Pattern Recognition Classification of Early Voting Ballot (EVB) Return Envelope Images for Signature Presence Detection

An Engineering Systems Approach to Identify Anomalies to Advance Integrity of U.S. Election Processes

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SMVS, SMME, SBEE
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PRESENTED TO

Arizona State Senate

Agenda

- Executive Summary
- Background
- Maricopa EVB Results
- Scope of Audit & EchoMail Analysis
- EchoMail Results
- Comparative Analysis
- Key Findings and Anomalies
- Questions for Maricopa Election Officials
- Conclusion & Summary
- Conclusions

Executive Summary

- The Early Voting Ballot (EVB) Return Envelope is the ***protective vehicle*** by which the EVB is transported and processed
- The authentication/verification of the Signature on the EVB return envelope is critical to reliability of the process
- This audit reveals anomalies raising questions on ***the verifiability of the Signature Verification Process.***

Background

Author's Expertise & Bio[1]

- Four M.I.T. degrees: PhD, SMME, SMVS, SBEE
- Inventor of Email, Fulbright Scholar, Lemelson-MIT Finalist, Westinghouse Science Honors Recipient[2,3]
- Nominee for National Medal of Technology & Innovation
- 40+ years of experience in pattern recognition and classification of diverse signals and signatures across industries and applications:
  - Industries: Biology & Medicine; Engineering: Aeronautics, Civil, Electrical; Banking & Finance; Military
  - Applications: Handwriting recognition on bank checks, electronic document e.g. email analysis and categorization, ultrasonic and radar wave signature classification for non-destructive evaluation (NDE), speech analysis for tadoma signature identification, biomarker patterns analysis for efficacy of combination therapy, sleep pattern signature categorization for identification of SIDS patients, signal detection of fluid flow anomalies in fluidized bed reactors
- Winner of White House competition for automatic classification of email
- Seven successful high-tech companies:
  - EchoMail - Pattern recognition classification of documents (1994-Present)
  - CytoSolve - Computational modeling (2007-present)
- Patents, books, and publications in peer-reviewed high-impact journals: IEEE, IJPRAI, Nature Neuroscience, CELL Biophysical, etc.
- Invited Distinguished Lectures: NSF, NIH, FDA, Harvard, MIT Presidential Fellows Lecture

[1]Dr. Shiva Ayyadurai, Biography and Curriculum Vitae: https://vashiva.com/about-va-shiva-ayyadurai/
[2]Facts on the invention of email, https://www.inventorofemail.com/thefacts/
[3]The Man Who Invented Email, TIME, https://techland.time.com/2011/11/15/the-man-who-invented-email/

Systems and Modeling

The System

Systems and Modeling

The System

The Signal

Sudden Infant Death Syndrome

Signature Detection of Abnormal Sleep Patterns to Prevent Baby's Death (1978 – 1984)

Baby

The System

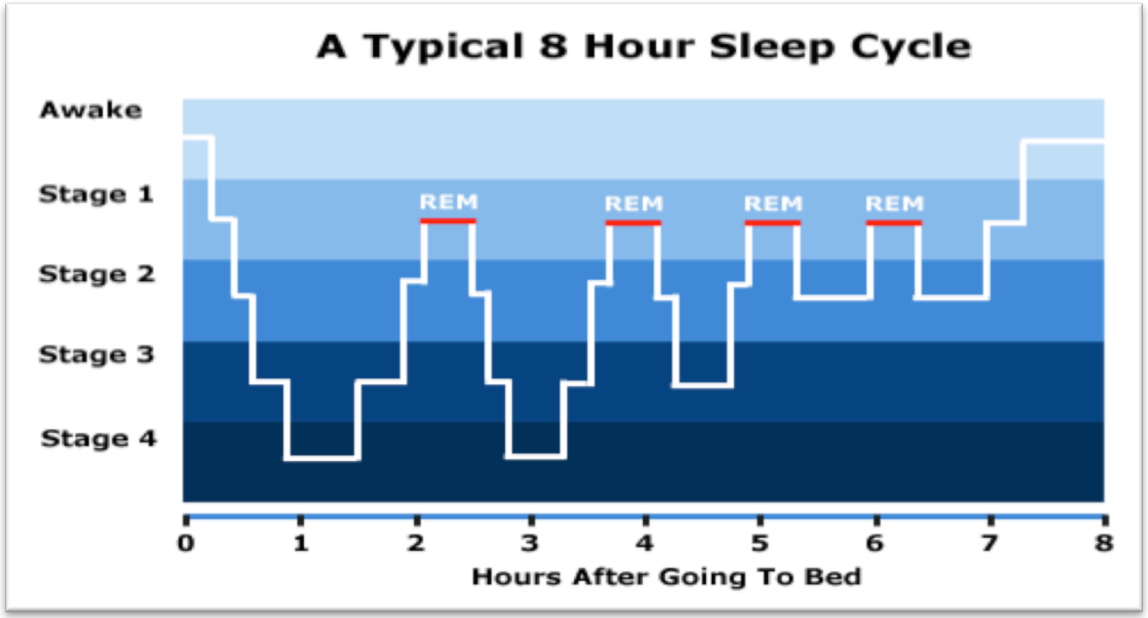
Sudden Infant Death Syndrome

Signature Detection of Abnormal Sleep Patterns to Prevent Baby's Death (1978 – 1984)

Baby

The System

Sleep Signature Patterns



The Signal

Tadoma

Signal Detection of Non-Vocal Communication for Supporting Deaf-Blind (1983-1986)

Tadoma – Deaf-Blind Communication

The System

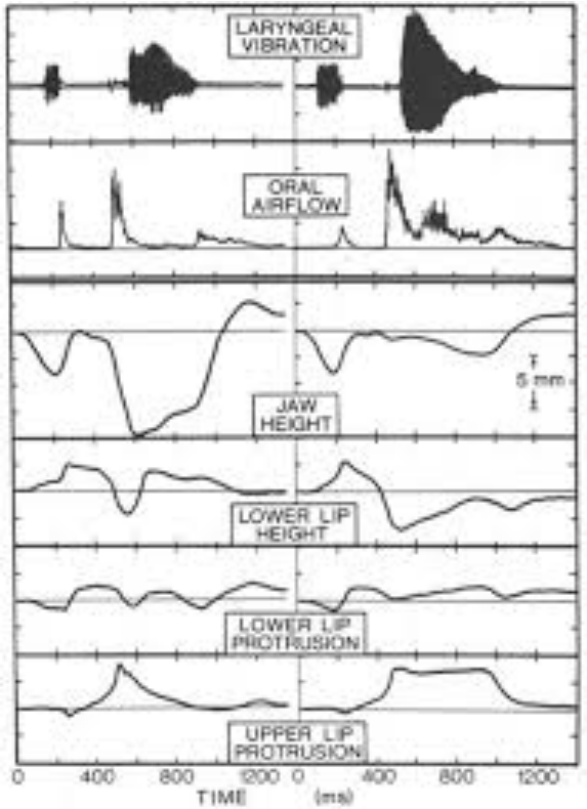
Tadoma

Signal Detection of Non-Vocal Communication for Supporting Deaf-Blind (1983-1986)

