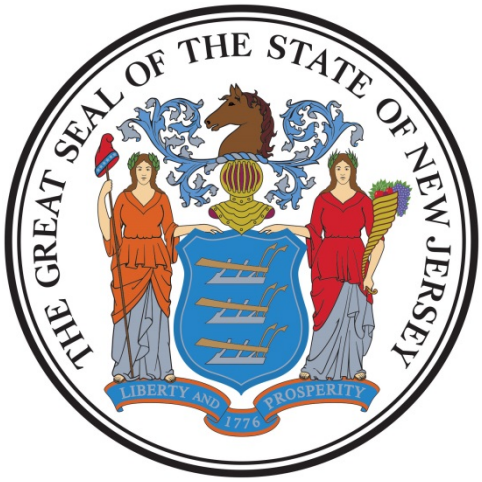

New Jersey Electronic Ballot Duplication System

Project Report

Released March 10, 2017

Prepared for The State of New Jersey by Scytl under an EASE Grant
From the Federal Voting Assistance Program (FVAP)

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1 Introduction

The New Jersey Division of Elections conducted a research project funded by the Federal Voting Assistance Program's (FVAP) Electronic Absentee System for Elections (EASE) grant. The purpose of the research project was to explore the development of an electronic ballot duplication system for absentee ballots received from military and overseas voters. The EASE grant also funded projects including: online blank ballot delivery, online voter registration, online ballot requests, and online ballot tracking. The resulting data will help identify and improve the true nature of the entire voting experience for military and overseas voters.

The New Jersey Divisions of Elections' vision is to reduce the additional workload of remaking or manually duplicating potentially thousands of ballots by exploring new technologies capable of automating the current manual duplication process.

The project's objective was to evaluate a technology approach referred to as "PDF scrapping" and determine if it was a viable approach to the automated duplication of ballots. If possible, this approach was hypothesized to be an alternative and cost effective solution. PDF scrapping refers to an approach involving direct digital image processing of the ballot as opposed to the processing of barcodes or other encoded images for the duplication logic. PDF scrapping reads the ballot returned by the voter, determines the ballot style and interprets the voter's selections using image processing, and then duplicates the ballot in the appropriate ballot format, which can be read by the jurisdictions' optical or digital scan tabulator.

During the course of the project, SCYTL developed a solution that performed PDF scrapping using digital image processing and successfully tested it with the duplication of thousands of ballots. These ballots represented different election vendors and voting rules. SCYTL concluded that "PDF scrapping" is a viable option based on the results seen during this project and detailed in this report.

2 Project Background

2.1 Absentee Voting

Every year, hundreds of thousands of voters choose to vote via absentee voting methods. History has shown that the availability of this voting method is important to ensure that all voters have a chance to cast a ballot for each election. Many of these voters are Military and Overseas voters who are away from their residence on Election Day and do not have the option to vote in person.

2.2 Absentee Ballot Duplication

Absentee voting is a process of two parties remotely sending documents back and forth. During this process, ballots can be modified intentionally or unintentionally in such a way that they cannot be read by the jurisdiction's ballot tabulators when they are returned. This can happen if the ballot is returned via fax or email, which can change its size and image quality, or when a ballot is damaged during the return.

These ballots are often unreadable because the systems that scan ballots work based on a set of expectations and tolerances to which these ballots do not conform. If something is off with one of the expectations or tolerances, the ballot may not be read or may not be read correctly.

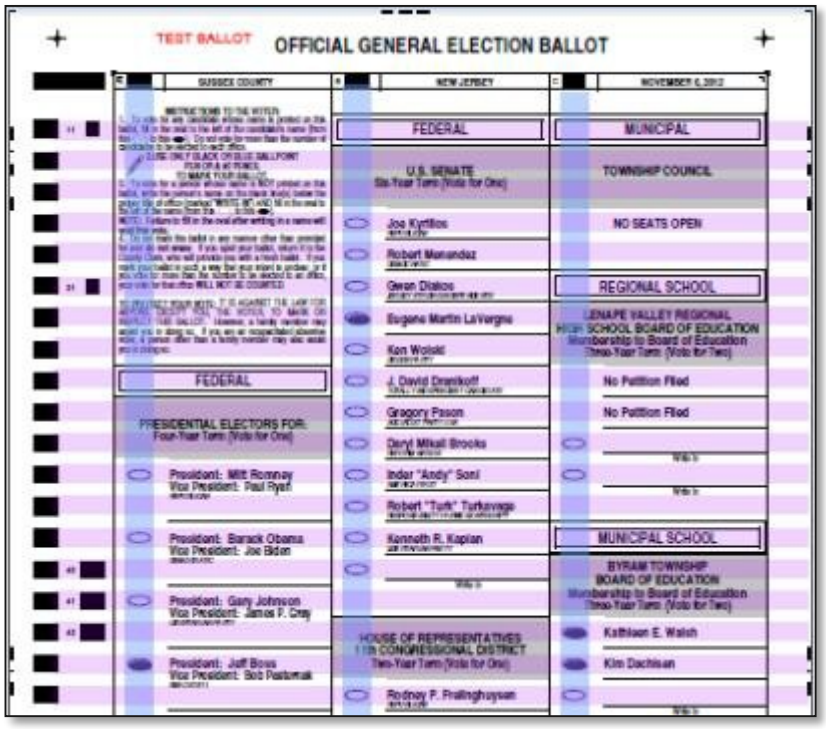
First, the ballot itself needs to be the same paper stock quality and weight, ink density, size, orientation, and oval compression as the system expects and is programmed to accept. All of these expectations are important to the correct reading of the ballot for different reasons:

- **Paper Stock Quality and Weight** – this helps the scanner check and make sure it is only reading one ballot at a time. If the paper weight is too thin or thick, it will cause an error because the scanner is not sure if it is processing only one ballot.
- **Size** – the size of the ballot must match expectations so the scanner ensures it is reading the full length of the ballot.
- **Orientation** – the scanner is expecting the ballot to contain certain markings that help it determine the ballot style and where to read the selections. If the ballot orientation is changed from portrait to landscape, the scanner will not find the timing marks and not be able to understand the ballot. Timing marks are explained in more detail below.
- **Compression** – the scanner is programmed to expect a certain number of timing mark rows and columns per inch. Therefore, if the ballot is significantly compressed or expanded, it will not be able to read the timing marks.

Second, the scanners base much of their ability to interpret ballots on distinct machine-readable markings on the ballot which help determine which ballot style the current ballot is and where to look for the voter's selections. These markings are referred to as timing marks, and their conformance to expectations is very important. Furthermore, the scanners are typically set up with scanning heads in certain places in the paper path to read only the timing marks and the ovals. This means that the ballot must be aligned with these scanning sensors in order to be read.

Timing marks are important because they establish an invisible grid for the scanner based on the location of marks down the side and across the top. At the intersection of these invisible lines, the scanner knows to expect an oval if the ballot style is programmed for one to be there. The scanner then uses optical mark recognition (OMR) to sense the darkness of the region and determine if a selection has been made or not. This threshold is set differently per jurisdictional requirements and is affected by paper thickness. If the area where the scanner is looking for a mark is off, it is possible for the ballot to not detect important sections of the voter's selection. The timing marks can also allow the scanner to do some small amount of correction for skew and scan speed.

The image below shows the timing marks in black as they appear down the side and across the top. The blue and purple lines depict the scanning grid, which is used by the scanner to detect selections.



When ballots are determined to not be machine-readable, election officials have two options: 1) manually count the ballot, or 2) manually duplicate the ballot to a new ballot to be scanned by the tabulating system. The decision on which option to use typically depends on the size of the jurisdiction and the expected number of unreadable ballots. For more specific information about the process used in New Jersey and other duplication alternatives, see Section 5.2.

2.3 Project Goal

The primary goal of the New Jersey Electronic Ballot Duplication System Research Project was to provide an automated method to remake or duplicate ballots that would not require a barcode on the ballot. For more specific information about the use of a barcode on the ballot, see section 5.2.

2.4 Project Constraints

The following constraints were established during the project:

- Many UOCAVA voters print their ballots using desktop printers and local paper styles. This generates a wide variety of ballot styles, which will all have to be processed by the solution proposed.
- There are various channels that are utilized to return UOCAVA ballots: postal mail, fax, and email.
- Barcodes shall not be used.
- The ballot duplication data will be gathered from 11 different tabulation systems (ballot formats and tabulators). See Section 4 Project modifications for changes to this item.
- The output of the processing will be a tabulator-ready (machine-readable) ballot.
- The project includes the development of a Proof of Concept (POC).
- The POC will demonstrate the results obtained during the execution of the project.

3 Project Scope

The project was commissioned with a very specific scope of determining and demonstrating the feasibility of an automated ballot duplication system.

3.1 Determination

SCYTL was responsible for the research and analysis necessary to develop a solution for the duplication of non-machine-readable ballots into machine-readable ballots. This included the identification of key issues and obstacles that were necessary to overcome to make this technology possible. Included in this area of the project was an evaluation of the following aspects of the technology:

1. **Difference in Page Dimensions** – the project and technology solution needed to account for the differences in page dimensions caused by the printer capacity of voters.
2. **Setup/Configuration** – the project and technology solution needed to account for any setup and configuration of the system to read the ballots and any user interface necessary during the duplication of ballots. This also included the processing of physical ballots into an electronic format so they could be interpreted.
3. **Mapping of Ballot Selections** – the project and technology solution needed to account for the process of translating the voter's selections on the returned ballot to the correct selections on the final ballot. This included the consideration of accidental voter markings, page folds, or other unexpected information on the returned ballots.
4. **Marking of Final Ballots** – the project and technology solution needed to account for a method of obtaining and marking the final ballot to reproduce the voter's original ballot. This included the process of determining the correct ballot style and reproducing the voter's selections.

3.2 Demonstration

Once the feasibility was determined, SCYTL was responsible for the documentation and demonstration of the auto-duplication technology that properly scans a non-machine-readable voted ballot and reproduces the ballot in the form and condition required by the various tabulating equipment.

SCYTL was to demonstrate that voted ballots could be interpreted for their contents and reproduce the voter's selections when ballots are returned in the following conditions:

- Returned by fax
- Returned via email
- Returned as photocopies through the mail

In each case, SCYTL was to demonstrate the "scrapping" of the voter's selections from the ballot and generate a machine-readable ballot with the same selections.

SCYTL was responsible for testing ballots using the types of ballot readers used in New Jersey.

SCYTL was responsible for assessing the effectiveness and accuracy of the ballot duplication process.

SCYTL was responsible for reporting how many ballots were submitted into the auto-duplication system, how many machine-readable ballots were produced, the auto-duplication processing speed, the time-savings over manual duplication, and how the auto-duplication can produce reports as necessary.

4 Project Modifications

During the course of the project, the scope and goals of the project remained the same. There was one significant change, which is detailed below.

4.1 Ballot Formats

The initial scope of the project called for ballots representing 11 tabulators to be evaluated using the automatic ballot duplication technology. Due to certain constraints and the opportunity to include an additional ballot type, it was agreed to evaluate the following formats:

- Monmouth County, NJ, Dominion Teamwork Format – this ballot format is generated using the Dominion Teamwork system. An example of this format is provided in Appendix A.
- Sussex County, NJ, ES&S Format – this ballot format is created using the ES&S Election Management software. An example of this format is provided in Appendix B.
- Dominion ICC Format – This ballot format is a landscape ballot, which is read left to right. An example of this format is provided in Appendix C.
- Orange County, CA, Hart Format – This ballot format is created using the Hart Election Management software. An example of this format is provided in Appendix D.

5 Ballot Duplication Process

5.1 Current New Jersey Ballot Duplication Process

The vote by mail (absentee voting) process for uniformed and overseas civilian voters in the State of New Jersey begins in advance of the requirement to begin sending ballots 45 days before Election Day. During that time, County Clerk's prepare ballots to send to UOCAVA voters. Paper ballots are mailed to all UOCAVA voters unless the voter requests the ballot be sent by fax or email. Those voters requesting a ballot by email receive a PDF of the same ballot that would be provided by postal mail. When the completed ballot is received from the UOCAVA voter, the signature is compared to the signature on the voters' application for a vote-by-mail ballot. This is done by the Boards of Election. If the signatures are considered a match and there are no other issues, the affidavit is separated from the secrecy envelope to ensure voter privacy.

Because many UOCAVA ballots are not machine-readable, they must be duplicated on to machine-readable ballots. Those ballots received by email receive the same treatment. The process is as follows:

1. The ballot is determined to be non-machine-readable by inspection.
2. A machine-readable blank ballot of the same style is selected.
3. Two election office workers or more, one Republican and one Democrat, jointly verify the votes on the UOCAVA ballot and then transfer those votes to the blank machine-readable ballot of the same style.
4. The original UOCAVA ballot is stamped "spoiled ballot" and then stamped with a number and initialed by one or more of the Board of Election office workers. The same number and initials are placed on the duplicated ballot in an area so as not to affect the scanning of that ballot.
5. The original spoiled ballots are stored separately from the machine-readable ballots.
6. The duplicated machine-readable ballots are scanned.
7. Write-in votes are separated and counted separately.

The duplication takes approximately 4-5 minutes per ballot.

5.2 Barcode Ballot Duplication Process

While not currently in use in New Jersey, other states and counties have begun deploying automated ballot duplication with barcodes (typically a QR or PDF417 2D barcode). This approach became viable after the passage of the Military and Overseas Voter Empowerment (MOVE) Act of 2009. The MOVE Act required states to provide electronic ballot delivery options to UOCAVA voters who requested an emailed absentee ballot. Instead of email, some states opted to use electronic ballot delivery websites, which hosted electronic ballots for voters. This software provides a ballot marking tool and enables the software to generate a barcode encoded with the ballot style identifier and voter's selections. This barcode is added to the printed ballot that voters return to their election jurisdiction. Upon return, the barcodes are read by another piece of software that extracts the selections from the barcodes and makes the corresponding marks on a ballot, which are readable by the county's ballot scanners.

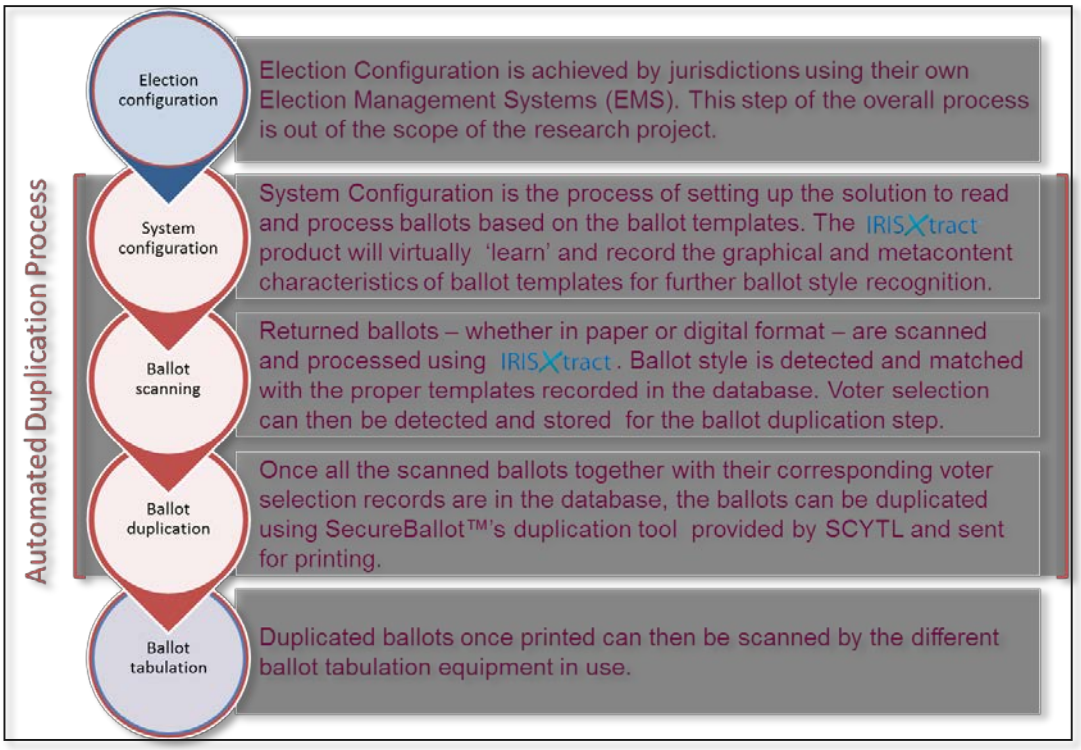
This approach has proven viable and helpful in jurisdictions where a significant portion of voters use the electronic ballot delivery system to receive their ballots. However, it is constrained to only automatically duplicating ballots generated through the electronic system. It does not help with emailed, faxed, or damaged ballots that do not contain the barcode. This approach is also plagued by the requirement that the two pieces of software talk to each other with an agreed upon barcode encoding format. The electronic ballot delivery solution must encode the barcode with a string of data that can be interpreted by the software that will read the barcode. Currently, there is no standard for this.

6 Automated Duplication Technology Solution

For this project, SCYTL proposed a proof of concept solution for automated ballot duplication using its existing Ballot Replication Tool (BRT) and the IRISXtract for Documents software.

As shown in the diagram below, the automated ballot duplication system was composed of two main complementary elements:

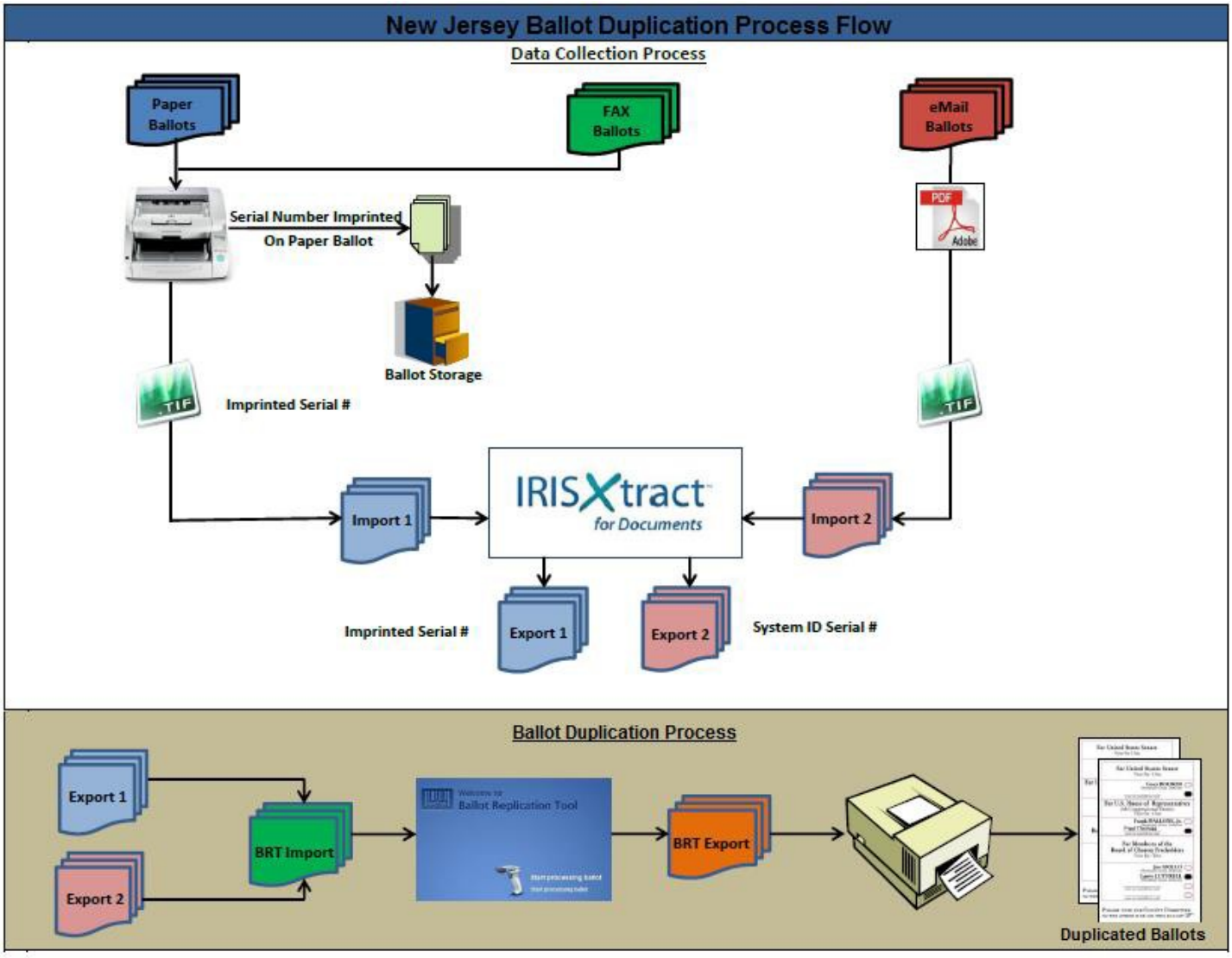
- The Ballot Scanning module (IRISXtract) will scan the incoming ballots, identify the ballot style, align the document to its correct orientation and size, and perform an Optical Mark Recognition (OMR) pass in order to lift the voter's selections and create a raw ballot export that will be used by the next module to generate the duplicated ballot. This module was set up and managed by IRISXtract for this research project.
- Ballot Replication Tool: The BRT captured the information generated by the Ballot Scanning module and duplicated the information onto the correct corresponding blank ballot style. The result is a machine-readable ballot that can be printed on a ballot-on-demand or similar printer. This module was developed initially for duplication using barcode technology but was customized by SCYTL for this project.



