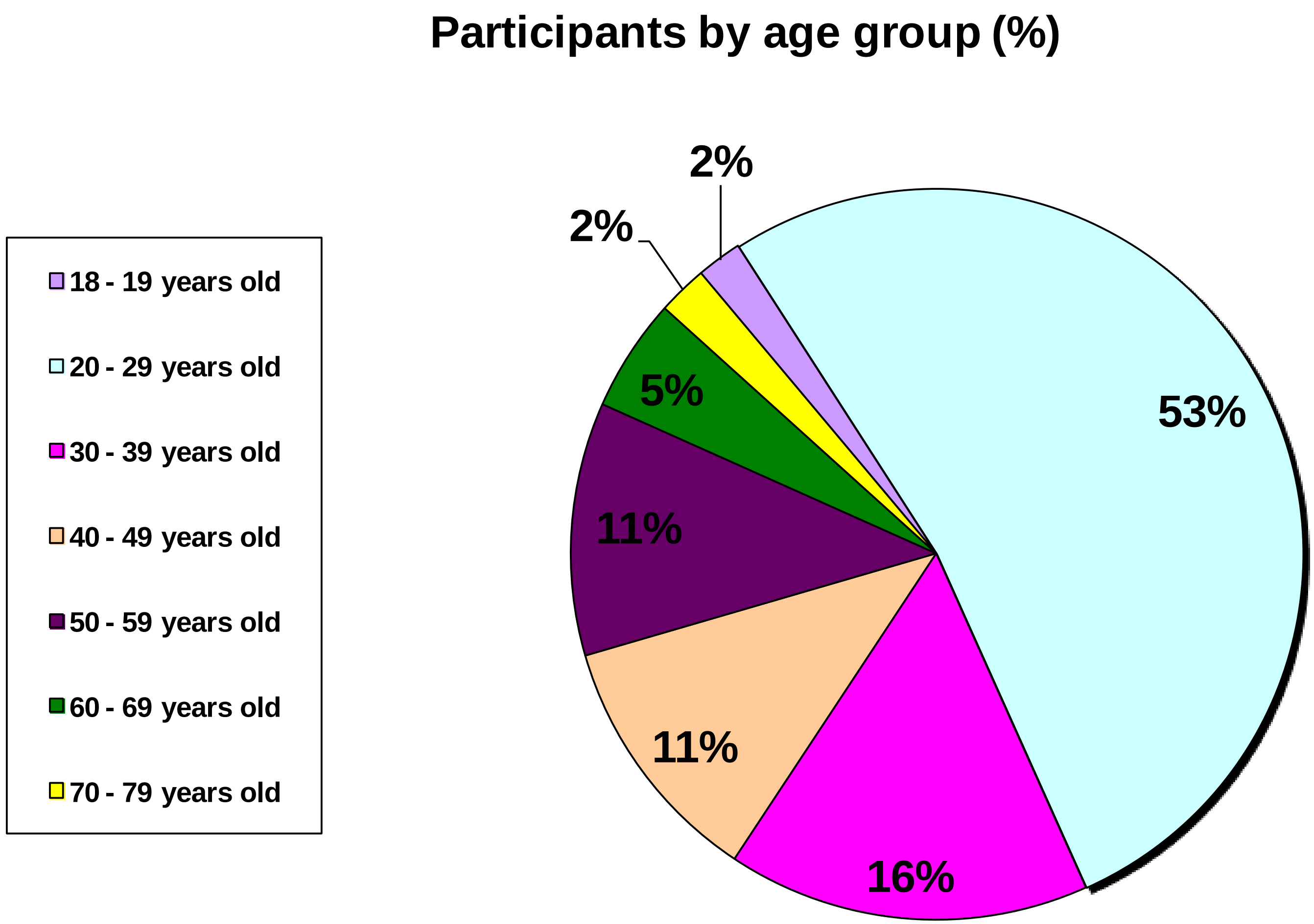

Figure 18: Participant age.