Tadoma – Deaf-Blind Communication

The System

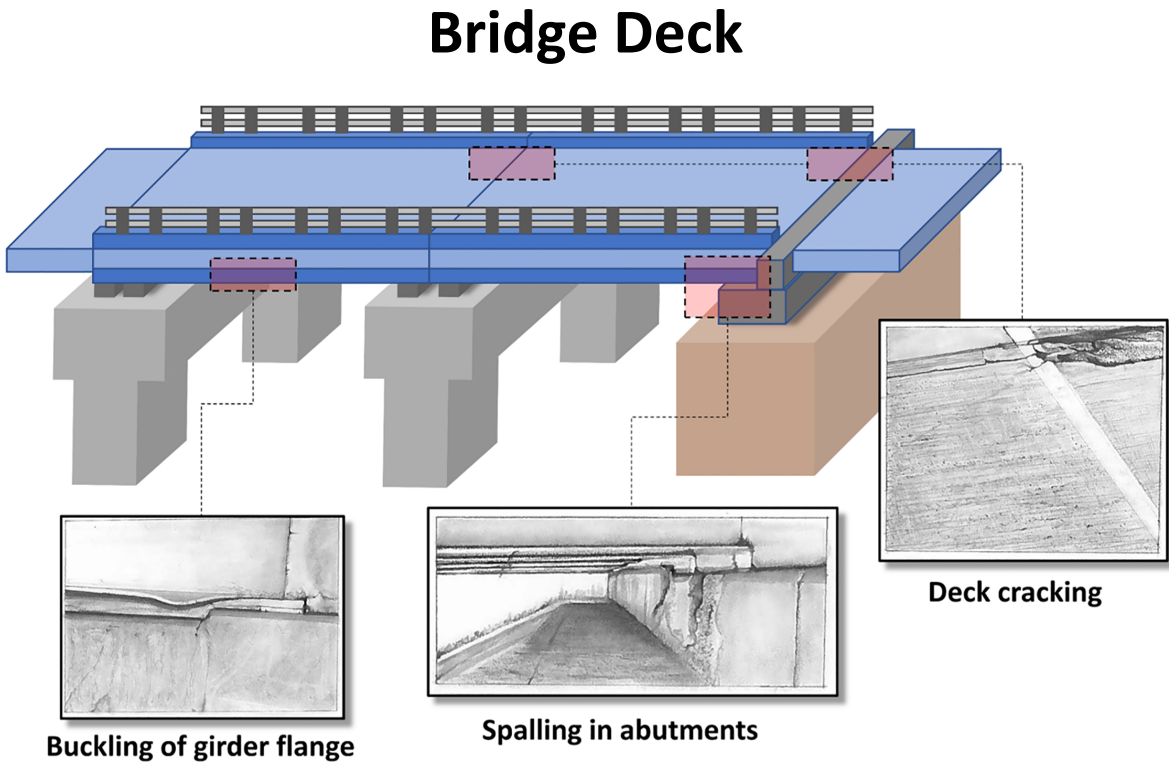
Multiple Signals from Mouth



The Signal

Bridge Deck Deterioration

Signal Detection of Flaws in Bridges for Prediction Bridge Deck Failures (1986-1988)



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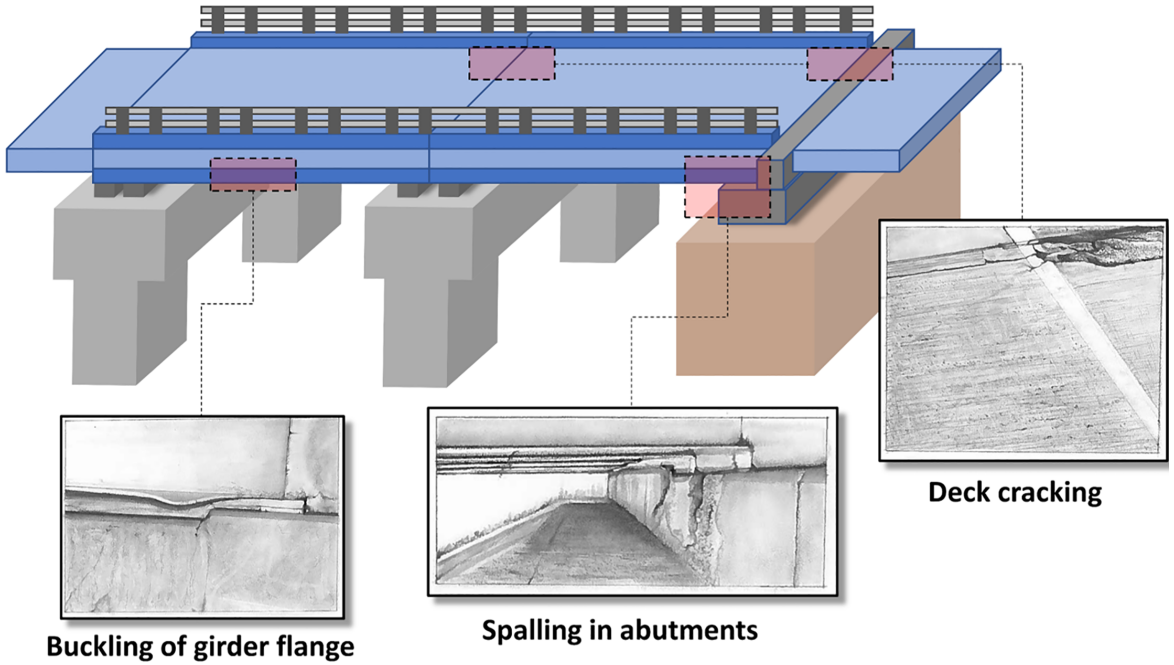
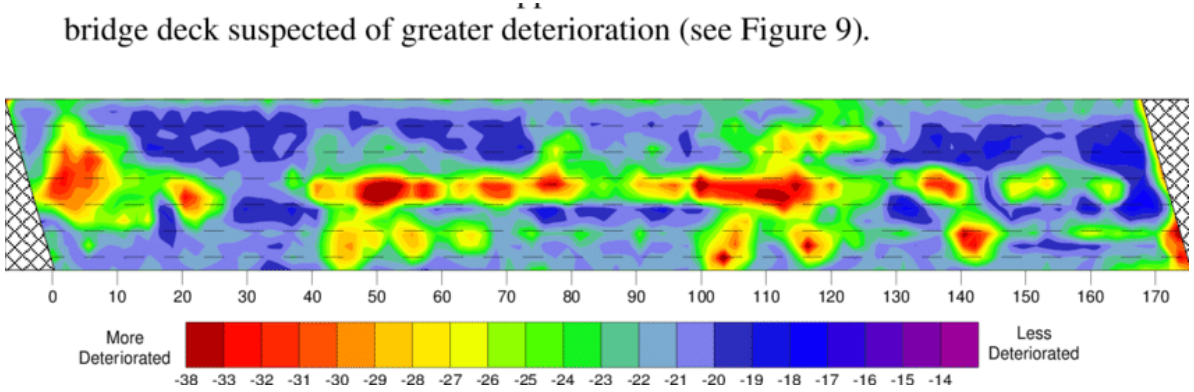