The above technology will work on top of standard COTS (commercial-off-the-shelf) software and hardware available in the market:

- Microsoft Windows operating system
- Microsoft SQL database
- Standard computers/laptops (meeting minimum specification requirements)
- Standard document scanners with emboss capabilities
- A standard printer capable of printing official ballots
- Standard Local Area Networking appliances

The workflow diagram below shows the duplication process using IRISXtract and BRT.



6.1 Setup

For the ballot duplication technology used in this project to work properly, both modules needed to be set up by subject matter experts. IRISXtract was configured by IRISXtract project managers and BRT was configured by SCYTL IT staff.

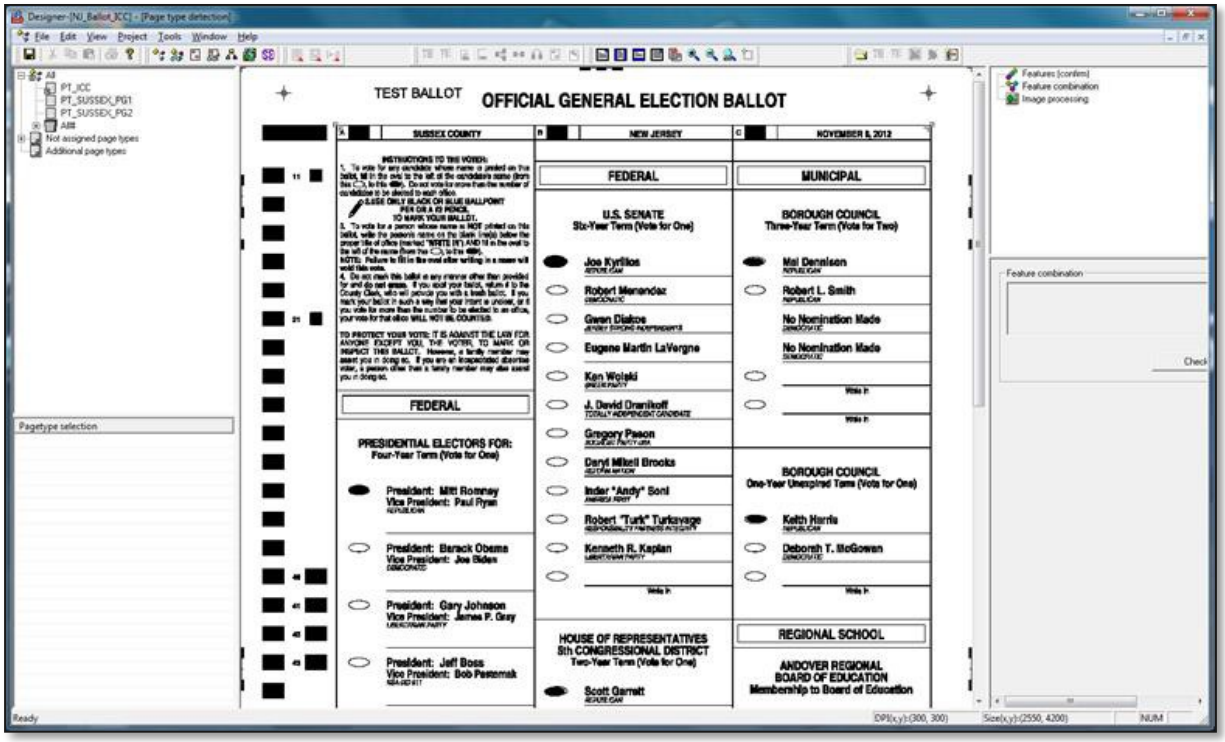
6.1.1 IRISXtract Setup

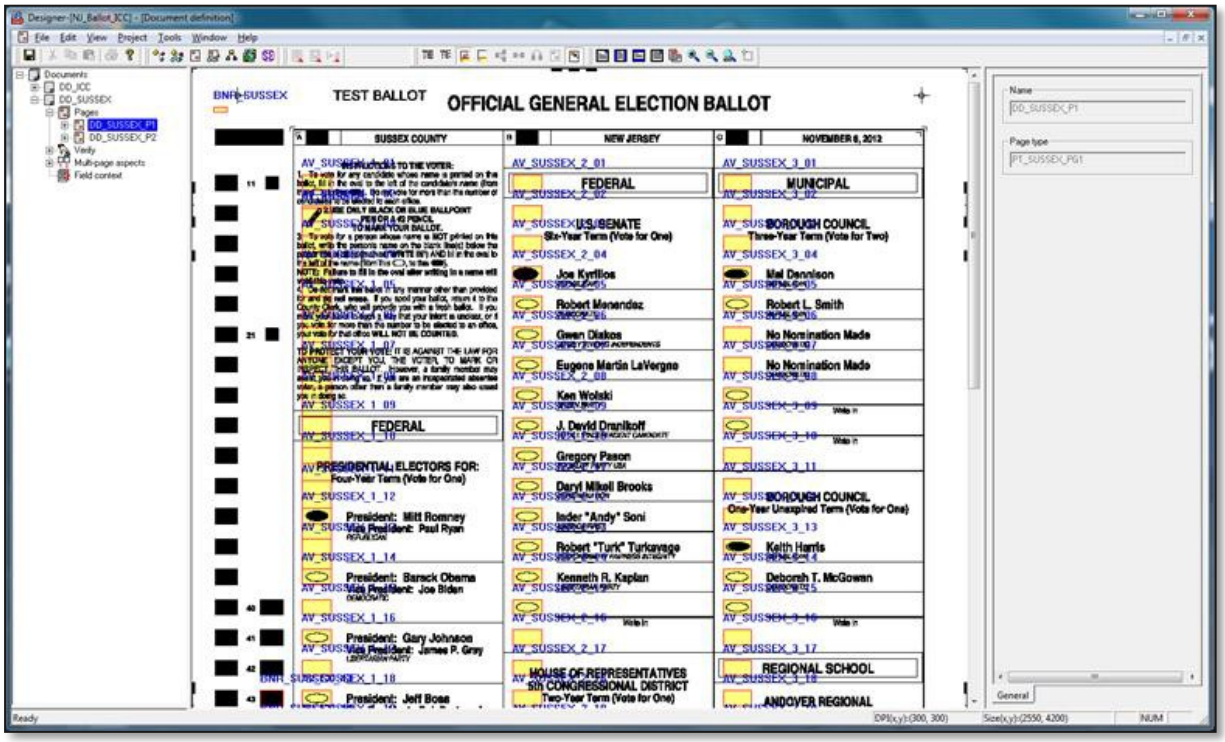
The IRISXtract setup is a two-step process. First, the ballot template must be programmed into IRISXtract. This is a process that requires a high technical skill set. It has to be done only once for a ballot template. A ballot template is a unique design of a ballot based on where the oval, square, or arrow positions might be and where the ballot style identifier is placed. This step has 3 important aspects:

- **Identify Error Correction Attributes** – this identifies unique aspects of the ballot that will help the software detect and correct skew, rotation, variations in size, variations in scanning speeds, etc.
- **Identify the Grid of Allowable Voting Positions** – this creates a grid of possible marking positions and assigns them a row and a column.
- **Identify the Ballot Style ID** – this points the software to a place on the ballot to read the ballot identifier.

Once these 3 things are identified for a ballot template, they can be reused for each ballot style that uses this template. For example, if a county uses the same ballot generation software and always uses a 3-column, 14-inch ballot, and a 3:1 oval-to-inch ratio, this setup will only need to be performed once. If the ballot design varies, this setup process will need to be repeated.

The following images show the process of setting up the oval grid for a ballot template.


TEST BALLOT
OFFICIAL GENERAL ELECTION BALLOT
SUSSEX COUNTY
NEW JERSEY
NOVEMBER 6, 2012
FEDERAL
MUNICIPAL
U.S. SENATE
Six-Year Term (Vote for One)
Joe Kyrillos
Robert Menendez
Gwen Diakos
Eugene Martin LaVergne
Ken Wolski
J. David Dranikoff
Gregory Pason
Daryl Mikell Brooks
Inder "Andy" Soni
Robert "Turk" Turkavage
Kenneth R. Kaplan
BOROUGH COUNCIL
Three-Year Term (Vote for Two)
Mel Dennison
Robert L. Smith
No Nomination Made
No Nomination Made
BOROUGH COUNCIL
One-Year Unexpired Term (Vote for One)
Keith Harris
Deborah T. McGowan
PRESIDENTIAL ELECTORS FOR:
Four-Year Term (Vote for One)
President: Mitt Romney
Vice President: Paul Ryan
President: Barack Obama
Vice President: Joe Biden
President: Gary Johnson
Vice President: James P. Gray
President: Jeff Boss
Vice President: Bob Peterniak
HOUSE OF REPRESENTATIVES
5th CONGRESSIONAL DISTRICT
Two-Year Term (Vote for One)
Scott Garrett
REGIONAL SCHOOL
ANDOVER REGIONAL
BOARD OF EDUCATION
Membership to Board of Education


TEST BALLOT
OFFICIAL GENERAL ELECTION BALLOT
SUSSEX COUNTY
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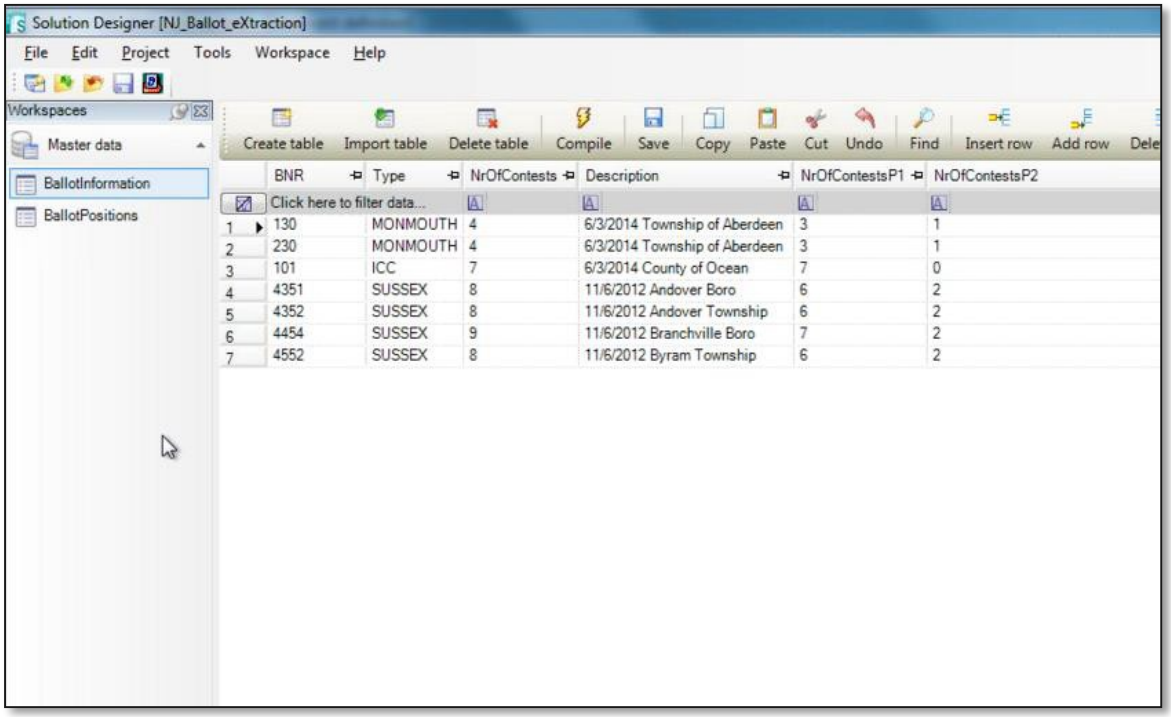
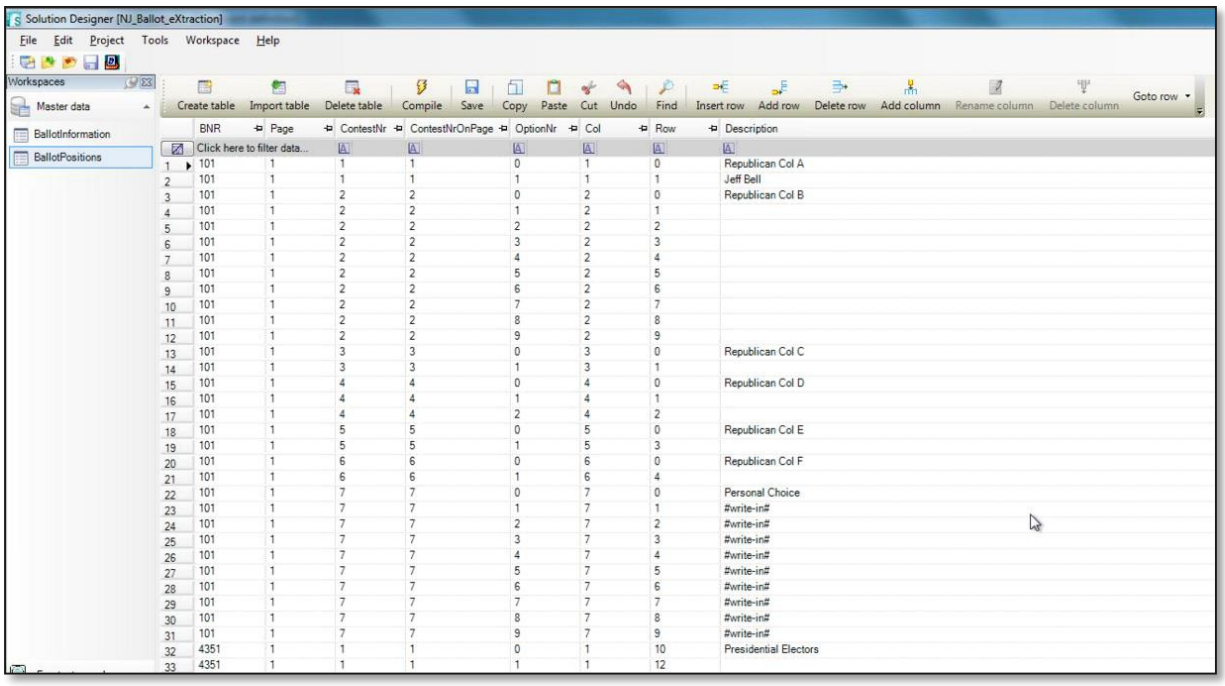
J. David Dranikoff
Gregory Pason
Daryl Mikell Brooks
Inder "Andy" Soni
Robert "Turk" Turkavage
Kenneth R. Kaplan
BOROUGH COUNCIL
Three-Year Term (Vote for Two)
Mel Dennison
Robert L. Smith
No Nomination Made
No Nomination Made
BOROUGH COUNCIL
One-Year Unexpired Term (Vote for One)
Keith Harris
Deborah T. McGowan
PRESIDENTIAL ELECTORS FOR:
Four-Year Term (Vote for One)
President: Mitt Romney
President: Barack Obama
President: Gary Johnson
President: Jeff Boss
HOUSE OF REPRESENTATIVES
5th CONGRESSIONAL DISTRICT
Two-Year Term (Vote for One)
REGIONAL SCHOOL

After the ballot design setup, the user will complete the election setup. This process identifies each of the ballot styles, the number of pages, and the number of contests in the election. Then, for each ballot style, the user will identify what each oval means in terms of its contest and option index on the ballot. This information is required in order for IRISXtract to identify marks and associate them to information that can be exported to the Ballot Replication Tool. There is no practical limit to the number of ballot styles and options supported.

The oval mapping is done on a per-ballot-style basis, only requires minimal technological skill, and is expected to take a person about 5-8 minutes per ballot style. Since this step can be performed in Excel or in an IRISXtract Solution Designer as shown below, it can be completed by election staff or an outside vendor.





6.1.2 Ballot Replication Tool Setup

The BRT module must be configured with a “sample” of the oval to be found on the official ballot. This “sample” is used in the BRT software to find all of the ovals on each ballot style and properly fill them in. This part of the setup must be done by a developer as it is a change in the BRT software. Since most ballots use a similar oval, this configuration should not need to occur often. In addition, the BRT module must be pointed at a directory where it can find the blank PDF ballots and to a directory where it can find the ballot exports from the IRISXtract module. This can be accomplished in just a few minutes during the initial setup.

6.2 Input

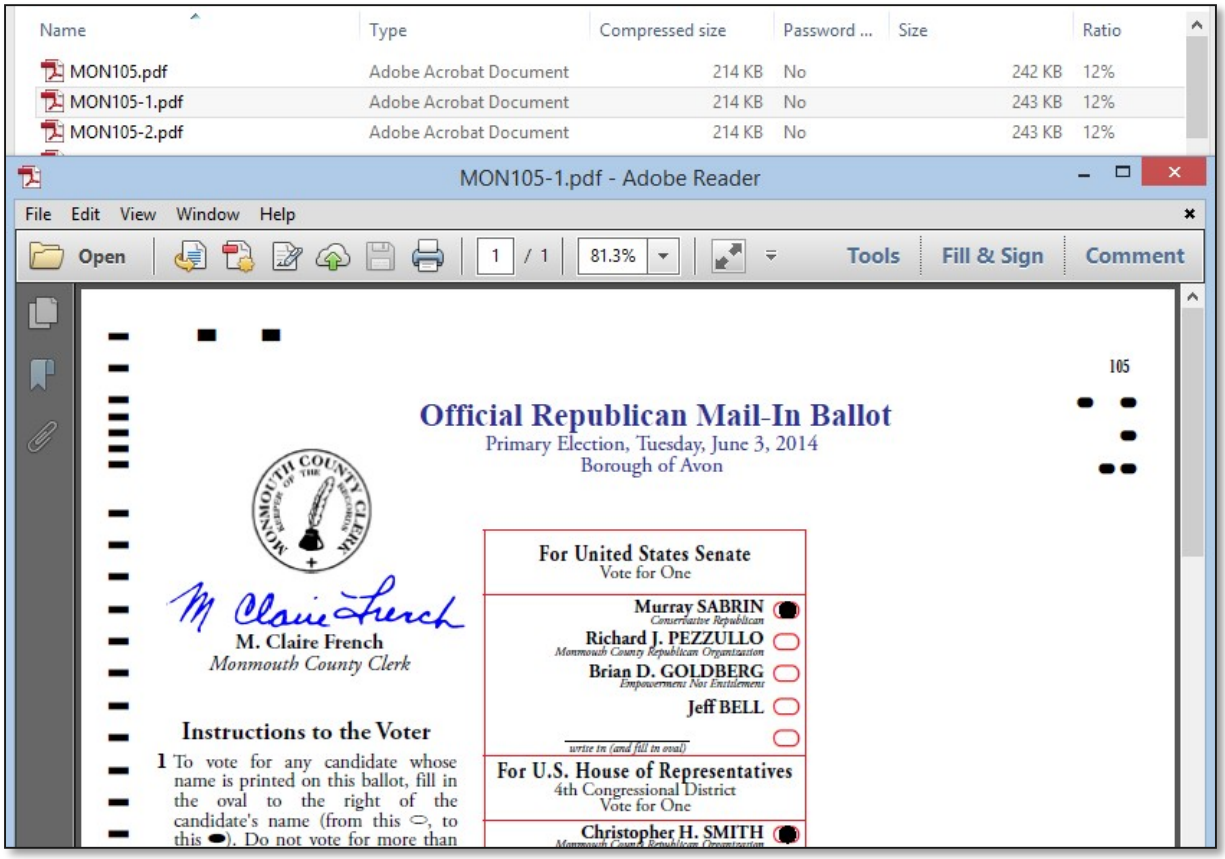
IRISXtract can handle ballot inputs from multiple types of files, such as JPEG, TIFF, PDF, etc. For this project, SCYTL considered one file type that would be universally used for mailed, faxed, and emailed ballots. It was recommended that Black & White TIFF was the best file format for the technology and is universal enough that ballots returned by any return channel can be converted. While PDF was also an option, IRISXtract is more accurate with TIFF files. Therefore, the ballots used in the project were all converted to TIFF with G4 compression before processing.