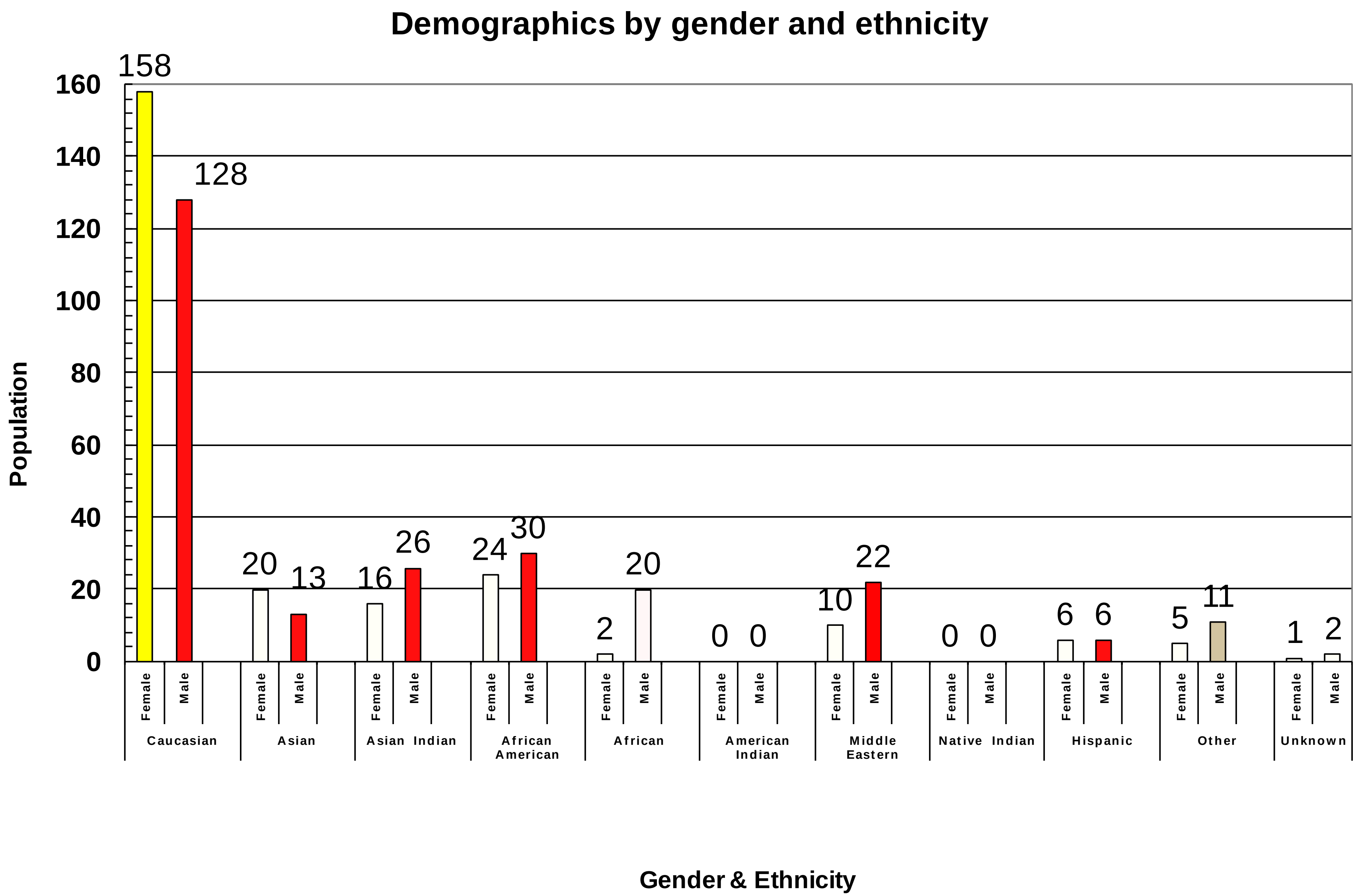

Figure 19: Breakdown of gender & ethnicity.

4. Prototype Issues and Operator Feedback

Overall, the prototype FlashScan3D devices performed considerably better than the previous hardware iterations of these devices that the WVU team has used in the past. The main operational issue that became apparent during this collection project involved the FlashScan3D D4 scanner. As mentioned in the error reporting documentation, this scanner would fail to capture slap prints from individuals with both dark skin and light palms. This was even more pronounced after the projector for the unit was replaced during a service performed toward the end of the collection (due to what seemed to be an overheating issue, but could not be replicated by FlashScan). WVU and ManTech staff discovered that this failure to capture may be a result of the brightness setting of the projector, which was varied to mitigate the problem, but did not eliminate it completely.