The System

Bridge Deterioration Signatures



The Signal

Non-Destruction Evaluation

Signal Detection of Ultrasonic Signals for Preventative Maintenance of Aircraft Wings (1988-1990)

Aircraft Wings

The System

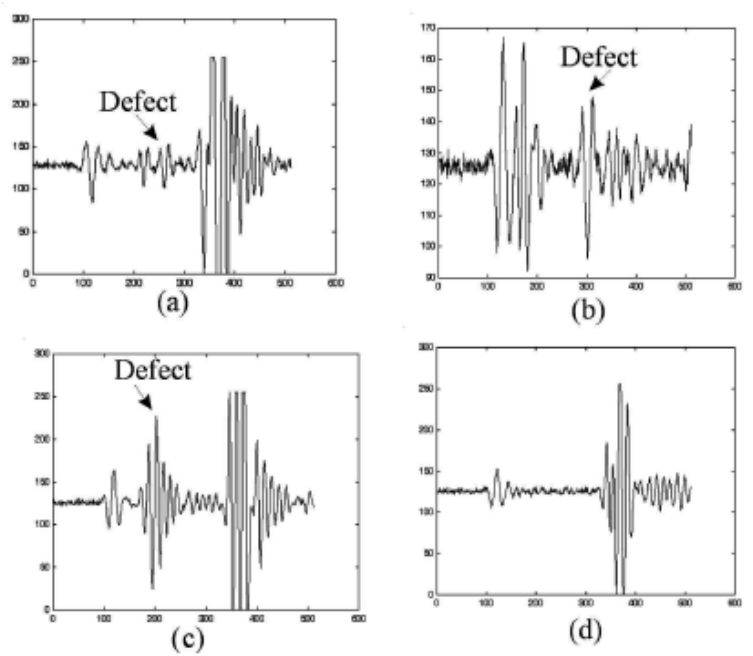
Non-Destruction Evaluation

Signal Detection of Ultrasonic Signals for Preventative Maintenance of Aircraft Wings (1988-1990)

Aircraft Wings

The System

Aircraft Wing Ultrasonic Signatures

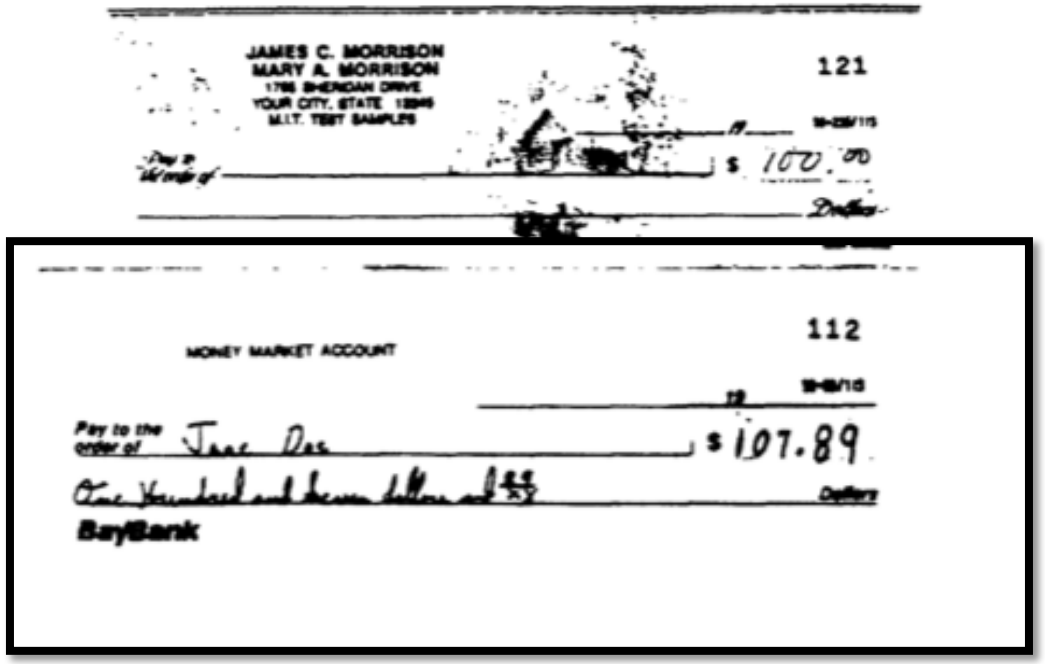


The Signal

Handwritten Numerals on Bank Checks

Integrated Architecture for Recognition of Handwritten Numerals on Bank Checks (1992-1994)

Bank Checks



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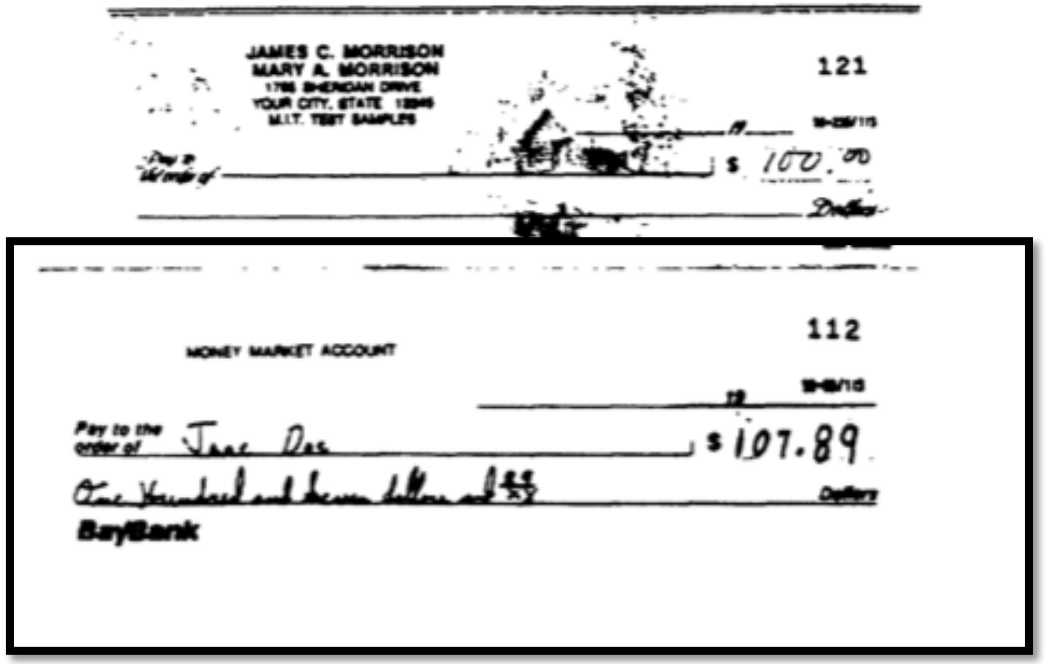
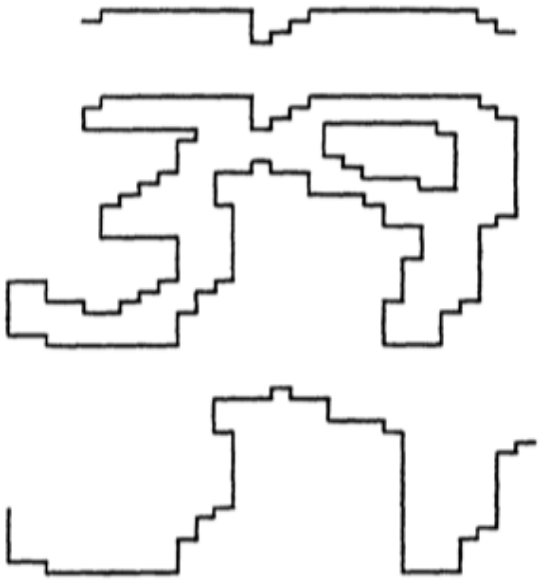