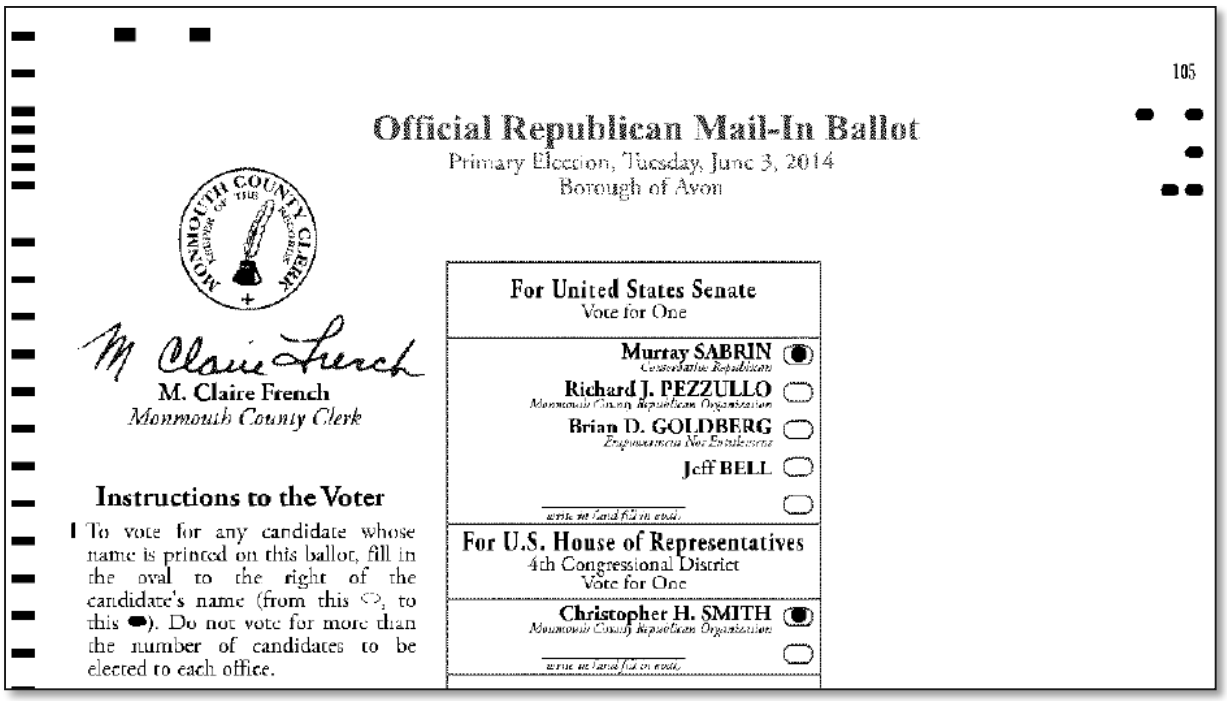
The PDF to TIFF conversion was done outside of IRISXtract and files were converted to .tif files at fax compression CCITT T.6 and 300 dpi. Pro Smart PDF converter software was used to meet this objective.

During the course of the evaluation, many different examples of inputs including ballots returned by mail, fax, and email were tested. Additionally, the software was tested with ballots that were of different size, skewed, spoiled, rotated, of different image orientation, B&W vs. color, folded, and torn. More information about this is shared in the Section 8.

While the project did not use all of IRISXtract's capabilities, many features, such as the ability to take ballots directly from emails and faxes have the potential to be useful. More information on IRISXtract capabilities can be found in Appendix E.

The following images represent the types of inputs that SCYTL used with IRISXtract during this project.



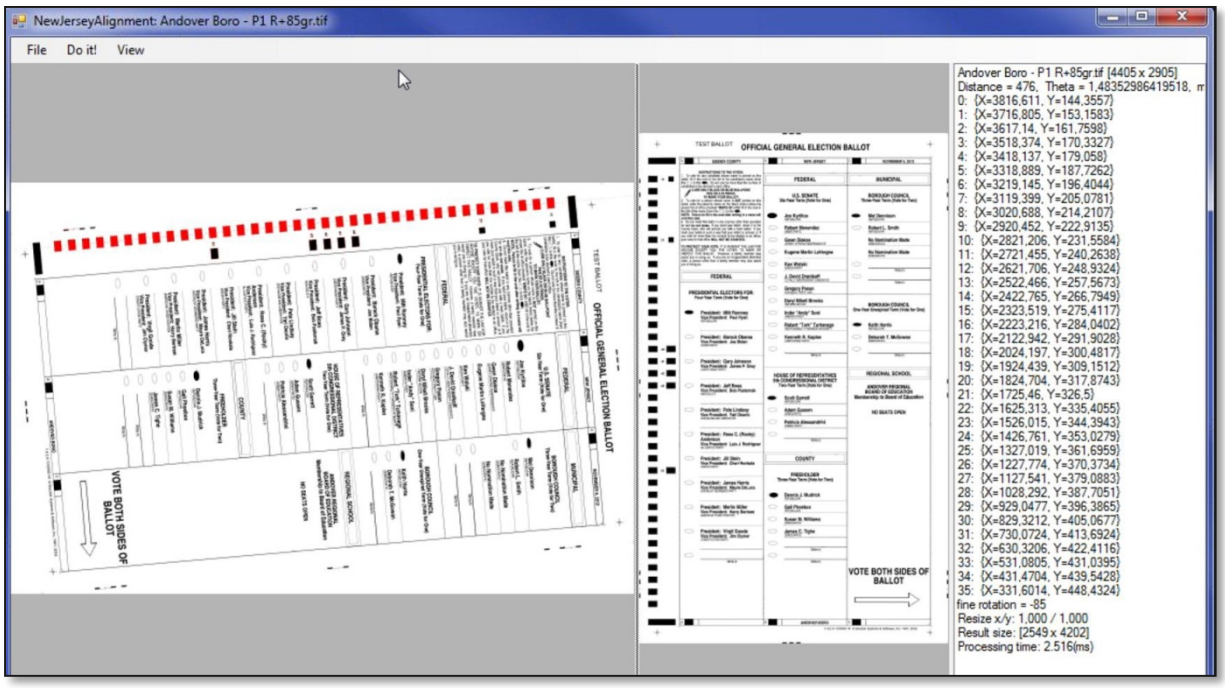


6.3 Ballot Processing

Once the ballots are introduced to IRISXtract, each ballot is processed in 4 steps:

1. Image Error Detection and Correction
2. Ballot Style Identification
3. Detection of the Voter's Selections on the Ballot
4. Export to BRT

The Error Detection and Correction step finds a series of marks that were preset in the setup and determines if those marks are correctly sized and oriented. If it detects the ballot is skewed and shrunken, for example, IRISXtract will apply an adjustment to un-skew and un-shrink the ballot to return it to a correct orientation and size. This is accomplished by using a set of blocks with profiles that are easy to find and are good representations of the ballot to IRISXtract. The accuracy and flexibility of IRISXtract to detect and correct errors depends heavily on how well the ballot is designed to allow for this to occur. The best results are achieved when the ballot has at least 3 square blocks on different corners of the ballot that are separated from other content. This allows the IRISXtract software to detect issues in any dimension and to do so easily without interference from other content on the ballot. The example shown in the following image is a one-dimensional line of squares that were set up for this error detection and correction. The software identified this line in the skewed input and corrected it in the image on the right.



If the error detection cannot find the distinct object it is looking for to do the error checking, the ballot will be sent to the Verify tool, which will be described later, for further manual evaluation.

Once the error detection and correction step is complete, the processing will search for the ballot style identifier. If this process is unable to read the ballot style ID, the ballot will be sent to the IRISXtract Verify tool. If the ballot style is found in the database, the processing moves to the next step in order to identify selections on the ballot.

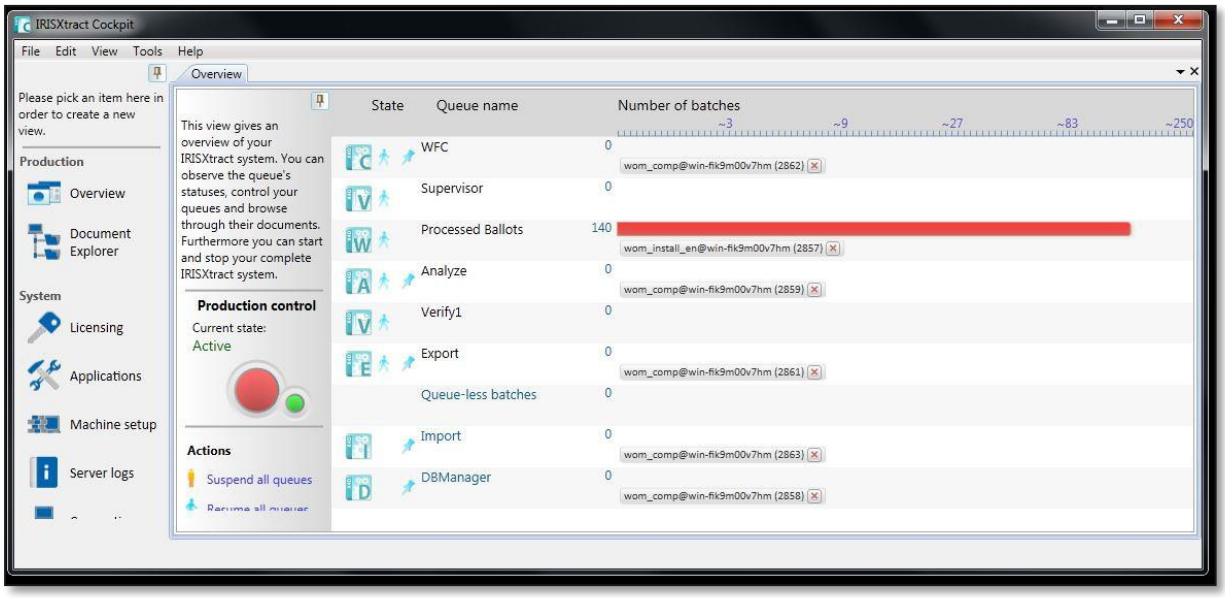
The detection of the voter's selections is performed by IRISXtract searching for a certain threshold of pixels within the areas of the ballot identified as oval positions. IRISXtract can be configured with a threshold for the detection of a mark. It can also set a range of pixels that can be considered "possible" selections. If the software detects pixels in this range, the ballot is sent to the Verify tool for manual inspection. Lastly, the software is set up with a pixel count where anything below that count will be considered a no-vote.

In order to handle write-ins, IRISXtract is configured to lift the write-in name and store it in a separate image file. The software will take and create a TIFF image of the area where the write-in name is expected to be placed and export this along with the rest of the selections.

Once the ballot processing is finished, the ballot is either considered processed or has been sent to the Verify tool because of one of the errors mentioned.

6.3.1 IRISXtract Cockpit

IRISXtract main user interface component for the processing of ballots is called the Cockpit. A screenshot of the Cockpit is shown below. This is where an operator can see ballots ready to be processed and ballots processed and use the IRISXtract Verify tool.

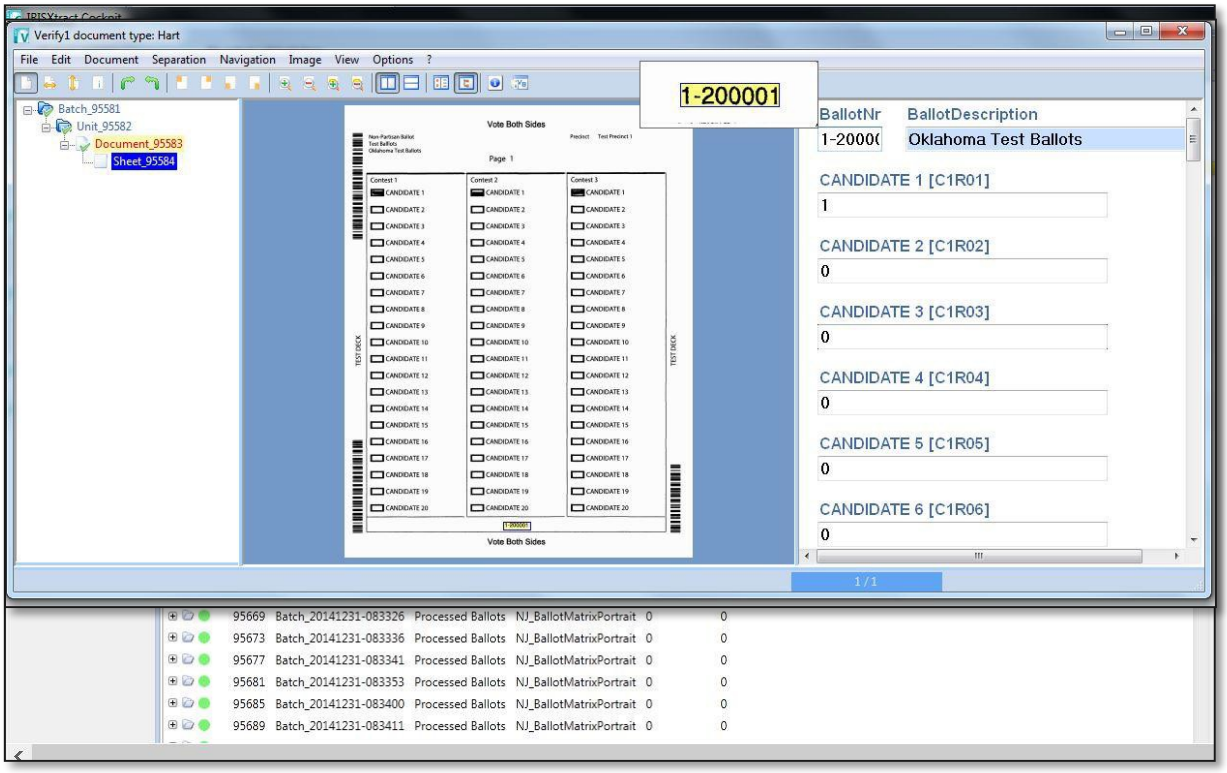


6.3.2 Verification

IRISXtract includes a verification tool that allows for the review of the scanned ballot and the interpretations. This is the primary tool for manually reviewing ballots, which the software had problems reading. For example, if a ballot style identifier cannot be determined, the ballot will not be processed but instead will be sent to the Verify tool for manual inspection. The operator can manually read the ballot style ID from the ballot and enter it into IRISXtract and reprocess the ballot.

The operator can also review all of the interpretations that IRISXtract has made. This includes the ballot identifier and each of the voter's selections and write-in choices.

Users can select any part of the image and the Verify tool will zoom in and show any interpretation of the content to the user. The user can then modify the interpretation if necessary.

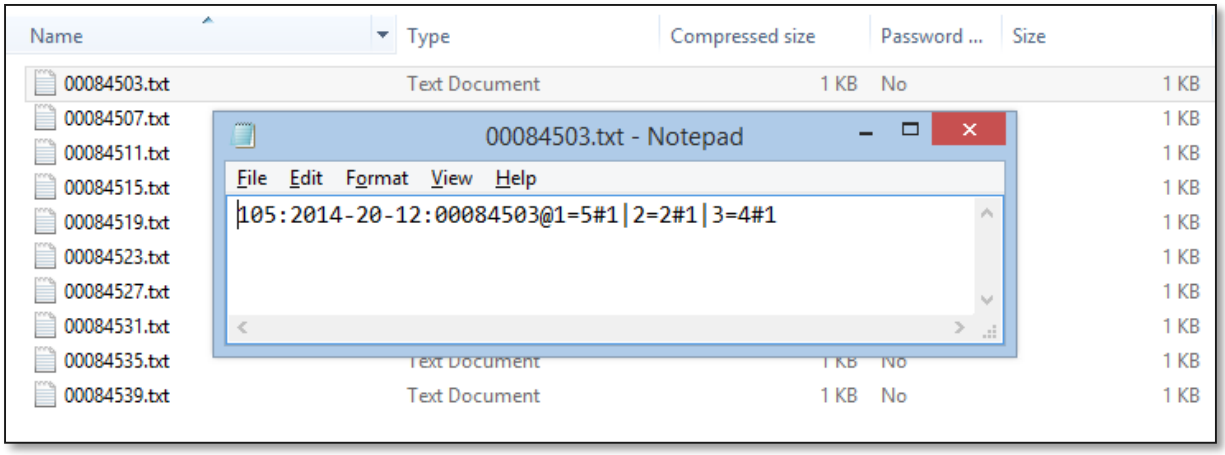


All changes made by the operator are logged. There are also special permissions that can be applied to the Verify tool so that only authorized personnel have access to it.

6.4 Ballot Duplication

Once the ballot processing is complete in IRISXtract, it exports the ballot selections and other information into separate text files for each ballot. Each text file contains the ballot style, date, serial

number, and an array of selections. The array of selections is the index of the contest and the index of the selected option(s) within each of the contests.



The export files are stored in a directory and then processed by the Ballot Replication Tool. The BRT was originally designed to receive barcode strings and convert the content to the machine-readable ballot. The BRT was modified to receive a collection of export files and perform the same process.

The BRT does not require any knowledge about the ballots in order to work; however, it does need the PDF code to appear a certain way, as described below. It needs to recognize what an oval (or symbol that represents a selection) represents in PDF terms (underlying PDF code) and how the ovals relate to the options. It also needs the blank machine-readable PDF that it will be populating. Once completed, it will marry the IRISXtract export with the blank PDF to create a complete voted ballot, which is machine-readable.

BRT's processing will first pull the blank PDF ballot style for the IRISXtract export it is processing by searching for a file named after the ballot style in the directory. Once it has the ballot style PDF, it will identify the ovals in the PDF and begin to fill in the ones listed in the IRISXtract export as selected. It is important that the IRISXtract export have the correct number of total options and the correct index

listed for the selected oval. BRT does not recognize contest or candidate names, only the order of the ovals on the PDF.

6.4.1 Reading PDF Code

BRT reads PDFs at a low level using spec code, the base codes and operators that encompass all Adobe PDFs. Below is an example of the way BRT reads the PDF code (Monmouth PDF example):

```
/Cs6 cs
1 0 0 scn
0 Tc
0 Tw
(l) Tj
/F1 1 Tf
10.8 0 0 10.8 112.08 394.56 Tm
0 g
.0259 Tc
-.0215 Tw
[St, 37.8, ev, 16.2, e, 23.7, n, 20.3,  W, 8.1, E, 18.9, L, 10.9, Z, 17.7, E, 18.9, R] TJ
-1.5778 -.7333 TD
```

Most of this data is not relevant to BRT, but there are a few key pieces of data that BRT uses to detect and select ovals. First, inside the square brackets there are letters representing a candidate name, “Steven Welzer” in this example (the numbers are for spacing). At the end of the brackets is an operator, “TJ.” This operator signifies that what came prior is shown visually on the PDF. Six lines up from that name, there is another “TJ” operator that comes after “(l).” The “(l)” happens to be what this PDF uses as the representation of an oval. With this, BRT has all the information it needs, as this oval corresponds to the candidate name that comes next. Therefore, some operation on this oval will result in the PDF showing this candidate as being selected.