The four operators who performed the bulk of the data collection over the summer performance period were asked to provide feedback on their experience using the non-contact devices alongside other commercial fingerprint acquisition devices. They were to also comment on how the general public adapted to using the varying types of sensors included in the collection. They provided a written description of following aspects of their interaction with the various devices during the data collection process:

- How would you compare the use of the FlashScan3D non-contact systems with the more mature livescan device technologies?
- How would you compare the use of the FlashScan3D non-contact systems with the commercial non-contact TBS 3D-Enroll?
- How do you think the general public adapted to using the new fingerprint technologies?

Anonymized, unedited responses from these operators are provided below.

<u>Operator 1</u>

2D vs. 3D Scanners:

The 2D scanners used for the collection varied in captured data quality and ease of use. The glass surfaces on the i3 digID Mini and the L-1 Touch Print 5300 caused large variations in data quality which was mainly caused by the dryness or wetness of the participant’s fingertips. If the participant’s fingertips were very oily or sweaty, these two scanners would pick up dark smudges, and the participant’s prints would have to be recaptured after some of the excess oils or sweat were wiped off. If a participant’s fingerprints were too dry, these two scanners could barely pick up the prints at all; in this case participants were asked either to apply some hand lotion to their fingertips or rub their fingertips on the back of their ears or neck. Afterward the scanner could pick up the print much easier. It was a simple solution, but some participants had frustrations with the procedure.

The 3D scanners proved to be simpler to use than the 2D scanners. Some participants had difficulties, such as persons with crooked fingers and/or arthritis. However, many of the participants seemed more comfortable using the 3D scanners than they did with the 2D methods. Once the participant understood where to place his or her finger to retrieve a quality fingerprint capture, the process moved smoothly and efficiently. The recapture capabilities of the 3D scanners proved to be much easier to use, as well.

TBS vs. FlashScan:

The TBS scanner was generally a very quick and simple device to use. The quality of the prints varied slightly depending on the exact position and angle of the participant’s finger once the scanner began data capture. Occasionally data capture would result in blurry or warped images, but the recapture capabilities of the scanner were convenient and easy to use. However, some participants had troubles with the TBS.

There were some difficulties positioning their fingers correctly in the scanner, whether this was from small or short finger size, inflexibility, crooked and/or arthritic fingers, or the participant had issues due to hand-eye coordination.

The FlashScan devices were also simple to use, and many participants had an easier time using these two devices. The D4 scanner did have some trouble capturing fingerprints of participants with darker skin. There were also issues with initiating the machines. The single print FlashScan device occasionally had problems when starting up, but the D4 scanner was rather difficult to turn on properly. The issues with the D4 scanner appeared to be caused by loose video cables not connecting properly with the devices inside the machine.

<u>Operator 2</u>

The purpose of this project was to gather different sets of fingerprints in order to test two new scanners in their effectiveness and efficiency against other older models. The main differences between these two and the others is that these were touch-less scanners while most of the others involved a place to press your finger or hand on them. Based on the completion of the project, the researchers favored the newer prototypes.

The two prototypes were the FlashScan 3D and Flashscan3D D4. The 3D was a single finger while the D4 used four fingers at a time. To operate the 3D, one would start up the computer, then plug in the hdmi, usb, and power cables, in that order. Next, one would open up the program and a GUI would pop up. Also, a white light would appear from inside the machine. After camera toggling, the white light on the machine would change to green and then the GUI screen light would switch from white to black. The machine would be ready after that. A subject would then place their right thumb inside the machine underneath the lip and right above the hole. Clicking on the FlashScan button on the screen would then take a picture of the thumb and put it into a selected folder. After running through all ten fingers, the data was copied into the subject's own id folder. The D4 operated similarly, except both sets of four fingers and the two thumbs together were scanned instead of each finger individually. The difference between the 3D being great and the D4 being not so great is that the D4 continuously crashed as time went on. It would get almost finished and then randomly crash, with only a couple of prints left to go through. When working, it seemed like an upgrade to the touch scanners, but it crashed significantly throughout the course of the project, which was a serious problem.

These two machines seemed better than the 2D scanners. The 3D machine was by far the quickest to go through. The D4 machine took longer due to the software having to match the thumbs to the fingers. They seemed better because they got rid of misprints and smudges. There also was no need on either of them to stop to clean the fingerprint pad since there wasn't one. They had better quality pictures since there was no smudging or misprints.