The System

Detection of Numerals

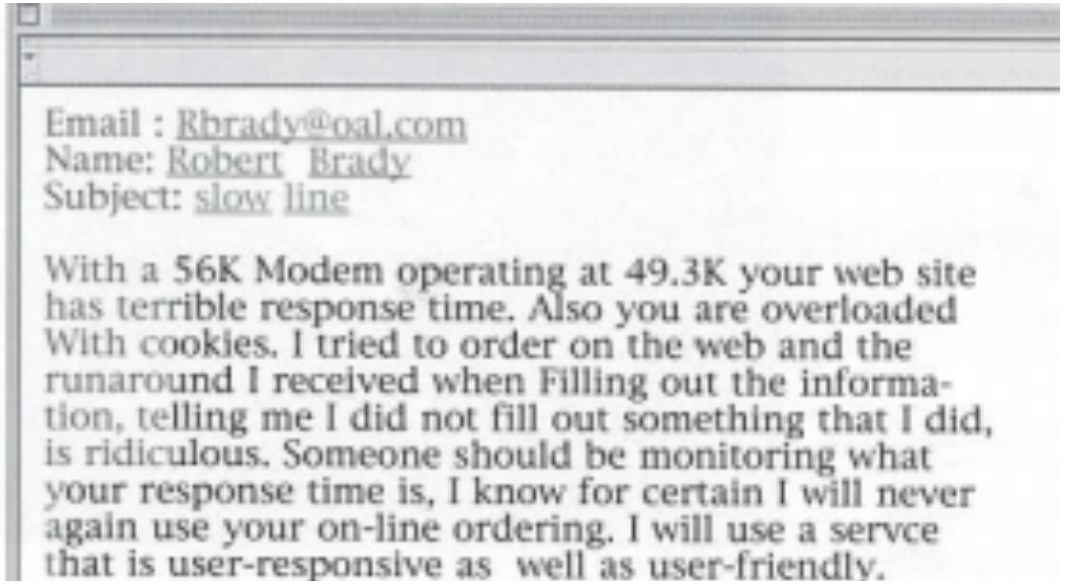


The Signal

EchoMail®: Automatic Document Analysis and Classification

Signal Detection of Email Signals for Automatic Categorization (1992 - Present)

Email Message



Email : Rbrady@oal.com
Name: Robert Brady
Subject: slow line

With a 56K Modem operating at 49.3K your web site has terrible response time. Also you are overloaded With cookies. I tried to order on the web and the runaround I received when Filling out the information, telling me I did not fill out something that I did, is ridiculous. Someone should be monitoring what your response time is, I know for certain I will never again use your on-line ordering. I will use a servce that is user-responsive as well as user-friendly.

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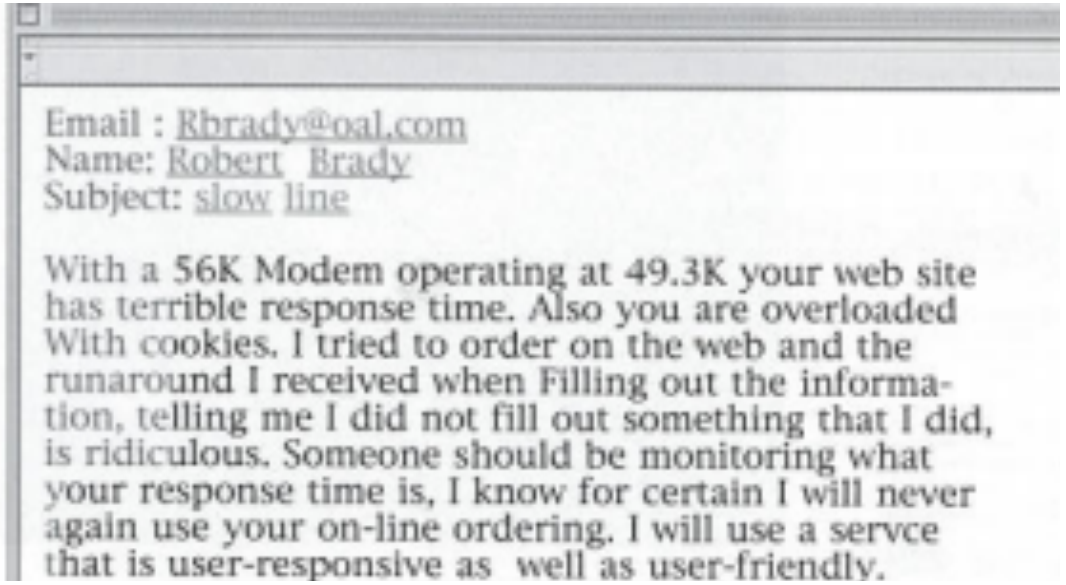
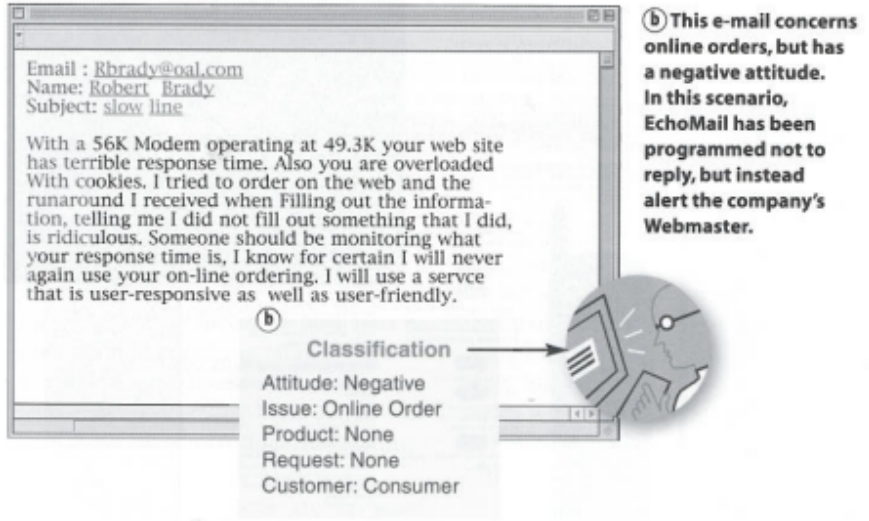