6.5 Output

Once BRT has processed the ballots, it yields a completed PDF using the correct ballot style PDF for each of the IRISXtract export files. These PDFs are named with the serial number that was assigned to the ballot originally when converted to the TIFF file. These ballots can then be printed on a ballot-on-demand printer and sent through an optical or digital tabulation system.

7 Major Precinct Milestones and Events

During the course of the project, SCYTL made strides towards both the determination and demonstration goals set forth in this project. The results of both the determination and demonstration goals is best described by reviewing the major milestones and events of the project. During each of these events, SCYTL was able to exhibit progress in both areas and adjust the activity and direction based on the feedback received.

7.1 Initial Client Demonstration

This was the first major demonstration of the technology to be used in the project. The demonstration took place on September 16, 2014. The demonstration used the Monmouth County ballots and processed them through IRISXtract and BRT. Both IRISXtract and BRT had undergone modifications to set up and/or configuration to work for the project. The demonstration exposed the potential of the technology but also the unpolished exchange of information between the IRISXtract and BRT solutions.

The demonstration successfully took voted Monmouth ballots in TIFF form all the way through to the generation of fully machine-readable PDFs. The demonstration used hand marked and scanned ballots. SCYTL was unable to demonstrate multi-page or write-in support for this demonstration.
After the demonstration, SCYTL had the following takeaways in order to improve the technology:

- The technology needed to support a method of capturing write-in votes. A process was proposed and discussed with the State that would capture a .tif file in the IRISXtract Software and export it with the export data. BRT would be required to place the .tif file in the proper location on the duplicated ballot.
- The State also requested the technology have a method of adding a serialized number to the two ballots (original and duplicated) for aiding in the review process. It was believed this would be achievable with some work on both the IRISXtract and BRT side of the project.
- The BRT tool needed to support a bulk import feature instead of taking the IRISXtract export strings one at a time.
- A data conversion tool needed to be developed to seamlessly move the exported IRISXtract data to a format acceptable for import into BRT.

7.2 Council of State Governments' Overseas Voting Initiative Technology Working Group Demonstration

On December 9, 2014, SCYTL demonstrated the technology solution to the Council of State Governments' Overseas Voting Initiative Technology Working Group in San Antonio, TX. The demonstration provided a robust solution and included additional ballot formats and a broader range of ballot conditions.

The notable improvements in the solution for this demonstration were:

- The IRISXtract and BRT solutions communicated to each other in a single file format that was exported from IRISXtract and could be imported into BRT.
- BRT supported a bulk import method where it could process hundreds of export files at one time.
- Serial numbers were added to the TIFF files during the initial conversion from the original PDFs and were carried through to the final PDFs generated by the BRT solution.
- Support was added to pull write-in selections from the original ballots into TIFF files, but there was no capability to add them to the final ballots.

The following issues were identified during the meeting for continued improvements:

- The serial number created for the duplicated ballot needed to be added to the original paper ballot in order to identify the two in the case of a recount. SCYTL recommended a scanner that imprints a serial number on the document being scanned. That serial number could be used for all the paper ballots and would still use the system generated ID on the .pdf files received.
- The technology would have to be able to capture a write-in vote even if the voter did not select the write-in voting position (some states have court rulings that writing in a name is enough to show voter intent).
- The solution needed to be able to support multi-page ballots. To this point in the project, the system supported single-page ballots only.

7.3 New Jersey Association of Election Officials (NJAEO)

On March 17, 2015, The State of New Jersey's Election Director and SCYTL conducted the final demonstration of this project. The end-to-end demonstration included support for multi-page ballots and for the complete transfer of write-in votes from the original ballot to the final ballot. It included a scanner to obtain the original ballot image from a physical ballot, processing through IRISXtract and BRT, and then printing a full ballot for scanning. Due to the complexity of coding a tabulator to accept the duplicated ballot, the demonstration did not include the tabulation of the ballot. Instead, a manual comparison of the original ballot to the duplicated ballot was performed.

8 Testing and Analysis

The project included testing and analysis with multiple ballot styles from the various counties. The testing was divided into feasibility testing and then accuracy testing. For feasibility testing, SCYTL used multiple ballot formats to demonstrate the system's ability to perform duplication on multiple types of ballots. The accuracy testing used multiple ballot conditions and studied their impact on the accuracy of the duplication on a large set of ballots. The overall testing methodology involved varying types of ballot styles, voter selections, return channels, and various types of marks and spoiled ballots. The full methodology and results are below.

8.1 Feasibility Testing

SCYTL evaluated a number of different ballot formats to determine what formats could be supported with the proof of concept system. The following formats were evaluated:

- Monmouth County, NJ, Dominion Teamwork Format
- Sussex County, NJ, ES&S Format
- Dominion ICC Format
- Orange County, CA, Hart Format

8.1.1 Feasibility Testing Results

8.1.1.1 Monmouth County, NJ, Dominion Teamwork Format

This ballot format is created using the Dominion Teamwork or Sequoia Optical Scan technology. The ballots use timing marks and follow a consistent template where the ovals occupy a consistent column on the ballot. The ovals are to the right of the option text and write-in blanks. The ballot style is printed on the ballot and encoded in a series of automatically completed ovals in the top right of the first page of the ballot. The ballot styles used in this evaluation had a three-column setup. The first column was used for instructions and the second column was used for voting options. The third column was unoccupied. The ballots evaluated were 11 inch ballots.

The results of these ballots were positive. There were no issues for the technology solution using IRISXtract and the BRT components. The ballots were able to be configured in IRISXtract and read by its process, and BRT was able to accurately determine what ovals to transfer the voter's selections to in its routine to build the final ballot.

8.1.1.2 Sussex County, NJ, ES&S Format

This ballot format is created using the ES&S Unity Election Management system and is designed to be read via optical scan technology. The ballots are 3-column ballots with consistent columns for the ovals. The ovals are placed to the left of the option text and write-in blanks. The ballot uses timing marks to delineate the oval positions. The oval-to-inch ratio is 3:1. The ballots evaluated were 14-inch ballots. The ballot style was printed in text at the bottom of the middle column.

The results of these ballots were positive. There were no issues for the technology solution using IRISXtract and the BRT components. The ballots were able to be configured in IRISXtract and read by its process, and BRT was able to accurately determine what ovals to transfer the voter's selections to in its routine to build the final ballot.

8.1.1.3 Dominion ICC Format

The Dominion ICC format is a left-to-right formatted ballot that can be up to 22 inches in length. It is one large grid per ballot side. Each row is a contest, and each column is an option. There is an oval in each resulting square of the grid where the voters make their selections. The ballot style is identified in the ballot title. These ballots are not generated in the election programming software but are created by a vendor who creates and prints the ballots. Bergen, Ocean, and other counties in New Jersey use this type of ballot.

For this ballot type, IRISXtract was able to be set up, and it performed the scanning and lifting of ballot selections without issue. BRT, however, was unable to completely interpret the PDFand was unable to accurately duplicate the ballots. This was due to the way the underlying PDF code was constructed.

For BRT to work in its current design, the PDFs need to be created in a similar fashion to the Monmouth County ballot example described in Section 6.4. Too many variations make it programmatically impossible for BRT to handle a large quantity of ballots, especially with the variations discussed below.

The following is the way the code appears in a Bergen County PDF ballot:

```
h
111.24 1.095 m
111.25 1.061 111.24 .992 111.21 .89 c
111.19 .81 111.17 .75 111.16 .71 c
111.15 .636 111.15 .565 111.17 .496 c
111.26 .103 111.56 -.302 112.06 -.718 c
112.61 -1.18 113.18 -1.445 113.77 -1.514 c
113.53 -1.822 l
113.28 -2.164 l
112.73 -2.01 112.21 -1.742 111.72 -1.36 c
111.22 -.972 110.9 -.582 110.75 -.188 c
110.59 -.61 110.27 -1.004 109.81 -1.368 c
109.34 -1.733 108.78 -2.007 108.15 -2.19 c
108.07 -2.041 108 -1.924 107.94 -1.839 c
107.87 -1.725 107.79 -1.619 107.71 -1.522 c
108.45 -1.397 109.08 -1.083 109.6 -.582 c
110.13 -.063 110.41 .522 110.43 1.172 c
111 1.172 l
111.13 1.172 111.21 1.146 111.24 1.095 c
```

With this construction, BRT sees numbers and “c” operators at the end of strings. These operators are for drawing curves, and the numbers tell the positioning. This is Bergen’s oval representation. This is unreadable to BRT as it takes a representation of an oval and does an operation; there is no single oval representation in this PDF, just curve groups. The PDF is compiled with thousands of these curves, which brings about another issue: the entire PDF is populated with ovals. When trying to move a single oval, every oval on the PDF moves with it. To keep from displaying all of the ovals, white rectangles are placed over ovals that were not meant to show up. Finally, the candidate names were placed over the rectangles. Since the ovals are drawn segments, BRT cannot pick out what segments create what ovals, as there are so many.

Finally, here is a snippet from the end of the PDF's code:

```
(CHRIS ) Tj
/F8 1 Tf
13.23 0 0 13.23 352.098 526.626 Tm
(CHRISTIE) Tj
/F12 1 Tf
7.056 0 0 8.82 318.879 511.506 Tm
.0001 Tc
-.0001 Tw
[KIMBERL, 60.5, Y M. ] TJ
/F8 1 Tf
10.584 0 0 13.23 359.217 511.506 Tm
0 Tc
0 Tw
(GUADAGNO) Tj
/F12 1 Tf
8.82 0 0 8.82 347.389 450.35 Tm
[DA, 37, VID C.] TJ
/F8 1 Tf
13.23 0 0 13.23 344.28 439.01 Tm
(RUSSO) Tj
/F12 1 Tf
8.82 0 0 8.82 349.772 492.543 Tm
(KEVIN J.) Tj
/F8 1 Tf
13.23 0 0 13.23 342.066 481.203 Tm
(O  TOOLE) Tj
/F12 1 Tf
8.82 0 0 8.82 349.04 412.293 Tm
(SCOTT T.) Tj
/F8 1 Tf
13.23 0 0 13.23 339.486 400.953 Tm
(RUMANA) Tj
```

This is at the bottom of the PDF's code and is where all the candidate names are held. This poses two problems that BRT cannot correct. First, the names are all grouped together at the bottom; this gives no relation to the ovals. Therefore, there is no way to match an oval to the candidate it corresponds to on the visual PDF. This grouping of candidate names at the end of the PDF happens when the ovals are added first and the candidates are added later using a separate PDF editing software application. Second, the names themselves are not in the same order here as they are on the visual PDF. Since the IRISXtract software pulls markings from a ballot order based on visual order, a mismatch would happen when feeding that output to BRT.

Because of the different way of creating this PDF document, the BRT component is unable to understand the contents of the ballot PDF fully enough to accurately transfer the voter's selections onto the correct corresponding ballot. IRISXtract does not have any problems processing the ballot. SCYTL evaluated a different design approach to BRT that would remove its dependence on the underlying PDF code. This proposed new design is discussed more in Section 11.6.

8.1.1.4 Orange County, CA Hart Format

During the San Antonio, TX, demonstration Orange County, CA, communicated that they process as many as 80,000 ballots per election that could result in the need for duplication. Orange County uses the election management system from Hart, and SCYTL was asked to evaluate the ability to duplicate Hart ballots. SCYTL used a stock example of a Hart ballot for the evaluation.

This ballot format is created from the Hart Election Management system. The ballot has 3 columns of races and has square marking areas to the left of the option text. There are no timing marks or consistency of marking position on these ballots. The squares are added as the ballot style is rendered, and there is no grid for determining where the squares will end up per ballot style. The ballot style identifier is printed at the bottom of the center column. The ballots used in this evaluation were 11-inch ballots.

Due to the nature of the Hart ballot generation, this ballot style was difficult to process through IRISXtract or BRT. Since the voting positions move for each ballot style, there is no consistent grid by which to program IRISXtract. Furthermore, the BRT component also had difficulty duplicating ballots due to the way the PDF was created.

First, the Hart PDF ballot's creation method appears to cause all candidate names to be encoded. This encoding is not something BRT can decipher, thus making it unable to tell where candidate names are located in the example, as follows:

```
BT
11.8537 0 0 11.88 49.3209 529.3191 Tm
0 J
0 j
.238 w
1 M
.0106 Tc
<00290032003500030025002800360037000300 2b002c00360037003200350 02c00260024002f0003> Tj
T*
```

The “Tj” operator seen here is telling the PDF reader to display the candidate name, but there is a translation that happens at some point by the reader that is not known by BRT or SCYTL.

In addition, the ovals and candidate names are not being related in the file. Below is a small portion example from the end of the Hart PDF:

```
Q
18.481 561.479 16.8 .95996 re
f
.12 w
35.281 562.559 -16.92 -1.08 re
S
18.481 563.879 16.8 .96002 re
f
35.281 564.959 -16.92 -1.08 re
S
18.481 566.279 16.8 3.36 re
f
35.281 569.759 -16.92 -3.48 re
```

The ovals for this ballot are actually two rectangles drawn on top of each other, which is what a “re” operator creates. This is similar to the ICC ballot in that this grouping does not allow BRT to match a name to a marking space. One of the differences regarding the Hart ballot is that the rectangle shapes are able to be filled in by BRT, whereas the circle segments on the ICC ballot are not.

In conclusion, it was determined that IRISXtract could be adjusted to work with these ballots but would require additional configuration for each ballot style. The BRT solution, on the other hand, is unable to duplicate these ballots without a change in its marking algorithm, such as the proposed change outlined in Section 11.6. Alternatively, Hart’s existing ballot duplication technology could be used. Hart has certified a method of converting a barcode string to a duplicated ballot. IRISXtract could be set up to process the original ballot into the Hart barcode string format and pass this into the Hart ballot duplication routine. This would essentially replace the BRT component with Hart’s equivalent.

8.2 Accuracy Testing

In order to evaluate the feasibility, accuracy, and answer other important questions about the automated ballot duplication technology, SCYTL devised a testing strategy for a large-scale evaluation. This evaluation processed 3,000 ballots with a variety of conditions through the entire duplication process. Other smaller tests were also performed in order to evaluate the feasibility of certain aspects of the system, such as write-in votes, multi-page ballots, etc.

The testing consisted of the preparation of ballot test decks for Monmouth County's 2014 Primary Election. Once the test decks were prepared, SCYTL simulated the return of the ballots through one of the three return channels and imposed certain conditions on the ballots that were similar to those demonstrated on live ballots. Next, SCYTL processed the ballots through the IRISXtract system and audited those results and made observations about the process. SCYTL then processed the IRISXtract results through the BRT solution, which produced the final ballots. SCYTL audited the results from the BRT solution against the original ballot test deck and expected results. The ballots were tied back to the originals using unique identifiers generated during the TIFF conversion. Other observations and notes were made about the process as the testing was done: time to duplicate a ballot; technical skill involved; exception cases; auditability; etc.

8.2.1 Testing Setup

In order to achieve the most relevant results, SCYTL designed a ballot test deck that was representative of real conditions. The full breakdown of the test deck and conditions is provided below. The test deck consisted of ballots from all three return channels—postal mail, fax, and email—with the following statistical representation:

- Postal Mail – 50%
- Fax – 25%
- Email – 25%

For each return method, certain "conditions" were applied to the test ballots to represent typical conditions witnessed with live ballots. These conditions were applied evenly to each of the postal mail, fax, and email test sets.

- **No Conditions** – the ballot was marked normally and there were no conditions applied
- **Folded** – the ballot was folded for fitting into an envelope and introduced noise into the digital image where the folds were
- **Torn** – the ballot was torn in incidental ways
- **Defaced** – water marks at various transparency percentages were introduced to simulate various levels of spoiling

Additionally, different fax transmittal qualities were used, such as hyperfine/superfine – 408×391 dpi (dots per inch) or ppi (pixels per inch), fine – 204×196 dpi or ppi, and low/normal – 204×98 dpi or ppi. Various modifications were made to the digital copy to simulate potential ways in which voters return the ballots. The following modifications were made:

- **Reduced** – the 14-inch ballots were reduced to 11 inches
- **Expanded** – the 14-inch ballots were expanded to 17 inches
- **Orientation** – the ballots were processed by portrait and landscape
- **Rotation** – the ballots were rotated 90 degrees
- **Black and White** – black and white copies were generated
- **Color Copy** – full color copies were generated

8.2.2 Accuracy Test Results

Of the 3,000 ballots processed, 2,995 were processed completely through the IRISXtract and BRT solutions without any issues with reading, interpreting, or duplicating the ballots. Five (5) of the ballots had issues in the reading portion and were sent to the Verify tool for manual review. IRISXtract had difficulty reading the ballot style ID of these ballots on the initial pass. All five of these ballots were low DPI faxed ballots. It was possible within the Verify tool to manually enter the ballot style and proceed through the rest of the process. The ballots had no further issues. During all of the testing, there was never an incident where IRISXtract or BRT misinterpreted the ballot selections and incorrectly duplicated a ballot. There was never an incident where a ballot—in any condition—had to be duplicated outside of the technology.

During the large deck testing and ad hoc testing, the reduced, expanded, orientation, rotation, black and white vs color, and faxed variations were successfully read and understood by the IRISXtract software with two exceptions. First, IRISXtract did experience trouble processing the second page of the Monmouth ballots because they did not provide enough page alignment marks to facilitate error correction. As explained in Section 6.3, each ballot page needs to have distinct marks that allow IRISXtract to determine sizing or skew problems in order to correct them. Because the second page of the Monmouth ballot lacked any sort of error correction marks, IRISXtract was not able to process reduced, expanded, or skewed variations of this page. Second, if the ballots were folded, torn, or defaced where the Ballot Style code was printed, IRISXtract had trouble reading the value and would send the ballots to the Verify tool.

SCYTL also noticed the marking device seemed to be a significant factor in picking up marks. Since adjustments can be done in the IRISXtract tool to adjust the sensitivity, the variations in marking devices can be accommodated to a large extent. One proposal for improvement was to introduce a dynamic analysis to the processing to determine the voter's typical marking style on a ballot and then automatically adjust the thresholds accordingly. This proposal was not tested.

8.3 Solution Limitations

Overall, the technology solution was capable of performing the entire duplication process with a great amount of accuracy, flexibility, and scalability. It does, however, still have limitations that were not able to be resolved in the time and scope of this project. These limitations are listed below. For possible solutions to these limitations, see Section 11.

8.3.1 Reporting

The reporting capability of IRISXtract and BRT are limited at the current time. There is great potential for the collection and reporting of important data points, and this limitation can be removed. Currently, the IRISXtract software has a Cockpit that clearly shows the disposition of each ballot, number processed, number requiring verification, serial numbers, etc. IRISXtract also has the ability to report what has happened to the ballot, what modifications were made to the ballot in Verify and by whom, and how much time the ballot spent at each stage. The BRT Software does not create reports, but it can be modified to collect data and build reports for it.

8.3.2 Use of PDF Code

One of the main limitations is that the BRT Software requires that the PDF must have been created in a way that allows BRT to understand and manipulate its internal construction. This restriction can be removed by refactoring BRT, as described in Section 11.6.

8.3.3 Alignment Bar and Ballot Style Code

To enable all the functions of the IRISXtract Software (alignment, rotation, reduction, etc.), it is necessary to have some kind of page alignment marks or objects on each page. If the ballot is devoid of any sort of artwork that can be used as a reference point to fix a ballot that has been reduced, skewed, or rotated, the IRISXtract tool is limited in its ability to accept and read all returned ballots. This occurred with the second page of the Monmouth ballot: there were no markers on the second page that would allow the software to preform error correction. Also, IRISXtract needs to be able to read the ballot style indicator (either bar code, oval pattern, or number) to know what style to export to BRT. This ballot style indicator is best represented with a barcode or large image since the small text of a number is usually heavily pixilated when reduced or set to a lower resolution.