For the TBS model, many subjects found it hard to position their finger inside the machine for a good quality picture. The fingers were either off center or too far inwards. Also, fingernails messed up the quality of the picture taken. The scanner would think that the nail was the start of the finger and then the scanner would prematurely scan the finger resulting in a bad picture. Because the prototypes weren't automated, the user could choose when to scan the finger(s), therefore resulting in a better image.

The majority of the participants preferred the single finger FlashScan 3D machine to all the rest, mostly because it was faster and there was less physical interaction between the researcher and the subject. Some participants didn't prefer other people controlling their hand and so it was difficult to roll their fingers on some of the machines or ten-print cards. Their fingers would become stiff and rigid or just wouldn't move, and so some prints weren't full or they were smudged over. Also, some who got bored with the project or didn't have a complete understanding would sort of become less cooperative as the time went on. The 3D scanners were better because they removed many of the physical problems that the 2D scanners had.

<u>Operator 3</u>

Throughout the fingerprinting process, a few issues and differences arose between the 3D and 2D fingerprint scanners. The best of the 2D scanners, in my opinion, was the Crossmatch Guardian. The GUI was fully functional for the Guardian. The Guardian also took the best full prints with a very small error rate. One did not have to worry about the participants hands being too dry as the Crossmatch would pick up the print quite well. The only issue with the Guardian was that there was no error checking for partial prints, i.e. when there was a partial print, one would have to start the collection process over from the beginning. The other 2D fingerprint scanners had an issue with picking up on fingerprints that were too dry. The L-1 would sometimes take about 15 minutes alone to capture all the prints because the scanner would not recognize that a finger was actually on the glass. Once it did begin the capture, the scanner would also sometimes take a partial print. The i3 also had these same issues. The i3 and L-1 GUI did have the option to recapture quite easily, so those prints that were partial could be fixed. The Seek was the best 2D machine on error correction. It took the slap shots first and then compared the individual prints to the slap shots. In doing so, it checked to see if the fingers on the machine were actually the correct one. It also corrected partial prints and gave you a rating on the quality of the print. The only issues with the Seek occurred when the scanner stated that the wrong fingers were used, when in fact the right ones were. There were also issues if people had wrinkles on their fingers. The scanner labeled these as low quality, but there was no way that the user could have fixed this.

The best of the 3D scanners was the FlashScan 3D. The FlashScan 3D was user-friendly and simple. The participants did not have trouble figuring out where to place their finger once it was explained to them. The error rate on this machine was also very low. It was almost impossible for the user to mess up the print unless the participant moved their finger. If it was moved, the file was just deleted and rescanned. The worst of the 3D scanners was the FlashScan D4. The D4 had a very low usage rating. The start-up of the machine could take up to an hour if it was not cooperating. Everything had to be done in a specific manner, and even then, it would rarely operate on the first boot-up. Once booted-up, the machine still would not take a lot of participant's fingerprint images. For instance, if a participant's skin was too dark, the projector would not illuminate the hand enough, so the scanner would not recognize that there were indeed fingers under the hood. Also, once the fingerprints were scanned and being analyzed by the program, the system would sometimes time-out, and the process would have to be repeated. There was also no way to redo a single image. If it timed out on the left hand image, the process would have to be repeated starting with the right hand. The processing time of the software was also very large, so there was a lot of downtime associated with this machine. The other 3D scanner was the TBS. The TBS was a decent scanner and had good image processing. The problem with the TBS was the interaction required with the participants. The participant had to place their finger in the scanner and align it symmetrically. The finger also had to touch a dot on the screen that determined that the finger was in the correct position. This was difficult for the fingers that had lesser control, such as the middle and ring finger. The prints would also get ruined if the participant moved at any point after the image was taken. Participants with crooked fingers also had trouble aligning their fingers symmetrically, so the process could take some quite time to complete.