The System

Email Signals

(Attitude, Issue, Product, Request, Customer)

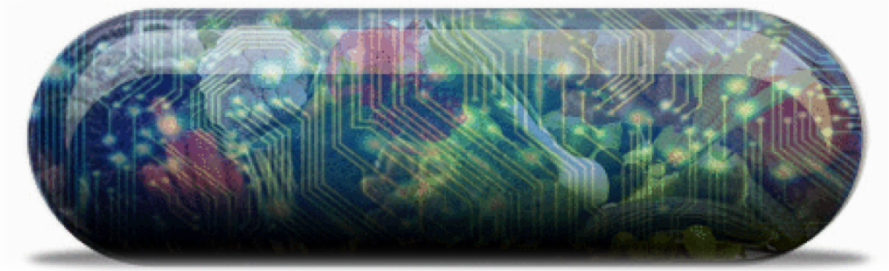


The Signal

CytoSolve®: Discovering Combinations That Work

Signal Detection of Combination Therapies That Alleviate Disease (2007 - Present)

Combination of Foods



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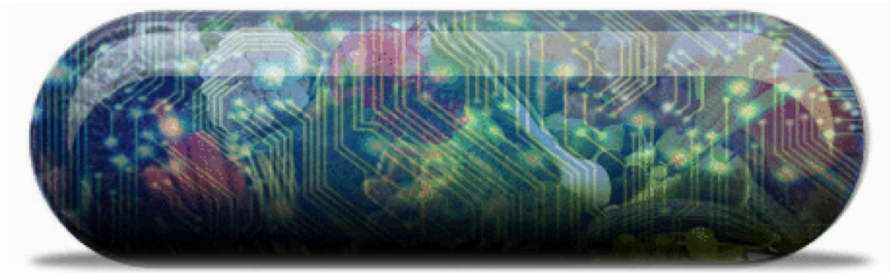
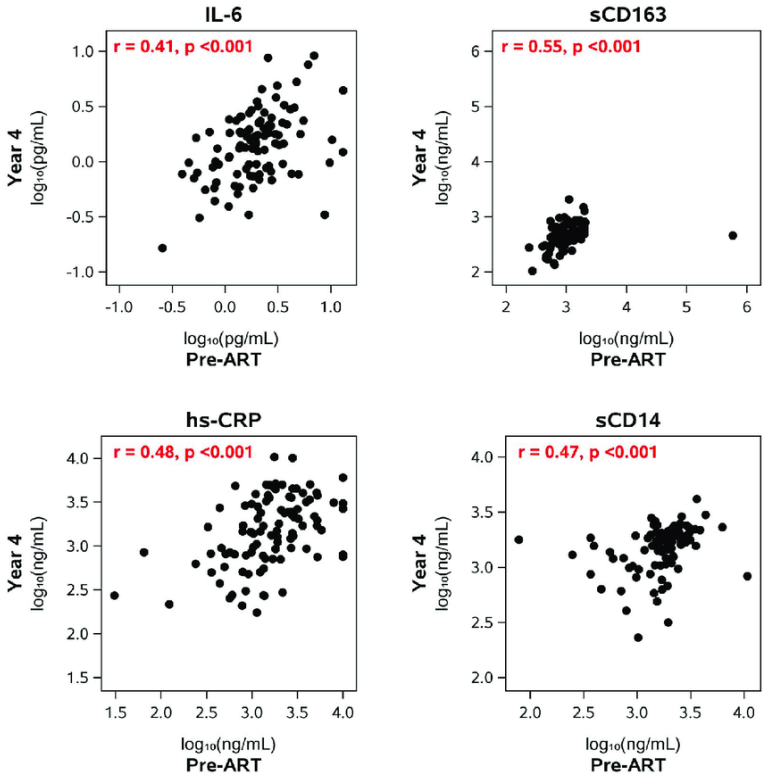


The System

Biomarkers That Reduce Inflammation



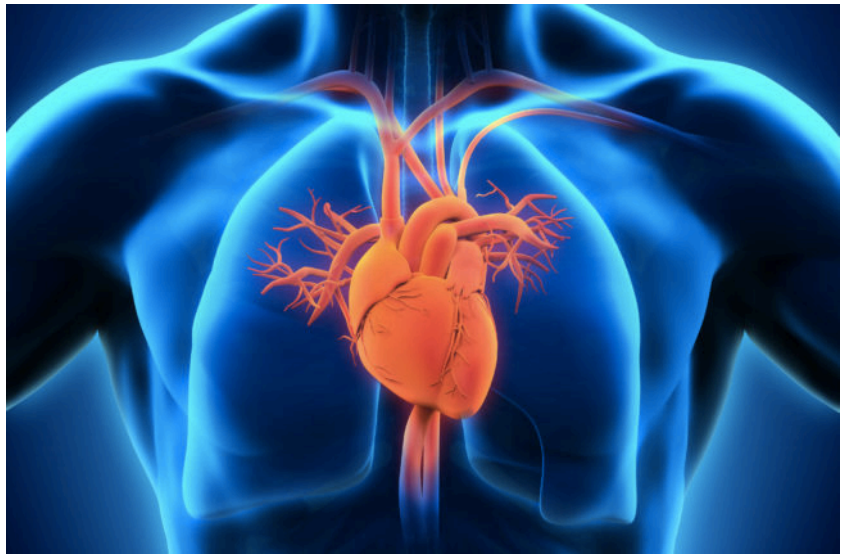
The Signal

Systems and Modeling

The System

The Signal

Systems and Modeling



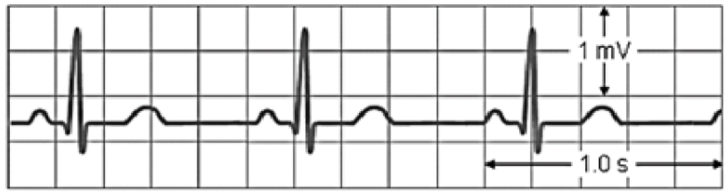
Cardiovascular Model

The System

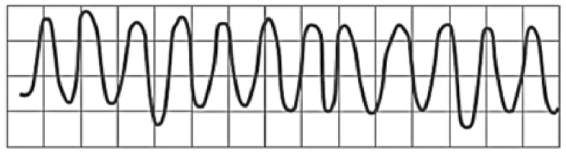
The Signal

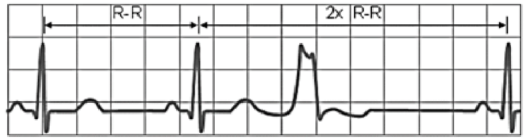
Cardiac Signature Detection & Classification