8.3.4 TIFF Files

The project limited the input files primarily to the Black & White TIFF file format. SCYTL did not evaluate additional formats, such as PDFs or other common formats, which may be preferable to other jurisdictions. While other formats are supported, it is not known if they are as accurate as the Black & White TIFF files. It is the Black & White—not the TIFF—that aids in accuracy of the optical mark resolution as opposed to grey scale and full color.

8.3.5 Number of Write-In Votes

Currently, IRISXtract and BRT are unable to lift and duplicate multiple write-in votes per contest. If there is a single write-in vote, IRISXtract will create an image file of the written name and BRT will place that image on the duplicated ballot. The solution, however, cannot do this for multiple write-in votes per contest.

8.3.6 Write-In Vote Without Marked Oval

It was presented that some jurisdictions—such as California—require the duplication of a write-in vote even when the corresponding oval is not marked. This means the voter wrote something in the blank to the right or left of the write-in oval but did not mark the oval itself. The request was for the solution to be able to detect the presence of the hand-written name without requiring the oval to be marked. This is currently not possible within the solution. The solution requires the oval to be marked in order for an image of the write-in selection to be captured.

8.3.7 Error Checking

Currently, the overall solution does not perform error checking for possible inadvertent errors made by operators or one of the components in the solution. The known gaps are:

Scanning a Ballot Twice – it is conceivable that an operator may process the same ballot twice through the duplication system and do so undetected if no audit is performed. This is possible when a user takes an emailed ballot and processes through IRISXtract twice or more to create multiple export files and thus multiple machine-readable PDFs from BRT. If there is no post-election audit to reveal more ballots cast than voters who voted, this will go undetected. There are numerous ways in which this can be mitigated but were not addressed in this project. These types of solutions to prevent this are discussed in Section 11.

Incorrect Reading of Ballot Style ID – due to the nature of BRT's marking algorithm, if the ballot style ID is misread by IRISXtract or if IRISXtract is off by an oval, the results in BRT could be completely incorrect. BRT does not perform any error checking to confirm the ballot style is correct or to verify if the number of ovals reported by IRISXtract matches the number of ovals on the ballot style. Adding this error checking step, as proposed in Section 11.2, could prevent possible issues.

9 Technology Evaluation

In order to fully review the automated ballot duplication technology, the SCYTL research team identified a series of criteria for which to compare the current ballot duplication process described in Section 5.1 and the proof of concept used in this research. The comparison should inform interested parties of the areas in which the automated ballot duplication approach can be helpful and areas where it may not be. For further review, SCYTL has added an additional section on how more optimal results can be achieved with the automated ballot duplication approach using SCYTL's recommended solution instead of the proof of concept.

For the analysis below, the testing results from the previous section were used along with information provided by the New Jersey Division of Elections and reports from election specialists familiar with typical manual ballot duplication processes.

9.1 Evaluation Criteria

The following evaluation criteria were used to compare and contrast manual ballot duplication to automated ballot duplication.

CRITERION	DESCRIPTION
ACCURACY	The likelihood that the duplication process leads to the correct transcription of ballot selections onto the correct ballot style and only creates one final duplicated ballot for each returned ballot
ADAPTABILITY	How easily the solution can be used in different jurisdictions, with different technologies and different processes (i.e. how universal is the technology)
AUDITABILITY	The presence of a chain of custody and other audit controls that would allow an auditor to confirm the correct duplication of ballots
LOW COST	The financial cost of the duplication technology and efforts over a 2-, 4-, and 8-year time period
EASE OF ADOPTION	The level of difficulty to adopt and begin use in a jurisdiction: How much training is required for each member of the staff to be prepared?
EASE OF SETUP	The amount of time and level of skill required to set up the duplication technology and/or process
EASE OF OPERATION	The ease at which an election official can manage or operate the procedure/technology
EFFICIENCY/SPEED	The amount of time spent actively duplicating ballots or operating the technology
RELIABILITY	The ability to complete ballot duplication accurately and timely for each ballot and election, factoring in personnel issues, technology down-time, etc.
REPORTING	The level of reporting available, including ballot statistics and analytics useful to improving the process
SCALABILITY	The amount of the process that can be scaled without a disproportionate amount of difficulty to maintain the current process
TRANSPARENCY	The visibility of the duplication process and results to voters, officials, and interests groups

9.2 Scoring Methodology

Each evaluation criterion is given a weight that represents the overall importance of that criterion relative to the other criteria. This weight is then multiplied by the score in each area for each duplication method. The results for each method/criterion are then compiled to give each method a total score. The ballot duplication method with the highest score should be considered the most viable approach for ballot duplication.

Weights are given from 1 to 10 with 1 being the least important to 10 being the most important. Scores are given from 1 to 10 with 1 representing a complete inability to perform in the area and 10 being a perfect ability to perform.

The weights used for scoring each category and the rationale are provided below.

CRITERION	WEIGHT	DISCUSSION
ACCURACY	10	Accuracy is the most important factor. The duplication process must properly obtain the voter's selections and must properly identify the correct ballot style on which to transcribe them.
ADAPTABILITY	4	Adaptability means the solution can be used with any election management and tabulation platform as well as any election rules. It allows many jurisdictions the ability to use automated ballot duplication. This also allows jurisdictions to update technology around the ballot duplication solution without having to upgrade this solution. This category refers to the technology adaptability and also how well the solution adapts to different voting rules, ballot designs, and return methods. Since this criterion does not impact the voter or the accuracy of the duplication, it does not receive a high weight.
AUDITABILITY	8	Auditability is important to ensure the accuracy of the system can be reviewed and proven accurate and reliable. This category instills public trust and enables recounts where the original ballot must be reviewed.
LOW COST	7	Costs are considered at 2, 4 and 8 years using a standard 4-year election cycle. The cost is important to ensure the process/technology is financially viable for jurisdictions to purchase and maintain. The category is weighted high since reducing cost is one of the main goals of the research effort.
EASE OF ADOPTION	3	This category refers to how easily the solution can be adopted by a jurisdiction. If it is too difficult for a jurisdiction to adopt, the solution is less viable. It should be as simple as possible without requiring large changes in processes. Since the criterion does not directly impact the voters, and it is typically a one-time process, it does not receive a high weight.
EASE OF SETUP	5	This is how easy the duplication process/technology is to set up per election. It should not be time consuming. While it is one time per election, the election staffs are very busy during the pre-election cycle and this setup cannot take up too much of their time.

CRITERION	WEIGHT	DISCUSSION
EASE OF OPERATION	6	This reflects how easy the solution is to operate. The operation should be simple, intuitive, and not require a highly technical skillset. Since this is part of the actual election processing, this category receives a higher score than the setup and adoption.
EFFICIENCY/SPEED	6	The ballot duplication should not delay other election processes. It should be efficient, take an appropriate amount of people, and not create an additional burden on resources.
RELIABILITY	5	The reliability of the duplication is important to the overall viability of the solution. The duplication should not require excessive troubleshooting. The duplication solution should work in nearly all cases.
REPORTING	4	Reporting is important to evaluate the duplication efforts, but it does not impact the overall outcome of the duplication.
SCALABILITY	5	The system's ability to increase its capacity without a similar increase of burden is an important factor. Many times, the amount of duplication required is unknown and planning becomes a challenge when the people or time devoted to it have to increase with the volume.
TRANSPARENCY	4	Due to the nature of duplication, it is important that the process is transparent. Users and the public should be able to see how the original ballot is processed into the duplicated ballot and be able to validate the correct duplication.

9.3 Scoring

9.3.1 Manual Ballot Duplication Evaluation

Manual duplication is the current approach taken in New Jersey and in major jurisdictions across the United States. The process involves multiple people from the election office sitting down, reviewing the ballot that cannot be scanned, and hand copying the selections to a machine-readable ballot of the same ballot style. The following table presents the scores for the manual duplication approach and the rationale for the score.

CRITERION	SCORE	DISCUSSION
ACCURACY	8	Human error is always a factor, even when multiple people are involved. While SCYTL does not believe that mistakes are made often, there is a chance that mistakes are made with any intense human-effort project. This risk increases as volume increases.
ADAPTABILITY	10	Manual duplication is 100% adaptable to any situation. If the original ballot can be marked by hand, then manual duplication can occur.
AUDITABILITY	5	One can create a chain of custody and impose serial numbers on ballots that will facilitate a full audit of the duplication process. This is an effective system which allows officials to trace back and audit duplicated ballots and their originals. While this is not difficult to maintain for a small number of ballots, the ability to maintain this system and conduct an audit is more difficult as volume increases.
LOW COST	4	Manual duplication has a high operating cost. The cost of manual duplication is roughly the same as each election before it. This means manual duplication costs remain constant for each election, assuming similar turnout, instead of reducing over time. This is a poor model for long-term cost reduction.
EASE OF ADOPTION	8	Manual duplication is a fairly easy concept to adopt and to incorporate a procedure and workflow around.
EASE OF SETUP	8	The setup for manual duplication typically involves the organization of three people to perform the duplication, along with the blank ballots and other supplies needed. This is not a difficult process to set up.
EASE OF OPERATION	4	Manual duplication is a laborious effort by multiple people. It requires that each person pay careful attention at all times and review each other's work. Each ballot must have the attention of each person and the effort does not scale well.
EFFICIENCY/SPEED	1	Manual duplication can typically occur at rates of 4-5 minutes per ballot side. This includes time for the persons performing the duplication to interpret the marks and make them on the new ballot and time for the observers to review the duplication before proceeding to the next side.
RELIABILITY	9	Manual duplication is extremely reliable since it only needs the original ballots, blank ballots, marking devices, and people to perform the duplication.

CRITERION	SCORE	DISCUSSION
REPORTING	2	There are very little reporting capabilities inherent in manual duplication. There is no data collection for reporting.
SCALABILITY	2	The ability to scale is directly proportional to the resources devoted to the project. There is very little ability to increase capacity without costing additional time or money.
TRANSPARENCY	8	Manual duplication provides a direct comparison of the original ballot to the duplicated ballot during the process. It does not rely on any software or other electronic process.

9.3.2 Automated Ballot Duplication Evaluation (Proof of Concept – POC)

The following table presents the scores for the automated duplication approach used in this project and the rationale for the score.

CRITERION	SCORE	DISCUSSION
ACCURACY	8	The solution offers an extremely accurate image processing component that ensures marks are correctly determined. No issues were found during any of the testing performed as a part of this project. However, the proof of concept does not perform as much error checking as the recommended system, and, thus, the accuracy is not as highly scored.
ADAPTABILITY	7	The proof of concept has limitations that may prevent it from being used everywhere. It does, however, have most of the capabilities needed across the U.S. and has been demonstrated to work with some of the popular ballot formats.
AUDITABILITY	3	The proof of concept system is not a unified solution; thus, the auditability is limited to each component trusting the prior one and vice versa. One other area of weakness is the original recording of an electronic ballot into the software (e.g., ballots returned by email). There is currently no scheme to ensure these ballots are marked with a unique tracking number only once. This weakness can be managed by people and processes, but it is preferred if the system had its own mechanism.
LOW COST	3	As discussed further in Section 10.5, the election cost of automated duplication reduces over time for larger counties (counties above 100,000 registered voters). Manual duplication costs, on the other hand, remain the same per election. This leads to mid- and long-term cost savings for automated duplication versus manual duplication. Cost savings are realized sooner for larger counties. For example, counties larger than 200,000 see a cost reduction versus manual duplication after the first 4-year election cycle.
EASE OF ADOPTION	3	The adoption of this new technology in its current form would be somewhat difficult. The jurisdiction would need to have a moderate/high technical staff and be trained. The change in their processes would be minimal, however.
EASE OF SETUP	4	The most difficult part of the setup could be done as part of a service offering since it is a one-time setup, as long as the ballot artwork remains the same between elections. The other aspects of the setup are simple but repetitive.
EASE OF OPERATION	8	Once it is running, the software is easy to operate. It can be started and left to run on its own. The operator can monitor and print the results when it is done. There are a few intermittent steps, but they are simple.

CRITERION	SCORE	DISCUSSION
EFFICIENCY/SPEED	9	IRISXtract can process ballots at 300/hour with some variance based on the complexity of the ballot. Other parts of the process can run faster, but the IRISXtract processing of the ballot is the limiting factor. This is still a significant increase over manual duplication but may take a few hours to complete for larger jurisdictions. Since it can be left to run on its own, this amount of time does not take away from time the operator can be doing other things.
RELIABILITY	7	Since there are machines involved, such as the scanner and printer, the reliability is equal to the reliability of those machines. The project did not test various machines for reliability, but industrial scanners and printers should have minimal issues.
REPORTING	6	Since the software can collect various data points, the reporting capabilities increase significantly compared to manual duplication. The proof of concept does not have as much reporting as the recommended solution could have.
SCALABILITY	10	With a high-speed scanner, printer, and this technology solution, the amount of time and effort grows at 1/100 of the pace of manual duplication. In other words, as the number of ballots grow, the amount of time needed to duplicate them using this solution will be 1% of the time it takes to manually duplicate them, per ballot. For example, for 100 extra ballots, it may take an additional 8 hours to perform manual duplication, whereas it would take an extra 5 minutes (of an operator's time) with automated duplication.
TRANSPARENCY	4	The operator has full transparency into the determination of all of the selections and ballot styles. This is only available to certain users, but the comparison of the original to the new can be saved and shown to others who need to see. Therefore, the potential for full transparency is there, but it is not present in the proof of concept.

9.3.3 Automated Ballot Duplication Evaluation (Recommended Solution)

Throughout the project, SCYTL has identified optional improvements that would increase the solution's ultimate viability. The following table presents the scores for the recommended automated duplication approach, with many of the improvements suggested in Section 11, and the rationale for the score.

CRITERION	SCORE	DISCUSSION
ACCURACY	9	Accuracy is improved from the proof of concept because of additional error checking. Error checking improvements are discussed more in Section 11.2.
ADAPTABILITY	8	Adaptability can be greatly improved by adding support for additional ballot types and multiple write-in votes. This could also be accomplished by refactoring BRT to use X-Y coordinates instead of the PDF encoding to mark ballots. This is discussed more in Section 11.6.
AUDITABILITY	8	Adding a unique serial number to each ballot with a scanner and embosser will facilitate a unique tracking number that will allow for the full comparison of original to final ballot. This is discussed further in Section 11.1.
LOW COST	5	While the cost of the actual duplication is less per page, the initial cost of the duplication software, training, etc., is higher than the initial cost of manual duplication. Over time, the initial cost plus ongoing costs are less than the same costs for manual duplication. This is especially true for larger jurisdictions that manually duplicate hundreds of ballots per election. In fact, after the first 4-year election cycle of using the recommended system, the cost for a jurisdiction with 200,000 voters breaks even and begins to be less and less with the automated duplication versus manual duplication. This is discussed more in Section 10.5.
EASE OF ADOPTION	6	The recommended solution would have better documentation and utilize a singular interface. This would make it easier to use and adopt. This is discussed more in Section 11.4.
EASE OF SETUP	6	The recommended solution would provide a singular module to set up and remove as many setup steps as possible. This is discussed more in Section 11.4.
EASE OF OPERATION	9	The operation is made easier by unifying the solution and removing the need for an operator to know how to use IRISXtract and BRT.
EFFICIENCY/SPEED	10	The efficiency and speed is improved by creating a unified solution that does not require operator assistance between IRISXtract and BRT.
RELIABILITY	7	Hardware and machine reliability would remain the same from the proof of concept to the recommended solution.

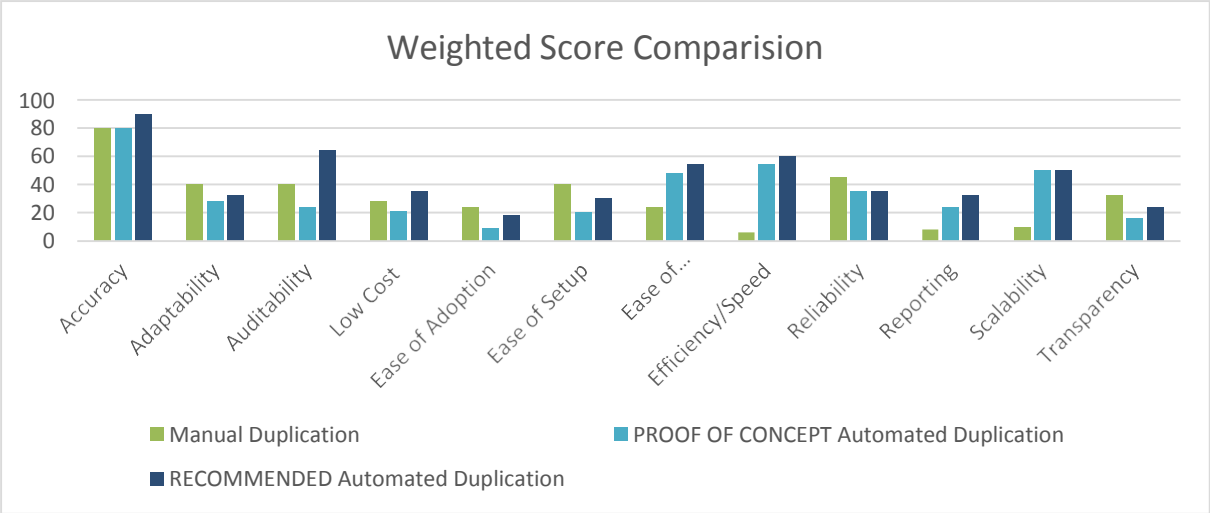
CRITERION	SCORE	DISCUSSION
REPORTING	8	Additional reports would be built into the recommended solution.
SCALABILITY	10	While the system is limited to processing 300 ballots/hour, a second parallel system with separate software and hardware could be built out to achieve 600 ballots/hours. This increase in capacity would not have any repercussions on the process.
TRANSPARENCY	6	The recommended solution will have a publishable side-by-side comparison of the original and duplicated ballots. This would allow anyone to see the original as marked by the voter compared to the final duplicated ballot and verify the duplication was performed correctly.

9.4 Overall Evaluation Scores and Discussion

The weighted scores per evaluation category are shown below.

	MANUAL DUPLICATION	PROOF OF CONCEPT AUTOMATED DUPLICATION	RECOMMENDED AUTOMATED DUPLICATION
TOTAL WEIGHTED SCORE	**377**	**409**	**524**

CRITERION	MANUAL DUPLICATION	PROOF OF CONCEPT AUTOMATED DUPLICATION	RECOMMENDED AUTOMATED DUPLICATION
ACCURACY	**80**	**80**	**90**
ADAPTABILITY	**40**	**28**	**32**
AUDITABILITY	**40**	**24**	**64**
LOW COST	**28**	**21**	**35**
EASE OF ADOPTION	**24**	**9**	**18**
EASE OF SETUP	**40**	**20**	**30**
EASE OF OPERATION	**24**	**48**	**54**
EFFICIENCY/SPEED	**6**	**54**	**60**
RELIABILITY	**45**	**35**	**35**
REPORTING	**8**	**24**	**32**
SCALABILITY	**10**	**50**	**50**
TRANSPARENCY	**32**	**16**	**24**



The weighted comparison shows that the recommended solution is the most viable approach. The manual duplication and the proof of concept's automated duplication received much lower results, but their total scores were very similar to one another. This is due to both approaches having different strengths and weakness. Manual duplication is more reliable, adaptable, transparent, and easier to adopt and set up than the proof of concept automated duplication option, while the automated duplication is easier to operate, much faster, and more scalable.

The full recommended automated duplication solution yielded the highest overall score because it addresses some of the weakness with the proof of concept. For example, by improving the ability to add unique serial numbers to the ballots, the auditability score is improved. By unifying the two modules—IRISXtract and BRT—into a single user interface, the ease of operation and efficiency are also further improved. Finally, by refactoring some of the duplication logic, additional ballot types can be supported.