The only other issue with this fingerprint collection was the participant's ability to cooperate. These machines required the participant's to understand and complete the process. For some of the machines, such as the TBS, this was a difficult task. Participants also had trouble relaxing and not allowing the research assistant to roll the fingers as needed. This would result in smudged prints or prints being rolled back which would have to be redone. This would sometimes happen because the research assistants did not have the ability to force the participants to roll the fingers how they should be rolled. Physical problems with the participants also became an issue at times. Participants with arthritis or broken fingers could not move their fingers the way they should be moved. This results in smudged prints as well. This was controlled to the best of the abilities of the research assistants, but was still an issue that could sometimes not be avoided. All-in-all, the participants did well when relaxed. The most user-friendly machines were the FlashScan 3D and the Guardian. Participants understood the process of both well and could complete what was required of them easily.

Operator 4

2D vs. 3D Scanners:

The best of the 2D scanners was the digi mini when the participant's hands were not dry. When their hands were dry the platen would not pick up the print and lotion would have to be applied to their hands or they had to rub their fingers behind their ears to get more oil on them. The L1 Touchprint was also uncooperative with dry hands but less so than the mini. With the finger started on the side the L1 wouldn't always read that a finger was on there and wouldn't beep for the process to begin. Also even if they did show up, it took a while for the machine to recognize and allow the process to begin. This machine would also take partial prints when their hands were dry and they would then have to be re-captured. The guardian worked very well but the program that was used to run it was not the greatest because it didn't allow the research assistant to go back and recapture the prints if wanted. The program chose which ones that needed re-captured but didn't catch all of them. This in turn made the research assistant delete the old data and restart the whole trial again which was very inefficient. All of the other programs had this feature and proved to be very helpful when the participants would not relax and cooperate with the assistant.

The 3D scanners were very different from the 2D. The only problem with the TBS scanner was that it was hard for some to extend their finger and get it in the particular spot for the cameras to take good pictures. When elderly participants came through and had arthritis, they couldn't get their finger in the correct place and after so long of working with them their fingers started hurting and such so the data was either not collected or had errors. The FlashScan 3D D4 worked fine with light skinned participants when it was working, however with darker skinned participants the scans would keep failing. This made many errors arise during the collection. The program was a little slow and the participants and researchers experienced "twiddle time" as in sitting and waiting which was not time efficient. Another flaw with the D4 was getting it working without errors coming up on the screen. When this happened the computer had to be restarted and everything unplugged from the computer and the device, then everything plugged back in after the computer had booted up. The single finger FlashScan 3D gave almost no trouble during the whole collection and provided good data. The program was very fast that ran it and the device could have a trial completed in under a minute unlike the D4.

TBS vs. FlashScan:

The single finger FlashScan 3D is the best out of any of these based off participant observation. It provided a comfortable place for the participant's finger and was completed in a matter of two minutes (both trials). The TBS was uncomfortable for many participants; however some participants had fun with it and treated it as if it was a game trying to get their finger in the right spot before the program started. The biggest problem with the TBS was the ring finger not working independently with most participants. Most of them had to either hold their finger straight or have an assistant maneuver their finger for them. It was easier to move the machine from left to right rather than move the participant's finger to the correct place. The FlashScan D4 worked well when it worked, however it only worked for a limited amount of time for a limited amount of participants. As stated above, the device would not cooperate with dark skinned participants and would only work sometimes near the end of the collection and even in the beginning it didn't work all the time and had to be unplugged and plugged back in after the computer restarted.

Public interaction:

As a whole the public interacted with the FlashScan 3D single finger scanner the best. There were many participants that said the machine was comfortable and were surprised when it was done so quickly. The fingerprints were easy to take when the participant was cooperative with the research assistant and relaxed instead of them trying to do it themselves. During the rolls on the 2D machines, some participants would try to do the rolls and would apply too much pressure or smudge the prints. The research assistant couldn't force the participant to cooperate other than asking them to relax and let them roll their fingers. The FlashScan D4 was slow and the participants did not enjoy sitting there waiting for the machine to be done processing the information. The participants had trouble with the TBS because some of them could not individually work their fingers. While older participants were doing the collection and had arthritis problems their hands would cramp up and it would be hard for them to complete the process. The research assistants had to help them keep their finger still and move the machine around while the finger didn't move. With the TBS raising the table to where the machine was about chest to neck level helped the participants keep their finger straight, also the participants tried using the bottom of the hole as a support. This in turn moved the machine when they tried to move their finger. It seemed as if the participants cooperated better on the machines where you started with the finger flat and then rolled to both sides instead of starting on the side (L-1).