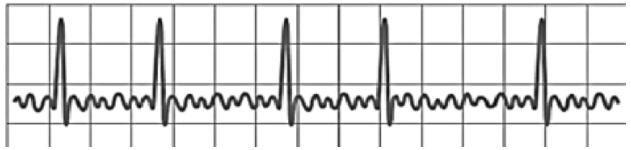
NORMAL STATE



ABNORMAL STATE(S)







Systems and Modeling

The System

The Signal

Early Voting Ballot (EVB) System

The System

Early Voting Ballot (EVB) System

EVB
System

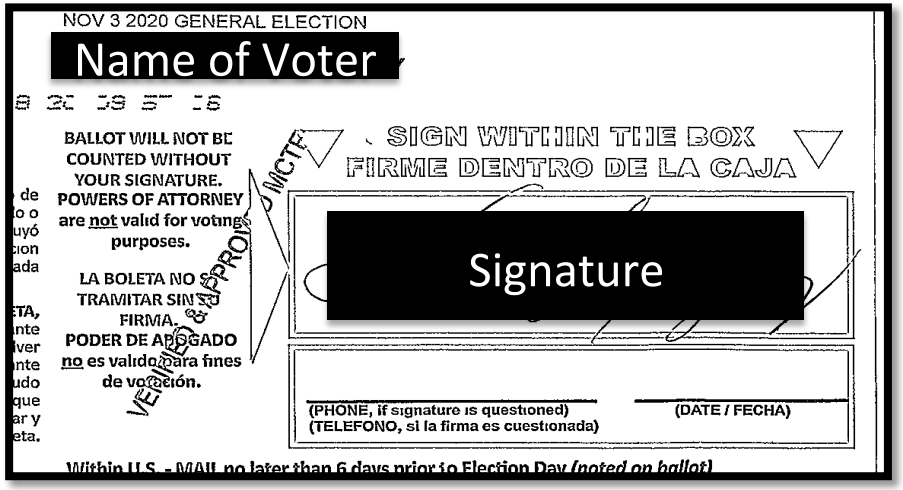
EVB
Return Envelope
Images

The System

The Signal

Early Voting Ballot (EVB) System

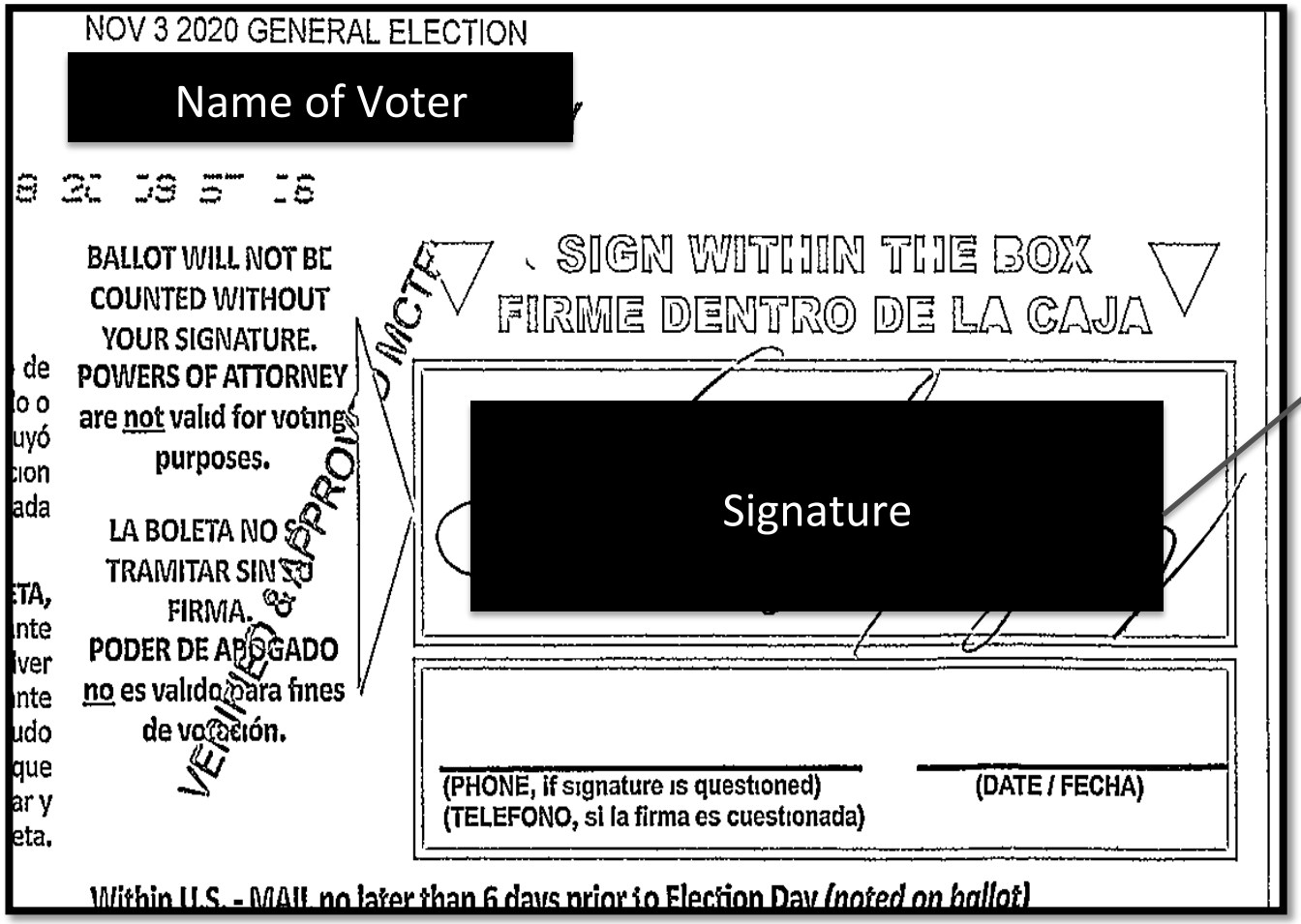
EVB
System



The System

The Signal

Early Voting Ballot Return Envelope

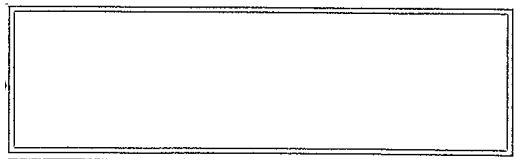


EVB Return Envelope Images
Signature Detection & Classification

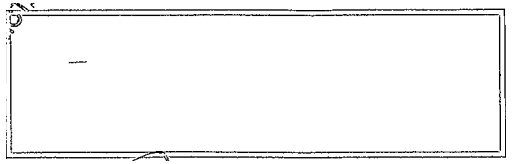
NORMAL STATE

ABNORMAL STATES

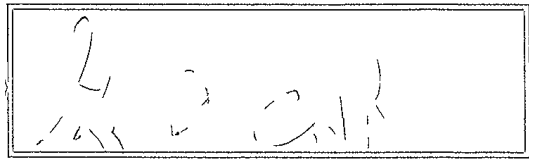
Signature



Blank



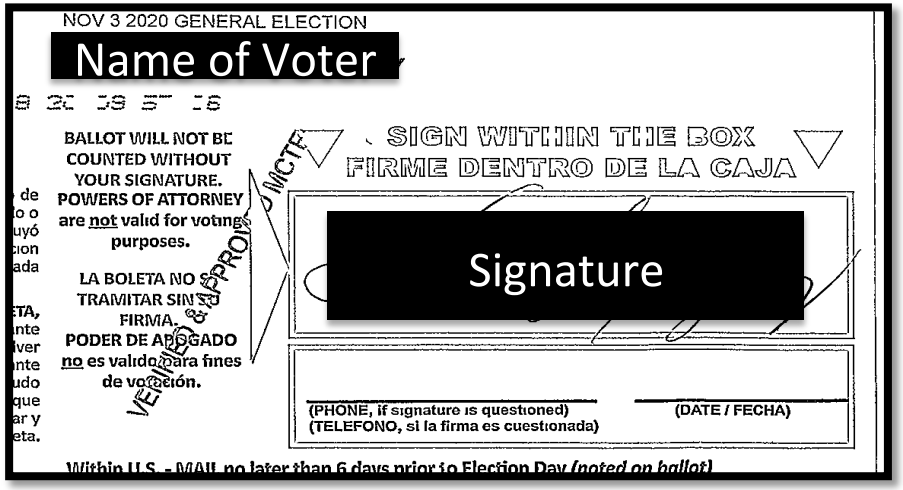
Likely Blank



Scribble

Early Voting Ballot (EVB) System

EVB
System



The System

The Signal

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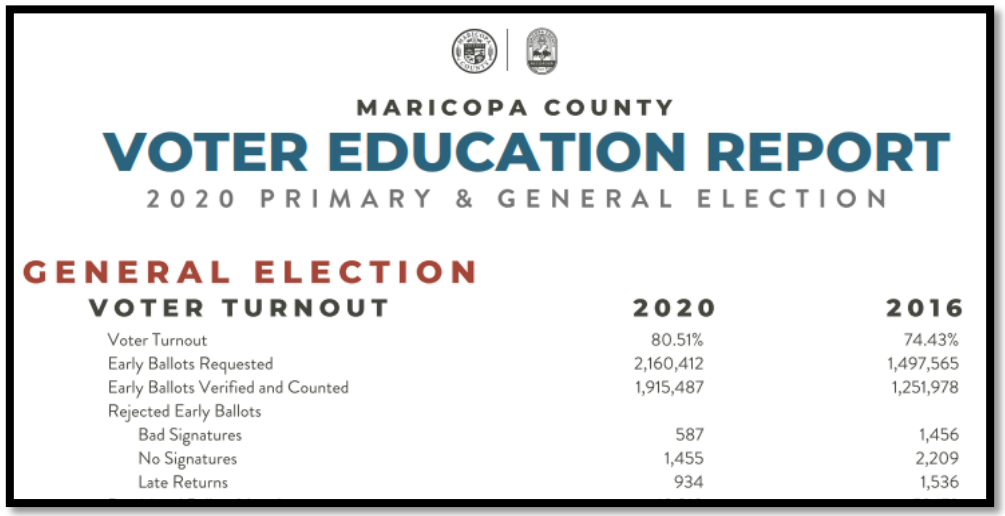


MARICOPA COUNTY

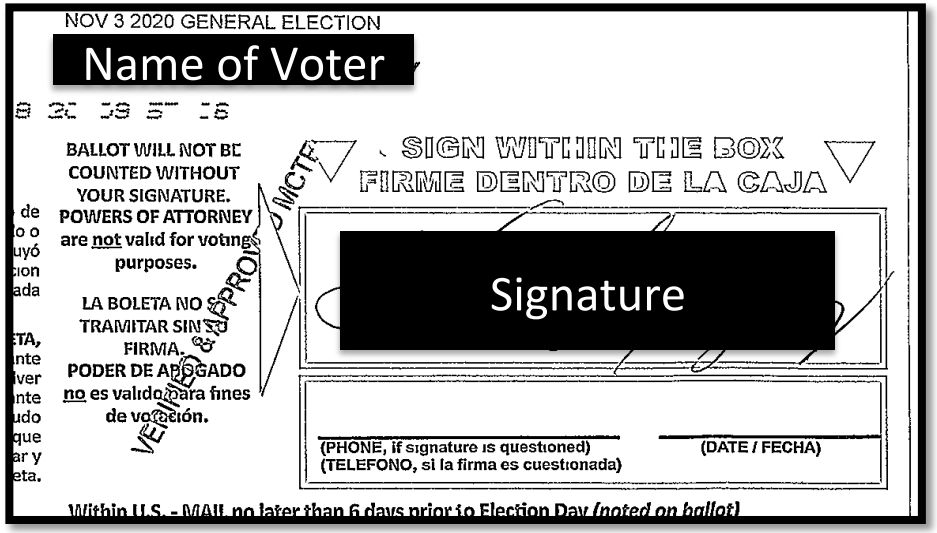
VOTER EDUCATION REPORT

2020 PRIMARY & GENERAL ELECTION

GENERAL ELECTION

VOTER TURNOUT	2020	2016
Voter Turnout	80.51%	74.43%
Early Ballots Requested	2,160,412	1,497,565
Early Ballots Verified and Counted	1,915,487	1,251,978
Rejected Early Ballots		
Bad Signatures	587	1,456
No Signatures	1,455	2,209
Late Returns	934	1,536

The System



The Signal

Maricopa EVB Results

MARICOPA COUNTY

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2020 PRIMARY & GENERAL ELECTION

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GENERAL ELECTION

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1,918,463

Summary of Results from Maricopa County

	Maricopa Reported in 2020
Total Unique EVB Return Envelopes	1,918,463

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Signature Verification Process	
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Signature Verification Process	
"Bad Signatures"	(587)
"Late Returns"	(934)
Total EVBs Verified and Counted	**1,915,487**