10 Accomplishments

The New Jersey Electronic Ballot Duplication System project achieved some great and important steps towards a full-scale automated ballot duplication solution that does not rely on barcodes. The project evaluated a new technology to read and duplicate ballots and found that it has great promise to be an accurate and scalable solution to ballot duplication problems. The project also evaluated very diverse ballots and found the technology will be able to transfer well across many different election platforms, though not all of them. If produced at the recommended level, the technology stands to be a cost-effective, accurate, and fast method for duplicating nearly all ballots that jurisdictions are currently duplicating by hand.

10.1 Duplication Without Barcodes

The primary goal of the project was to determine the feasibility of “scrapping” ballots for the information necessary to create a duplicate ballot. The technology could not assume the ballot style or any of the ballot content. A barcode, which stores this information in an easily transferable format, could not be used. The project successfully designed a solution to perform this activity and proved the solution’s capabilities through multiple demonstrations and testing events. Any similar testing of this type of technology has not been done to SCYTL’s knowledge. The only known solutions currently available rely on 2D barcodes imprinted by the marking technology the voter used. This encompasses a limited amount of ballots because it requires the voters to use an electronic marking technology. The PDF “scrapping” technology proven in this project is able to duplicate any ballot no matter the voter’s marking method and do so with a high degree of tolerance for ballot conditions.

10.2 Accuracy of Duplication

One of the main concerns of this technology was how accurate it would be given the high number of conditions that are normally found with returned ballots. In the testing conducted, the project team evaluated many common and uncommon conditions and found the technology to display a high degree of tolerance for these conditions while remaining accurate. Much of the tolerance depends on the original ballot design. In this report, each ballot layout should have some characteristics that will offer a basis for error detection and correction. This is already present in most ballot design but not all. Additionally, the software is trainable and can become more and more accurate over time and for different scenarios. For example, IRISXtract has a module that was not used during the project but has the capability to be shown images and associate them to an understood result. This can be applied to unique fonts, images, etc. Furthermore, it is believed that the software can even learn voter behavior as it scans a ballot and automatically adjust thresholds for mark-detection based on a pattern it sees with the ballot. This would improve the accuracy of the system for voters who tend to mark very light or who put slashes or Xs in the ovals instead of filling them in. Since the testing conducted during the project yielded completely accurate results, these further tuning activities were not evaluated.

10.3 Flexibility of Duplication

Another one of the main concerns when performing automated ballot duplication without an intelligent barcode is the flexibility of the solution to handle different ballot designs and nuances between election management systems in the United States. SCYTL found the solution had a high degree of flexibility with the various election concepts and ballots and could transfer between states and counties. There are some restrictions that can be removed to make the technology even more transferable. Here is a breakdown of different ballot characteristics.

Ballot Characteristic	Imaging Processing	Duplication
Write-in Votes	IRISXtract is able to lift the write-in votes and store them in TIFF files.	The BRT solution is able to stamp the TIFF image into the ballot PDF on the corresponding write-in line.
Multiple Write-in Votes per Contest	IRISXtract is able to lift multiple write-in votes.	BRT is not able to apply multiple write-in votes at the current time.
Vote for Multiple	IRISXtract is able to collect multiple voter selections for each contest. There is no limit to the number of options supported.	BRT is able to duplicate multiple selections per contest. There is no limit to the number of options supported.
Multiple Pages	IRISXtract can be set up and adjusted to read selections from multi-page ballots. There is no limit to the number of pages supported, as long as it is configured in IRISXtract.	BRT is able to duplicate voter selections onto multi-page ballots. There is no limit to the number of pages supported.
Original Ballot Dimensions	IRISXtract can be set up to work with any original size ballot. This includes the common dimensions of 11-, 14-, and 17-inch ballots. The orientation of the ballot is also not important for IRISXtract.	BRT is not affected by the original ballot dimensions.
Marking Shape	IRISXtract can work with any shape that is used by voters to make their selections. The software checks for a threshold of pixels in the image it is processing so that it can be configured to work with any shape, whether it is an oval, square, arrow, or something else.	BRT is also agnostic to the shape but must be programmed separately for each one.
Column-Based Ballot Design	IRISXtract can be set up to read ballot selections from multiple columns going top down.	BRT is able to understand the ballot and duplicate selections in a column-based ballot design.

Ballot Characteristic	Imaging Processing	Duplication
Left-to-Right Ballots	IRISXtract can be set up to read ballots that use an alternate reading direction, such as left-to- right in a grid configuration.	BRT can be modified to support left-to-right reading direction but is not currently set up to do so.
Alternating Marking Positions	If the oval positions vary in their X and/or Y coordinates for each ballot style, IRISXtract will need to be configured for each ballot style. This is not true when ballots have a fixed grid for the marking positions. Therefore, alternating marking positions is achievable but not preferred.	BRT can work with alternative marking positions as long as the PDF code enables it to read the ovals and associate them with candidates. It is also important that the order of ovals in the PDF code correspond to their visual representation.
Image/Document Formats	IRISXtract can accept nearly any image file to conduct its setup and to read during operation. TIFF was used in the project, but PDF, DOCX, JPEG, PNG, and others can be used.	BRT is limited to only supporting blank ballot style PDFs that have an underlying code structure that is interpretable and can be manipulated.

10.4 Duplication Speed and Scalability

The technology solution studied in this project can duplicate ballots up to 25 times faster than manual duplication. In other words, the automated ballot duplication can process 300 ballots an hours, while typical manual duplication can process 12. The automated duplication process also does not require an operator to be present during the duplication process. If it is done in stages, the operator only needs to assist the technology in stage transitions and to address any ballots that go to the Verify module. This greatly reduces the amount of time and attention the duplication process takes compared to manual duplication.

When scaling the operation due to unexpected volume or a larger election, the automated duplication takes a minimal amount of extra time during the setup and operation. The work in the setup is directly proportional to the number of ballot styles. This will not vary with how many ballots are returned and need to be duplicated. The amount of time required for duplication is only increased by the amount of time required by IRISXtract to run and does not necessarily mean that a staff member will need to devote additional time. IRISXtract and BRT can be scaled without purchasing additional hardware or software. If the user did need to go faster than 300 ballots/hour, the solution can be run in parallel, thus increasing the speed with every parallel system installed.

10.5 Long-Term Cost Reduction

SCYTL prepared a cost model by which it compared the current manual duplication process and the recommended automated ballot duplication solution. The model is based on a simple electoral model in a medium-sized county. Here are some of the parameters for the cost model:

Parameter	Description	Amount Used
Election Official Hourly Cost	The average hourly rate for the election officials who set up and perform the duplication responsibilities.	$ 21.00
Election Assistant/Staffer Hourly Cost	The average hourly rate for the election staff that perform the duplication responsibilities.	$ 12.00
Registered Voters	Number of registered voters in the county	200,000
Duplication Ratio	Expected percentage of ballots to duplicate	2%
Election Officials Involved	Average number of election officials involved in some way with the duplication process	2
Election Staff Involved	Average number of election assistants/staffers involved in some way with the duplication process	3

The research team used a 4-year election model consisting of Presidential, Gubernatorial/Statewide, county, and municipal elections. This included two Presidential (includes the Primary), two Gubernatorial/Statewide, four county, and four municipal elections. The research team varied the expected turnout and size of the ballots for each of these elections.

Using this model, the research team found that the manual and automated ballot duplication process cost about the same amount over the first 4-year election cycle in a county with 200,000 registered voters. The model further found that manual duplication is roughly 55 percent of the automated cost at two years and roughly 137 percent of the automated cost at eight years. This means manual duplication is cheaper at two years and more expensive by eight years. The automated approach has higher upfront costs and an annual license fee, whereas the manual duplication approach has higher operating and personnel costs. For every 4-year period after the initial 4-year period, manual duplication costs are basically the same amount for each election cycle, which is equivalent to 100 percent of the original cost. For automated duplication, the cost is only 47 percent of the original 4-year cost. In other words, manual duplication will increase its costs faster than the automated approach over time, and automated duplication will become increasing more cost efficient as time goes on.

This remains true for counties with 100,000 or more registered voters. For counties with less than 100,000 voters, the software license costs exceed the cost of manual duplication; therefore, automated duplication will not be as cost effective. Counties with greater than 100,000 will see a long-term cost reduction, but the breakeven point will vary. For counties between 100,000 and 200,000 registered voters, the breakeven point will be closer to eight years. For larger counties, the automated duplication approach will be cost effective as early as three years. The exact breakeven points depend heavily on the particulars for each jurisdiction.

11 Recommendations

Based on the analysis and the comparison completed in Section 9, SCYTL believes it is prudent to continue this overall course of action and follow up on the technology presented here with its recommended version. As shown, an enhanced version meeting these recommendations has the potential to remove some of the issues with the proof of concept and prove to be a better option than manual duplication.

Throughout the course of the project, SCYTL prepared thoughts and suggestions for improvements that went beyond the scope of the project. The following sections identify the areas SCYTL believes can be improved in a successor to the proof of concept.

11.1 Unique Identification of Each Ballot

In order for the system to be truly auditable, each ballot must be uniquely accounted for, and the system must be able to ensure no outside or inside user duplicated a ballot more than once. Even without advanced identification, this type of behavior can be caught by manually reconciling the voter history with number of ballots tabulated (this is already being done), but SCYTL believes the duplication technology must make this process easier.

The first step is to realize that paper ballots and electronically returned ballots present two unique issues. For the paper ballots, the paper itself must be marked in a unique way and the duplication software must record the unique mark and ensure it is not scanned again. For electronic ballots, malicious or inadvertent duplication before being uniquely identified is also an issue. For both of these situations, the solution is to uniquely identify each ballot before ballot canvassing.

Once each ballot has been marked with a unique identifier, IRISXtract will read the identifier and check against any previously processed ballots. Any ballots with the same identifier will not be processed and will later be rejected as a duplicate. The unique ID will be read and passed to BRT, which will stamp the same ID on the duplicated ballot to ensure the original and duplicated ballots can be paired together if necessary.

11.2 Additional Error Checking

There are a few errors that can occur during the duplication that can be better accounted for in an enhanced solution. First, the IRISXtract system can be configured with a range of pixels that can be read as “possible marks.” This establishes a range of pixels where the system can prompt the user for a manual determination instead of making an automated mark or no-mark determination. This was not used during the evaluation but should be because it will allow for greater scrutiny of potentially questionable marks.

Second, the BRT solution accepts the IRISXtract export without scrutinizing it. One of the validations it must do is validate that the IRISXtract export accounts for all marking positions on the ballot. This is because BRT works based off of contest and option counters. It marks options on the duplicated ballot based on whether the current oval count is listed as marked in the export. This approach is fine if the IRISXtract export correctly accounts for every oval—marked and unmarked. However, if the IRISXtract export is off by just one, it will throw off the duplicate marking on every contest from where the error occurs throughout the rest of the ballot. While this is an impractical scenario, the final recommended solution should prevent it by checking the export file to ensure it accounts for each oval. The best approach is to share the database of possible voting positions from IRISXtract to BRT. This will allow BRT to make sure the export contains the possible voting positions that the administrator configured.

11.3 Self-Learning IRISXtract Scanning

IRISXtract works from a threshold of pixels that is applied to the marking area. If there are a greater number of dark pixels than the threshold, this is considered a mark. Otherwise, it is not. This threshold is currently applied to the entire set of ballots being processed. It is potentially possible, however, for IRISXtract to dynamically adjust this threshold based on a pattern it sees for each ballot. For example, if the user takes all marks from a ballot, the system can do a statistical analysis of the types of marks the person is making. If the system sees a consistent pattern, it is possible to create new parameters for that one ballot. This is better than setting thresholds that remain constant across all ballots and should yield even more accurate results.

11.4 Unification of IRISXtract and BRT

One of the drawbacks to the proof of concept solution is its combination of IRISXtract and BRT through an export/import process. The final recommended system would create a unified platform that utilized the core frameworks of IRISXtract and BRT and presented a unified dashboard for the user. The solution would utilize the power of IRISXtract for Documents solution and combine it with the capabilities of BRT. This would be a .NET application using the IRISXtract Programming Toolkit for C#. This would result in a single application interface for users during the ballot duplication operation. This approach would remove the requirement for the two systems to coordinate through a file exchange during operation. There is some configuration of IRISXtract that may be necessary per election, but the intention is to automate that setup through the use of the IRISXtract toolkit.

One potential feature of the recommended system is user-less operation. For instance, the solution can be configured to work with a scanner and immediately begin processing scanned images or configured to search for a directory of images to process. As it scans each one, it will use IRISXtract and BRT to create side by side images of the original and duplicated ballots. Operators can see the ballots as they are being processed and review them when the processing is complete. The solution can also automatically print completed ballots when finished processing each one, or it can wait for operator conformation before printing.

The process will still report any uncertainty or errors and will launch the IRISXtract Verify tool if needed.

11.5 Improve Setup Requirements

The setup process can be improved by adding a preprocessing step to the solution to perform what the setup process is currently requiring an operator to perform. This preprocessing step will use IRISXtract technology to setup up IRISXtract for duplication. The preprocessing will identify a unique ballot style identifier and a list of contests, options, oval X position, and oval Y position mappings for each blank ballot style. This would eliminate the need for the user to point to each oval and map it to the contest and option for each ballot style. This will still assume consistent artwork is used in the jurisdiction for all elections. The preprocessing step will eliminate one of the more technical aspects of the setup.

11.6 Refactor BRT Logic

The SCYTL BRT software was designed to read the low-level PDF code to understand the ballot and convert the voter's selections into selections on the PDF's visual representation. This approach works well for ballots constructed using PDF code, which is interpretable and contains certain relationships. However, PDFs can be created in many different ways to achieve the desired visual representation and may not always have the underlying relationships necessary for BRT.

There is an alternative approach that could be taken to achieve the same results but without requiring the PDF to be created in any certain way. This approach is to overlay marks on the PDF ballots in the ballot positions corresponding to the voter's selections. This would add an additional layer of content on top of the current PDF content instead of manipulating the current content, which is the current approach. This new approach is only possible if BRT has a mapping of valid voting locations for each ballot style and the IRISXtract export referenced those locations. Fortunately, IRISXtract does have this information due to some of its setup requirements.

BRT could be refactored to use the absolute marking areas of the original ballot that are collected by IRISXtract when it is first set up to read the ballots. These are rectangular areas defined by the pixel locations of the top left, top right, bottom left, and bottom right of the rectangle. BRT would add a mark in this marking area if IRISXtract finds that the voter made a mark in the same area. This approach requires that BRT know nothing of the other ballot content and only where to place to marks.

This approach is a complete deviation from the way BRT works and would require a rewrite of the software. This approach may also have issues that are unknown at this time because the recommendation is untested.

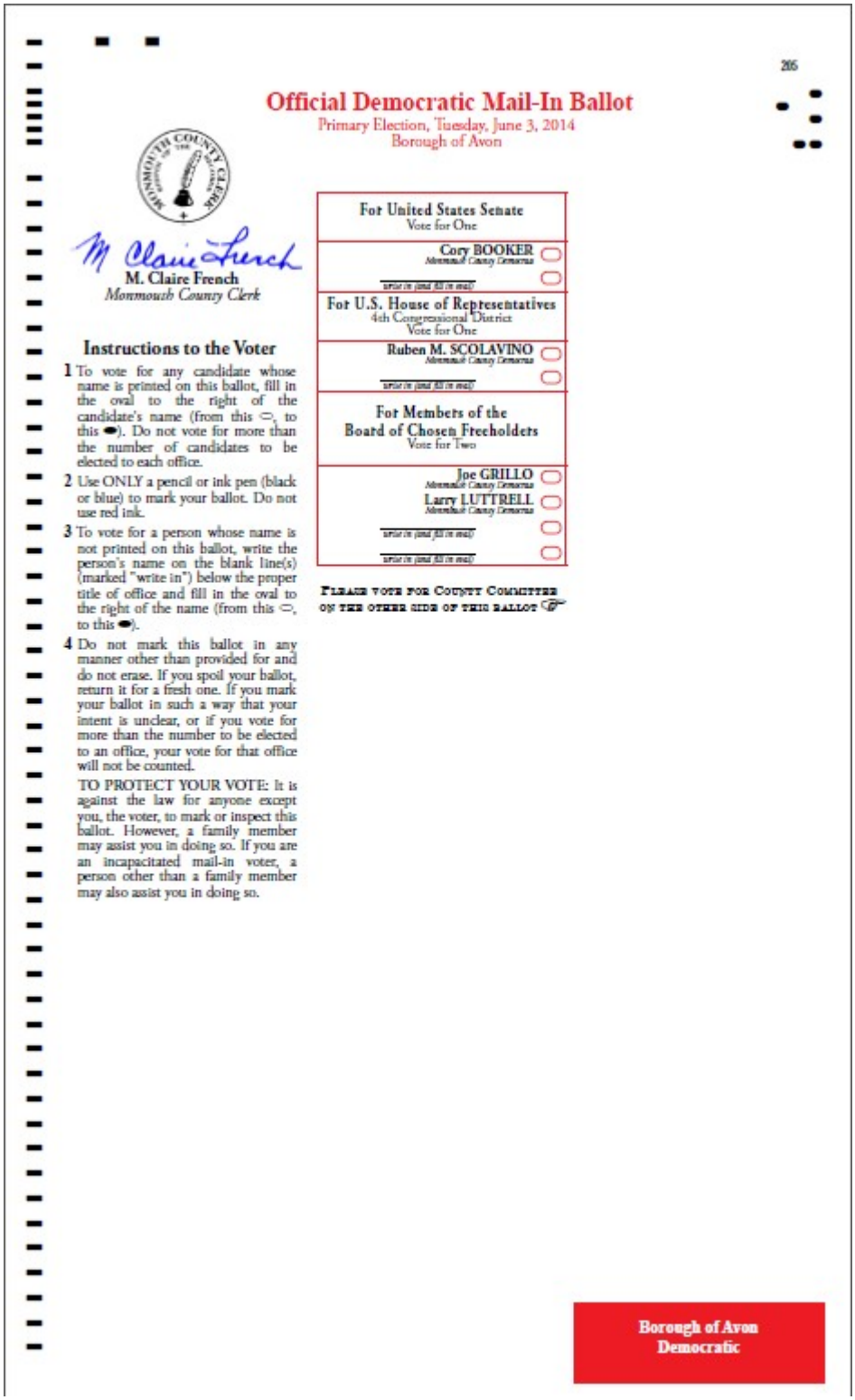
11.7 Improve Transparency

For third parties or the general public, the recommended solution should be able to produce a publishable side-by-side comparison of the input and output. This can be published to HTML or PDF so it can be easily distributed and thus enhance the transparency of the duplication effort.

12 Conclusion

The New Jersey Electronic Ballot Duplication System project achieved important steps toward a full-scale automated ballot duplication solution that does not rely on barcodes. The project evaluated a new technology to read and duplicate ballots and found that it has great promise to be an accurate and scalable solution to ballot duplication issues that exist in current manual and barcode systems. The research team believes that the technology should be further evaluated and developed using the recommendations in Section 11.

Appendix A Monmouth Ballot



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Official Democratic Mail-In Ballot

Primary Election, Tuesday, June 3, 2014
Borough of Avon

M. Claire French
Monmouth County Clerk

Instructions to the Voter

1 To vote for any candidate whose name is printed on this ballot, fill in the oval to the right of the candidate's name (from this ⬭, to this ⬬). Do not vote for more than the number of candidates to be elected to each office.

2 Use ONLY a pencil or ink pen (black or blue) to mark your ballot. Do not use red ink.

3 To vote for a person whose name is not printed on this ballot, write the person's name on the blank line(s) (marked "write in") below the proper title of office and fill in the oval to the right of the name (from this ⬭, to this ⬬).

4 Do not mark this ballot in any manner other than provided for and do not erase. If you spoil your ballot, return it for a fresh one. If you mark your ballot in such a way that your intent is unclear, or if you vote for more than the number to be elected to an office, your vote for that office will not be counted.

TO PROTECT YOUR VOTE: It is against the law for anyone except you, the voter, to mark or inspect this ballot. However, a family member may assist you in doing so. If you are an incapacitated mail-in voter, a person other than a family member may also assist you in doing so.

For United States Senate
Vote for One

Cory BOOKER
Monmouth County Democrats

write in (and fill in oval)

For U.S. House of Representatives
4th Congressional District
Vote for One

Ruben M. SCOLAVINO
Monmouth County Democrats

write in (and fill in oval)

For Members of the Board of Chosen Freeholders
Vote for Two

Joe GRILLO
Monmouth County Democrats

Larry LUTTRELL
Monmouth County Democrats

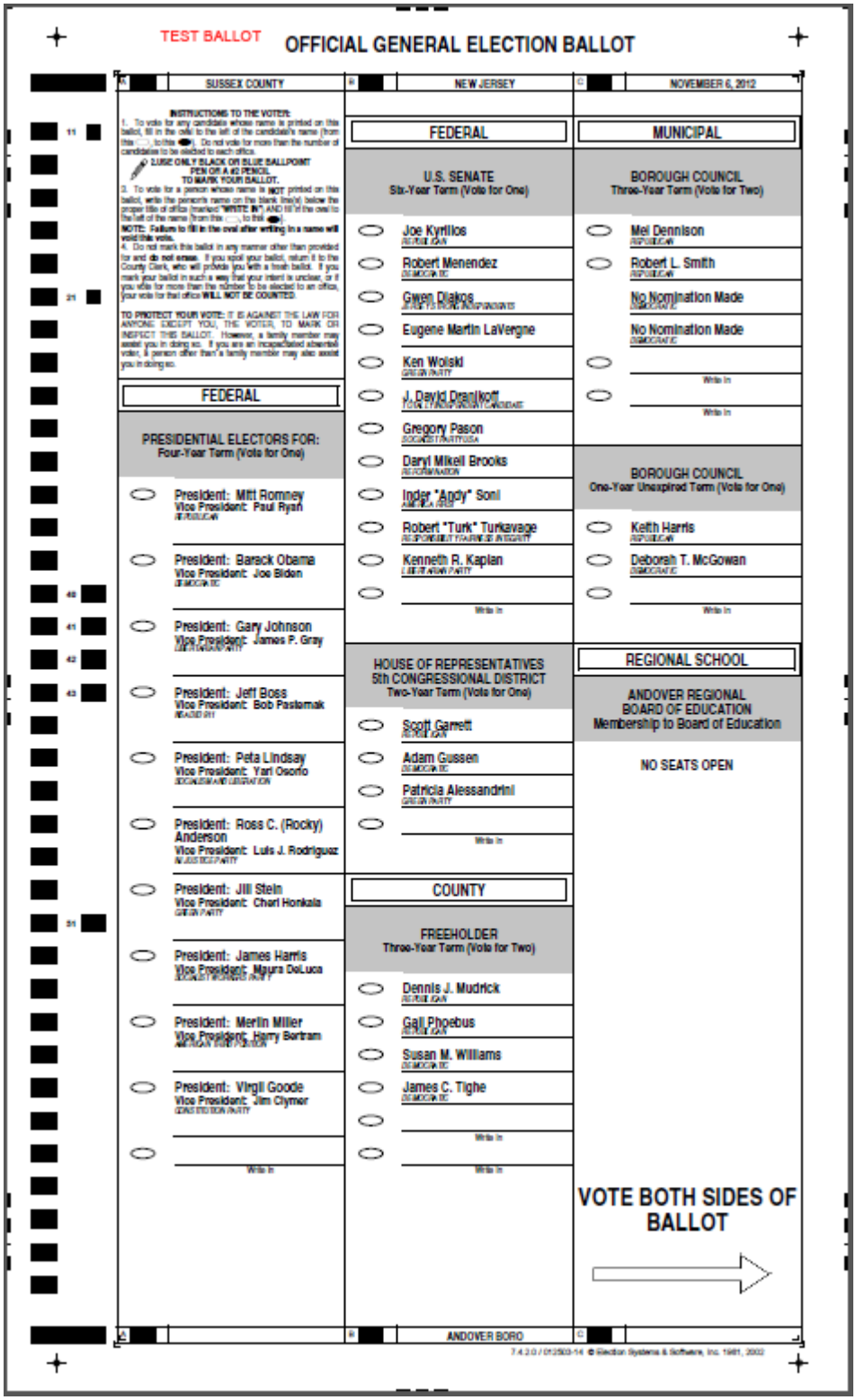
write in (and fill in oval)

write in (and fill in oval)

PLEASE VOTE FOR COUNTY COMMITTEE ON THE OTHER SIDE OF THIS BALLOT ☞

Borough of Avon
Democratic

Appendix B Sussex ESS Ballot



TEST BALLOT

OFFICIAL GENERAL ELECTION BALLOT

SUSSEX COUNTY | NEW JERSEY | NOVEMBER 6, 2012

INSTRUCTIONS TO THE VOTER:

1. To vote for any candidate whose name is printed on this ballot, fill in the oval to the left of the candidate's name (from this ( ), to this ●). Do not vote for more than the number of candidates to be elected to each office.

2. USE ONLY BLACK OR BLUE BALLPOINT PEN OR A #2 PENCIL TO MARK YOUR BALLOT.

3. To vote for a person whose name is NOT printed on this ballot, write the person's name on the blank line(s) below the proper title of office marked "WRITE IN" AND fill in the oval to the left of the name (from this ( ), to this ●).

NOTE: Failure to fill in the oval after writing in a name will void this vote.

4. Do not mark this ballot in any manner other than provided for and do not erase. If you spoil your ballot, return it to the County Clerk, who will provide you with a fresh ballot. If you mark your ballot in such a way that your intent is unclear, or if you vote for more than the number to be elected to an office, your vote for that office WILL NOT BE COUNTED.

TO PROTECT YOUR VOTE: IT IS AGAINST THE LAW FOR ANYONE EXCEPT YOU, THE VOTER, TO MARK OR INSPECT THIS BALLOT. However, a family member may assist you in doing so. If you are an incapacitated absentee voter, a person other than a family member may also assist you in doing so.

FEDERAL

PRESIDENTIAL ELECTORS FOR:
Four-Year Term (Vote for One)

- President: Mitt Romney, Vice President: Paul Ryan — REPUBLICAN
- President: Barack Obama, Vice President: Joe Biden — DEMOCRATIC
- President: Gary Johnson, Vice President: James P. Gray — LIBERTARIAN PARTY
- President: Jeff Boss, Vice President: Bob Paslomak — MEASURE BY
- President: Peta Lindsay, Vice President: Yari Osorio — SOCIALISM AND LIBERATION
- President: Ross C. (Rocky) Anderson, Vice President: Luis J. Rodriguez — JUSTICE PARTY
- President: Jill Stein, Vice President: Cheri Honkala — GREEN PARTY
- President: James Harris, Vice President: Maura DeLuca — SOCIALIST WORKERS PARTY
- President: Merlin Miller, Vice President: Harry Bertram — AMERICAN INDEPENDENT UNION
- President: Virgil Goode, Vice President: Jim Clymer — CONSTITUTION PARTY
- Write In
- Write In

FEDERAL

U.S. SENATE
Six-Year Term (Vote for One)

- Joe Kyrillos — REPUBLICAN
- Robert Menendez — DEMOCRATIC
- Gwen Diakos — JOBS 1ST STRONG INDEPENDENT
- Eugene Martin LaVergne
- Ken Wolski — GREEN PARTY
- J. David Dranikoff — TOEA STRONG INDEPENDENT CANDIDATE
- Gregory Pason — SOCIALIST PARTY USA
- Daryl Mikell Brooks — REFORMATION
- Inder "Andy" Soni — AMERICA FIRST
- Robert "Turk" Turkavage — RESPONSIBILITY FAIRNESS INTEGRITY
- Kenneth R. Kaplan — LIBERTARIAN PARTY
- Write In

HOUSE OF REPRESENTATIVES
5th CONGRESSIONAL DISTRICT
Two-Year Term (Vote for One)

- Scott Garrett — REPUBLICAN
- Adam Gussen — DEMOCRATIC
- Patricia Alessandrini — GREEN PARTY
- Write In

COUNTY

FREEHOLDER
Three-Year Term (Vote for Two)

- Dennis J. Mudrick — REPUBLICAN
- Gail Phoebus — REPUBLICAN
- Susan M. Williams — DEMOCRATIC
- James C. Tighe — DEMOCRATIC
- Write In
- Write In

MUNICIPAL

BOROUGH COUNCIL
Three-Year Term (Vote for Two)

- Mel Dennison — REPUBLICAN
- Robert L. Smith — REPUBLICAN
- No Nomination Made — DEMOCRATIC
- No Nomination Made — DEMOCRATIC
- Write In
- Write In

BOROUGH COUNCIL
One-Year Unexpired Term (Vote for One)

- Keith Harris — REPUBLICAN
- Deborah T. McGowan — DEMOCRATIC
- Write In

REGIONAL SCHOOL

ANDOVER REGIONAL BOARD OF EDUCATION
Membership to Board of Education

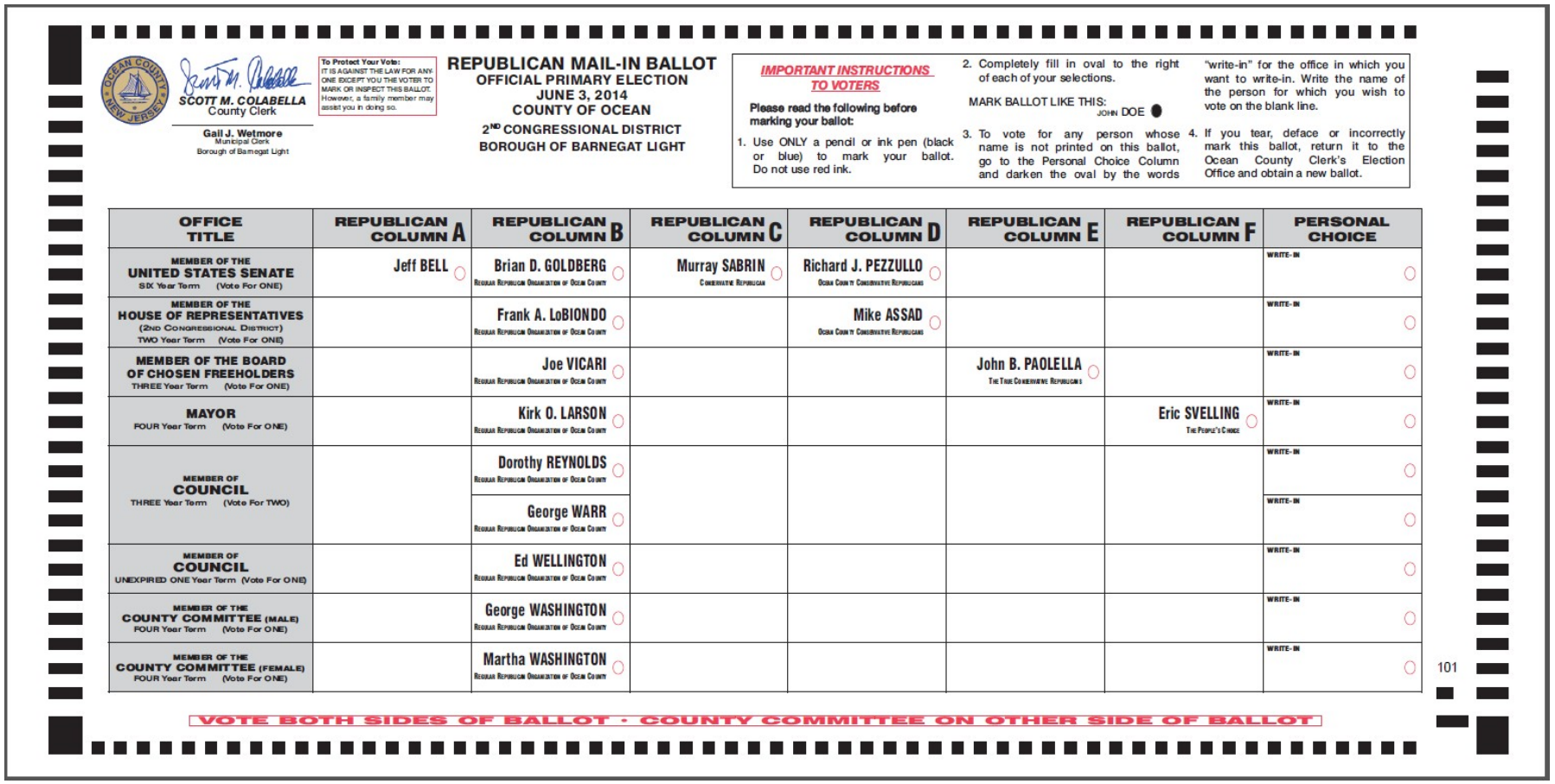
NO SEATS OPEN

VOTE BOTH SIDES OF BALLOT

ANDOVER BORO

7.4.2.0 / 012503-14 © Election Systems & Software, Inc. 1981, 2002

Appendix C Dominion ICC Ballot



SCOTT M. COLABELLA
County Clerk

Gail J. Wetmore
Municipal Clerk
Borough of Barnegat Light

To Protect Your Vote:
IT IS AGAINST THE LAW FOR ANY ONE EXCEPT YOU THE VOTER TO MARK OR INSPECT THIS BALLOT. However, a family member may assist you in doing so.

REPUBLICAN MAIL-IN BALLOT
OFFICIAL PRIMARY ELECTION
JUNE 3, 2014
COUNTY OF OCEAN
2ND CONGRESSIONAL DISTRICT
BOROUGH OF BARNEGAT LIGHT

IMPORTANT INSTRUCTIONS TO VOTERS

Please read the following before marking your ballot:

1. Use ONLY a pencil or ink pen (black or blue) to mark your ballot. Do not use red ink.
2. Completely fill in oval to the right of each of your selections.

MARK BALLOT LIKE THIS: JOHN DOE ●

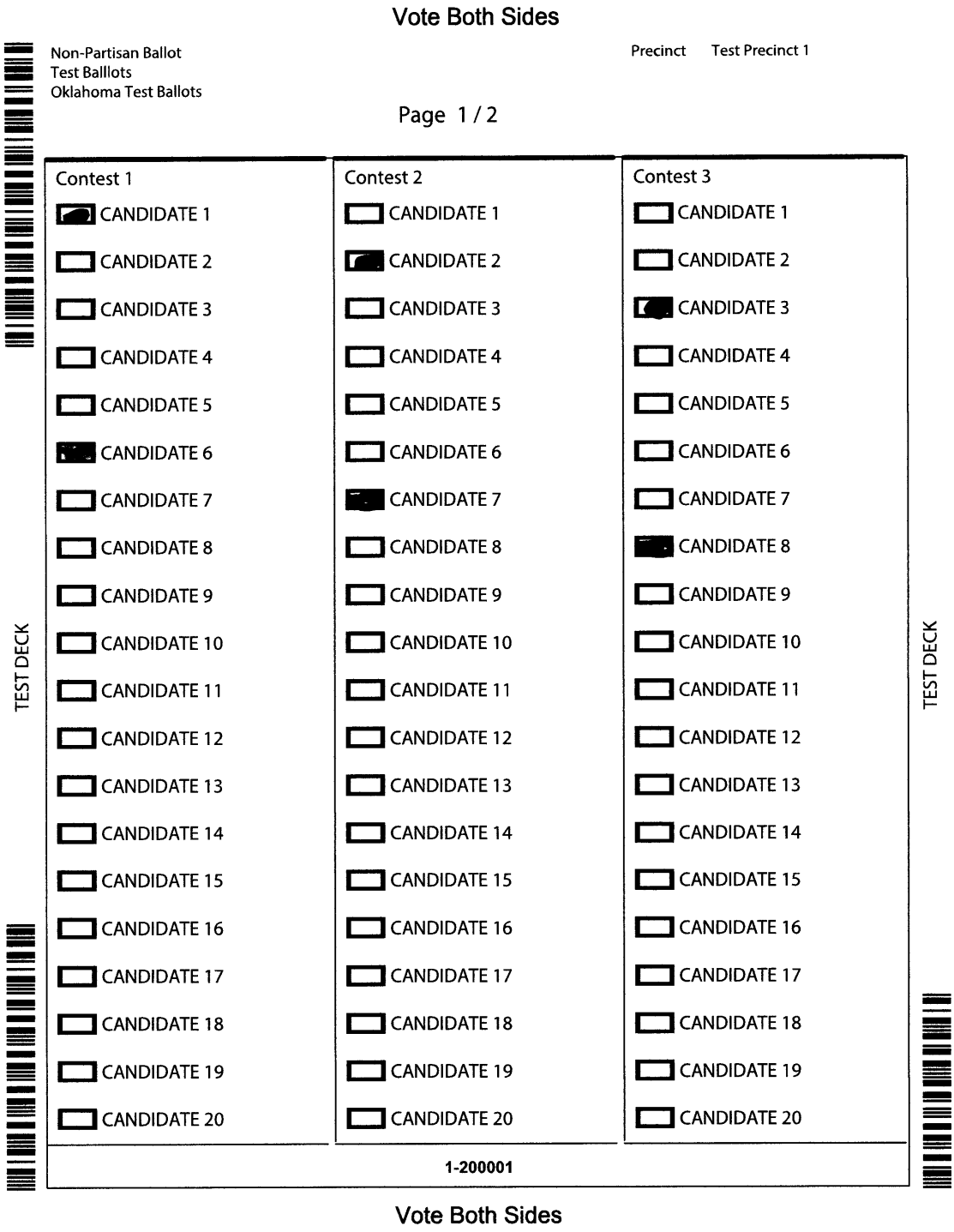
3. To vote for any person whose name is not printed on this ballot, go to the Personal Choice Column and darken the oval by the words "write-in" for the office in which you want to write-in. Write the name of the person for which you wish to vote on the blank line.
4. If you tear, deface or incorrectly mark this ballot, return it to the Ocean County Clerk's Election Office and obtain a new ballot.

OFFICE TITLE	REPUBLICAN COLUMN A	REPUBLICAN COLUMN B	REPUBLICAN COLUMN C	REPUBLICAN COLUMN D	REPUBLICAN COLUMN E	REPUBLICAN COLUMN F	PERSONAL CHOICE
MEMBER OF THE UNITED STATES SENATE SIX Year Term (Vote For ONE)	Jeff BELL	Brian D. GOLDBERG Regular Republican Organization of Ocean County	Murray SABRIN Conservative Republican	Richard J. PEZZULLO Ocean County Conservative Republicans			WRITE-IN
MEMBER OF THE HOUSE OF REPRESENTATIVES (2nd Congressional District) TWO Year Term (Vote For ONE)		Frank A. LoBIONDO Regular Republican Organization of Ocean County		Mike ASSAD Ocean County Conservative Republicans			WRITE-IN
MEMBER OF THE BOARD OF CHOSEN FREEHOLDERS THREE Year Term (Vote For ONE)		Joe VICARI Regular Republican Organization of Ocean County			John B. PAOLELLA The True Conservative Republicans		WRITE-IN
MAYOR FOUR Year Term (Vote For ONE)		Kirk O. LARSON Regular Republican Organization of Ocean County				Eric SVELLING The People's Choice	WRITE-IN
MEMBER OF COUNCIL THREE Year Term (Vote For TWO)		Dorothy REYNOLDS Regular Republican Organization of Ocean County					WRITE-IN
		George WARR Regular Republican Organization of Ocean County					WRITE-IN
MEMBER OF COUNCIL UNEXPIRED ONE Year Term (Vote For ONE)		Ed WELLINGTON Regular Republican Organization of Ocean County					WRITE-IN
MEMBER OF THE COUNTY COMMITTEE (MALE) FOUR Year Term (Vote For ONE)		George WASHINGTON Regular Republican Organization of Ocean County					WRITE-IN
MEMBER OF THE COUNTY COMMITTEE (FEMALE) FOUR Year Term (Vote For ONE)		Martha WASHINGTON Regular Republican Organization of Ocean County					WRITE-IN

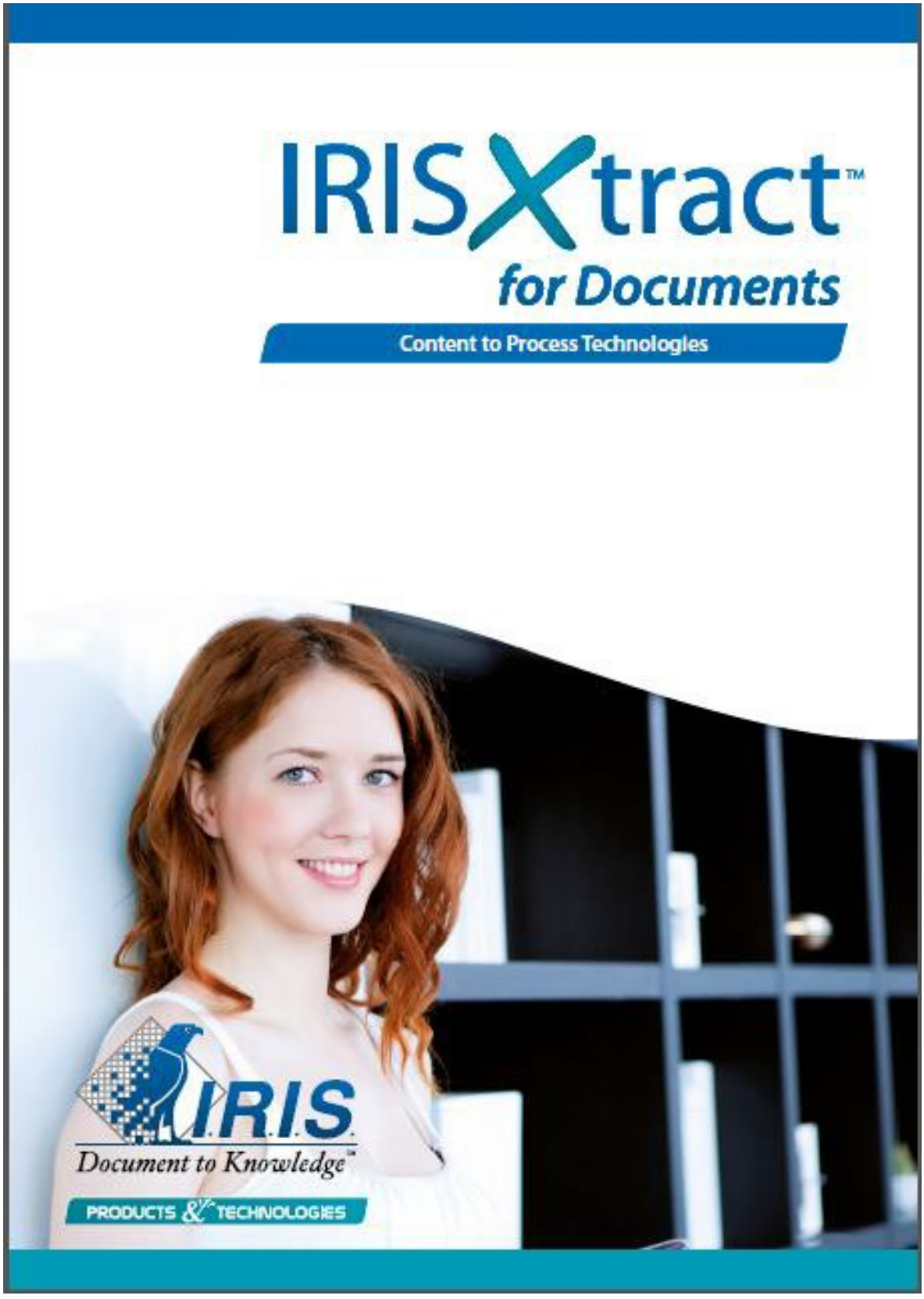
101

VOTE BOTH SIDES OF BALLOT · COUNTY COMMITTEE ON OTHER SIDE OF BALLOT

Appendix D Hart Test Ballot



Appendix E IRISXtract



IRISXtract™ for Documents – THE "CONTENT TO PROCESS" PLATFORM

BUSINESS PROCESS OPTIMIZATION STARTS IN THE MAILROOM!

ONE PRODUCT – MANY FEATURES

- **Intelligent Document Classification:** statistical classification
- **Intelligent Document Analysis:** data extraction and free-form analysis based on rule sets
- **Diverse Solutions:** for different business processes
- **Multi Application:** with one installation, different solutions for different business processes can run simultaneously
- **Multi Tenancy:** with one installation, one solution type in different configurations can run simultaneously
- **Multi Channel:** paper, electronic documents, fax, email in different formats (JPEG, TIFF, PDF, DOCX, XLSX, TXT etc.)
- **Easy Integration:** into subsequent information systems
- **Free Scalability:** individually adaptable to the amount of documents that need to be processed
- **Business Intelligence:** process optimization via reliable tracking and tracing concept
- **Fuzzy Reference Data Reconciliation:** with 80 million address data in under 1 sec
- **Set-Up Time Optimization:** efficient implementation and reliable project cost calculation
- **Multilingual:** recognition of 137 languages and Unicode ability
- **Cost-Efficient and Varied Conversion:** export of compressed high quality data

Companies receive a variety of documents and information on a daily basis, both electronically and in paper form. Processing them can be time consuming and resource intensive. Automatically and digitally processing incoming information considerably increases efficiency and advances business process optimization. I.R.I.S.' state-of-the-art technology lightens your workload: **IRISXtract™ for Documents** means paperless processing! Already far more than a thousand customers trust **IRISXtract™ for Documents**' reliability, and all around the world a new system is installed everyday.

IRISXtract™ for Documents is an award-winning Intelligent Document Recognition (IDR) solution platform that automatically classifies documents arriving from various sources and transfers extracted data to business process applications. Relevant information is thus available almost immediately, resulting in reduced operating costs. Automated document management leads to increased reliability and quality, particularly when compared to manual data processing. With **IRISXtract™ for Documents**, a company's data is where it needs to be: in process!

"Content to Process": Evaluating data in terms of whether it is relevant to a subsequent process and identifying the respective business process is what our solution platform **IRISXtract™ for Documents** does. The type of document a company receives through incoming mail (everything from orders, to delivery notes, invoices, and applications) is identified. Once the type of document is identified, so is the corresponding business process, department, and employee. The document is then forwarded accordingly and made available for processing. The information is interpreted and knowledge that is relevant to following business processes thus generated.

Thanks to the automation media discontinuity can be avoided. Incoming information is translated and made available for the corresponding business process. Subsequent information systems are immediately filled with reliable and high quality data.

The technology can be easily integrated into ERP, CRM, ECM, archive, and workflow systems. On the basis of **IRISXtract™ for Documents** an integral platform concept for automatic invoice and order processing, HR and supplier records as well as case management in legal, healthcare, and finance sectors is thus available.

2

Document Understanding Solutions

Fig. 1: Systemoverview IRISXtract™ for Documents

INNOVATION AND EVOLUTION: THE KEY TO SUCCESS

One of the essential ideas underlying **IRISXtract™ for Documents** is to always be one step ahead of future changes. The solution platform contains technology that guarantees companies will be able to immediately react and adapt to market developments. The structure and content of documents can change, and so does the kind of information needed for business processes. Therefore, I.R.I.S. does not use a rule-based classification system. The classification engine uses statistical operators based on certain features and characteristic values to analyze documents. The data extraction is based on a free-form, full text approach – templates are not necessary.

100% INTELLECTUAL PROPERTY

All technologies within **IRISXtract™ for Documents** are 100% the intellectual property of the I.R.I.S. Group. **IRISXtract™ for Documents** uses the globally known Optical Character Recognition (OCR) engine, ReadIRIS™ that can read more than 137 languages. In addition to its Unicode ability, the OCR/ICR-engine thus entirely fulfils the needs of international companies. Moreover, with the help of I.R.I.S.' IHQC™ technology, data and high quality (color) images can be exported in various formats.

THE PLATFORM CONCEPT

IRISXtract™ for Documents is a flexible solution platform that can be easily adapted to individual needs. An installation of **IRISXtract™ for Documents** can be run two different ways – Multi Application, different solutions simultaneously or Multi Tenancy, one type of solution that is configured differently for various projects or clients.

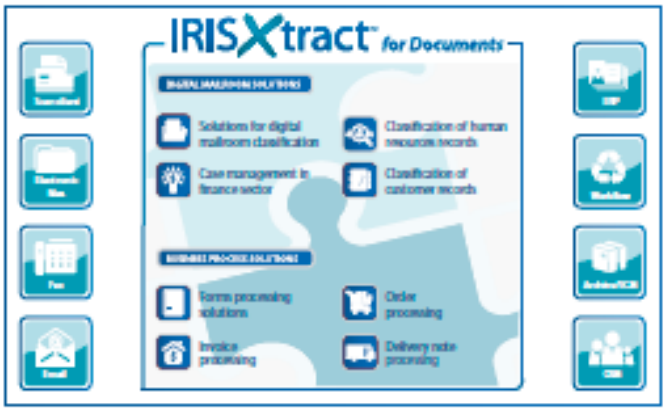


Fig. 2: IRISXtract™ for Documents Solution Packages

In order to address the different business processes of companies, I.R.I.S. has developed a variety of solutions. The portfolio focuses on two strategic objectives: Digital Mailroom Solutions (classification, indexing, and sorting) and Business Process Solutions (solutions for a specific business process). Classification, sorting and indexing solutions are available for e.g. HR and customer records, documents in the banking and finance industry as well as a toolkit with which further solutions can be designed. With the solutions for data extraction, invoices, orders or delivery notes can be processed. Another toolkit offers the possibility to design further extraction solutions for forms and other structured documents. The solutions can be configured individually and according to specific needs. The integral platform concept guarantees efficient implementation and reduces project length, risks, and costs.

3

CORE COMPONENTS OF IRISXtract™ for Documents

IRISXtract™ for Documents is a server based IDR platform. In IMPORT, documents are input into the system, and in EXPORT, extracted data is transferred to relevant systems. Configurations are done in the COCKPIT or the SOLUTION DESIGNER. The PRODUCTION DATABASE collects data for statistical and documentation purposes (Business Intelligence).

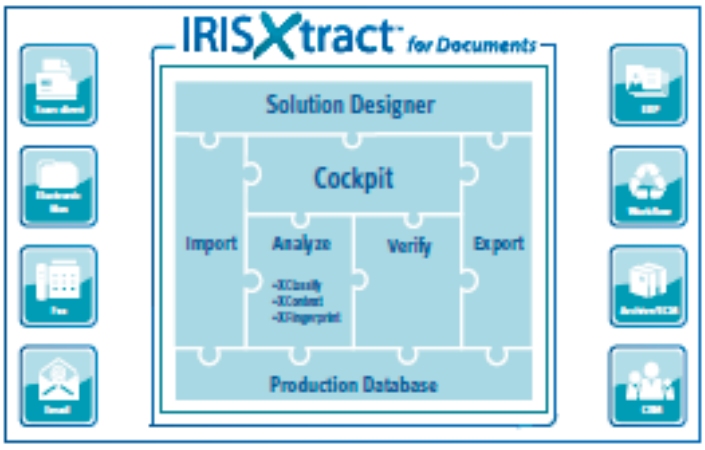


Fig. 2: IRISXtract™ for Documents Core Components

IMPORT

In IMPORT documents to be processed are brought into **IRISXtract™ for Documents**. The component supports different predefined IMPORT channels and offers the possibility to integrate own channels. The channels can be assigned to different applications with the help of the COCKPIT, and can be configured accordingly. It is possible to assign more than one channel to an application.

ANALYZE

The ANALYZE component classifies and indexes the incoming documents. Before passing on the text, process-relevant information is extracted. The intelligent data analysis is based on rule sets that are defined within the solution. Even the text that is included in images can be identified as such – the text layer that might be included in the electronic document is taken over as a whole. To summarize, the analyzing process is made up of the following steps:

1. Improving the overall image quality
2. Identifying different document classes in the mailroom as well as sorting the documents (XClassify)
3. Optional, pictorial classification based on predefined templates (XFingerprint)
4. Applying generic extraction rules for full-text recognition and interpreting the full-text result, or data extraction of forms on the basis of predefined templates (XContext)
5. Verifying the logical document (scripts, reference data reconciliation, and reference data completion etc.)

ANALYZE TECHNOLOGIES

XClassify is one of the core technologies of **IRISXtract™ for Documents** and allows configuration of a complex classification scheme with only a few clicks. The statistical and stochastic classification is based on the analysis of sample documents. XContext offers sophisticated, full-text recognition technology that searches the text for key information based on rule sets. XFingerprint metaphorically takes a 'fingerprint' of a document by transferring graphical information into a one-dimensional code, so similarities of document layouts can be determined on a mathematical basis.

4

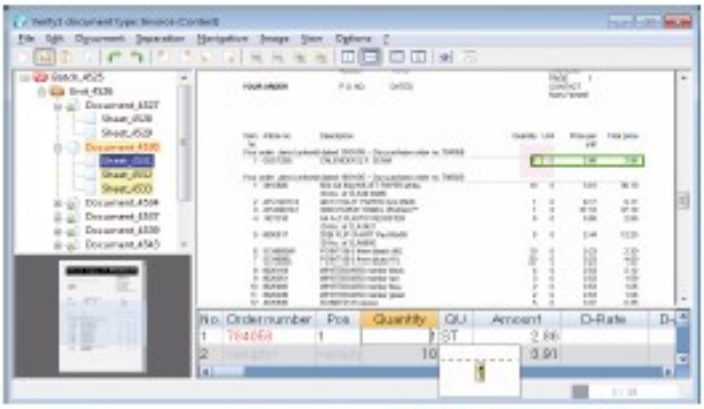


Fig. 4: Verification of Line Items in an Invoice

VERIFY

The VERIFY component depicts the data that was extracted from the processed document. The results and deviations from a particular rule set can be verified and corrected where applicable. In addition to the manual correction, the VERIFY component enables (in different configurations) the automatic verification and validation of extracted data. Regarding the manual verification in the VERIFY module, **IRISXtract™ for Documents** supports the display of grey level and color images. Moreover, the verification process can be adapted to functional requirements of business processes.

EXPORT

The EXPORT component ensures the delivery of images and index data to business applications as well as the business process and workflow applications that are implemented in those. An individual EXPORT can be assigned to an application when desired. **IRISXtract™ for Documents** offers technology with which extensive amounts of data and color images can be compressed for archiving purposes.

ADMINISTRATION OF IRISXtract™ for Documents

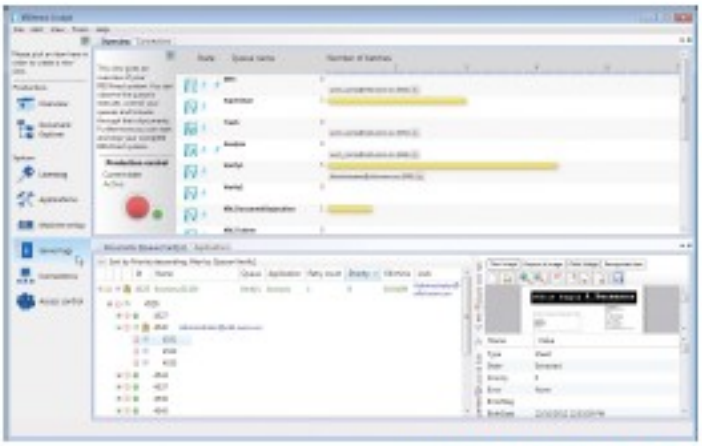


Fig. 5: IRISXtract™ for Documents Cockpit

COCKPIT

The COCKPIT is the central instrument for configuration and production control in **IRISXtract™ for Documents**. Using this tool, the system is first installed and then operated. It is designed intuitively and gives direct feedback so as to be able to easily react to potential problems. The COCKPIT is efficient and can handle large amounts of data. Thus, fast data processing is guaranteed. In addition, various sorting and filter mechanisms lighten the workload.

IRISXtract™ for Documents is freely scalable. Whether 100 or 10,000 documents need to be processed a day, the solution platform can be configured according to individual needs. Moreover, reference data can be accessed via the COCKPIT. Thanks to automatic reference data reconciliation, an address can be assigned to the corresponding supplier and a quick and accurate classification is guaranteed. For example, 80 million address data can be reconciled in less than one second.

ADD-ONS

The **IRISXtract™ for Documents** platform can be extended by a number of add-ons. Add-ons are applications that are not an integral part of the platform and can be operated separately.

XScanClient: The XScanClient is a scan tool that allows for automation and is part of the **IRISXtract™ for Documents** platform. The software supports ISIS and Twain scanner drivers, and scanning of images from disk. With **IRISXtract™ for Documents**, it is possible to save profile and scanner settings in a central data basis. Thanks to this function, multiple XScanClients can be configured simultaneously from a central location.

XMailFetcher: Standard formats such as JPEG, TIFF or PDF can be processed without a further IMPORT plug-in. To process the wide range of formats that arise in the digital age, including Microsoft formats, I.R.I.S. developed the XMailFetcher. This add-on converts documents into a standard transfer format that facilitates delivery to the **IRISXtract™ for Documents** system where they are then automatically captured and further processed. The XMailFetcher converts incoming mail, including its attachments, into readable images. A single installation in the mailroom can process up to eight different email addresses at the same time (e.g. accounting@company.com, order@company.com), with a maximum capacity of up to 10,000 pages a day. The XMailFetcher also generates indexing information (From, To, Cc, Subject), to be used for archiving purposes.

Fig. 6: IRISXtract™ for Documents XMailFetcher

SOLUTION DESIGNER

The SOLUTION DESIGNER is the central configuration unit that creates and maintains the **IRISXtract™ for Documents** applications. The full-text recognition in XClassify and the Solution Package Accounts Payable can be customized in the Solution Designer. With the help of the integrated VSTA Development Suite, .Net and VBS developers can:

- Make adjustments to meet customer specific requirements
- Edit project configurations and apply these to the entire system
- Customize form and free-form solutions for classification, indexing, and verification

Document Understanding Solutions

PRODUCTION DATABASE

Business process optimization calls for a quality management system that screens and improves the processes in a company. This calls for thorough and systematic data analysis, based on, for example, Business Intelligence concepts. **IRISXtract™ for Documents** contains an efficient statistical tool within its PRODUCTION DATABASE. Based on it, extensive live monitoring, tracking and tracing, and reporting of production processes can be carried out to ensure continuous process improvement.

Fig. 7: Suggested Illustration Production Database

SYSTEM REQUIREMENTS

OPERATING SYSTEM AND DATA BASE COMPATIBILITY:

IRISXtract™ for Documents is compatible with different operating systems and data bases. The soultion platform can be run on Windows systems – 32-bit and 64-bit-versions, and can be used in a virtual environment.

SERVER

- Standard-Server HW with Dual-/QuadCore CPU 2.0 GHz or faster
- 4 GB RAM (minimum when using one IRISXtract™ for Documents-component)
- More than 80 GB free hard disk space
- Network adapter with 100 MBit (minimum)
- Standard graphics card (1280 x 1024 pixel) with minimum 512 MB VRAM
- 19"TFT-flat screen
- USB 2.0 interface or alternatively USB-hub in network

CLIENT

- Standard HW/PC with Dual-/QuadCore CPU 2.0 GHz or faster
- 4 GB RAM
- More than 60 GB IDE/SATA hard disk storage
- Network adapter with 100 MBit/s
- Standard graphics card (1280 x 1024 pixel) with minimum 512 MB VRAM
- 19"TFT flat screen

7

ABOUT I.R.I.S.

Image Recognition Integrated Systems (I.R.I.S.) is a leading provider of 'Content to Process' technologies. I.R.I.S. offers solutions for automatic invoice and order processing, HR and supplier records as well as case management in legal, healthcare, and finance sectors.

I.R.I.S. provides technologies and solutions that capture data and information contained in documents, which are relevant to business processes. The goal is to make the data easily available while reducing operating costs.

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