Scope of Audit & EchoMail Analysis

Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

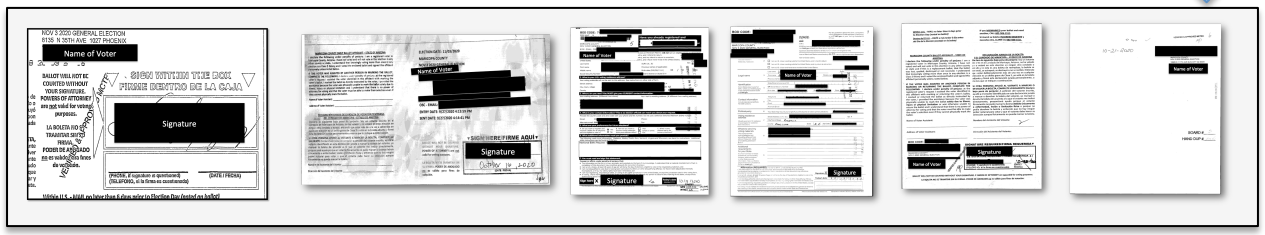
Voter Submits Early Voting Ballot (EVB)

Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

Voter Submits Early Voting Ballot (EVB)

EVB Return Envelopes Are Scanned into Images

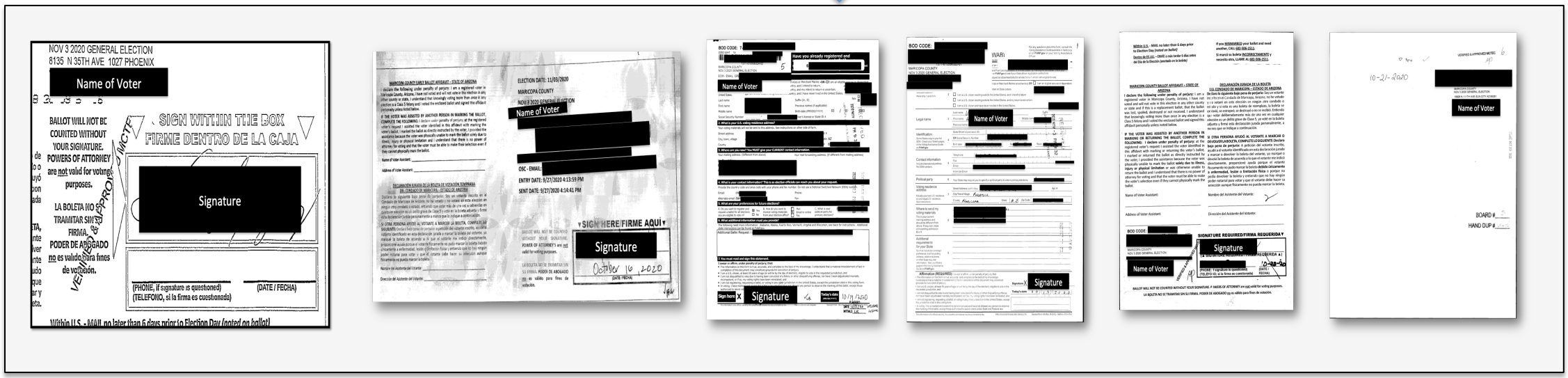


Six (6) different EVB return envelope formats

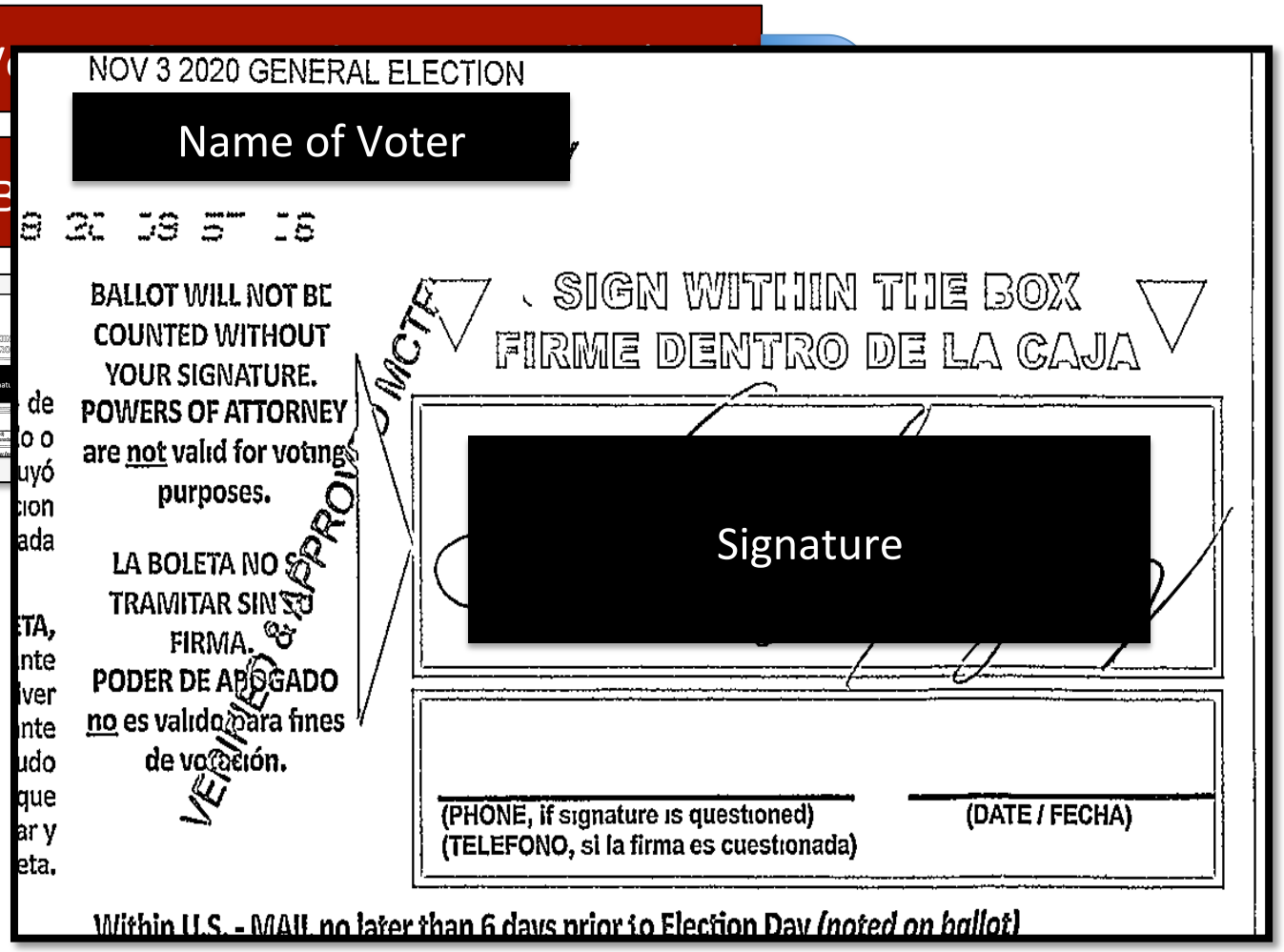
Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

Voter Submits Early Voting Ballot (EVB)

EVB Return Envelopes Are Scanned into Images



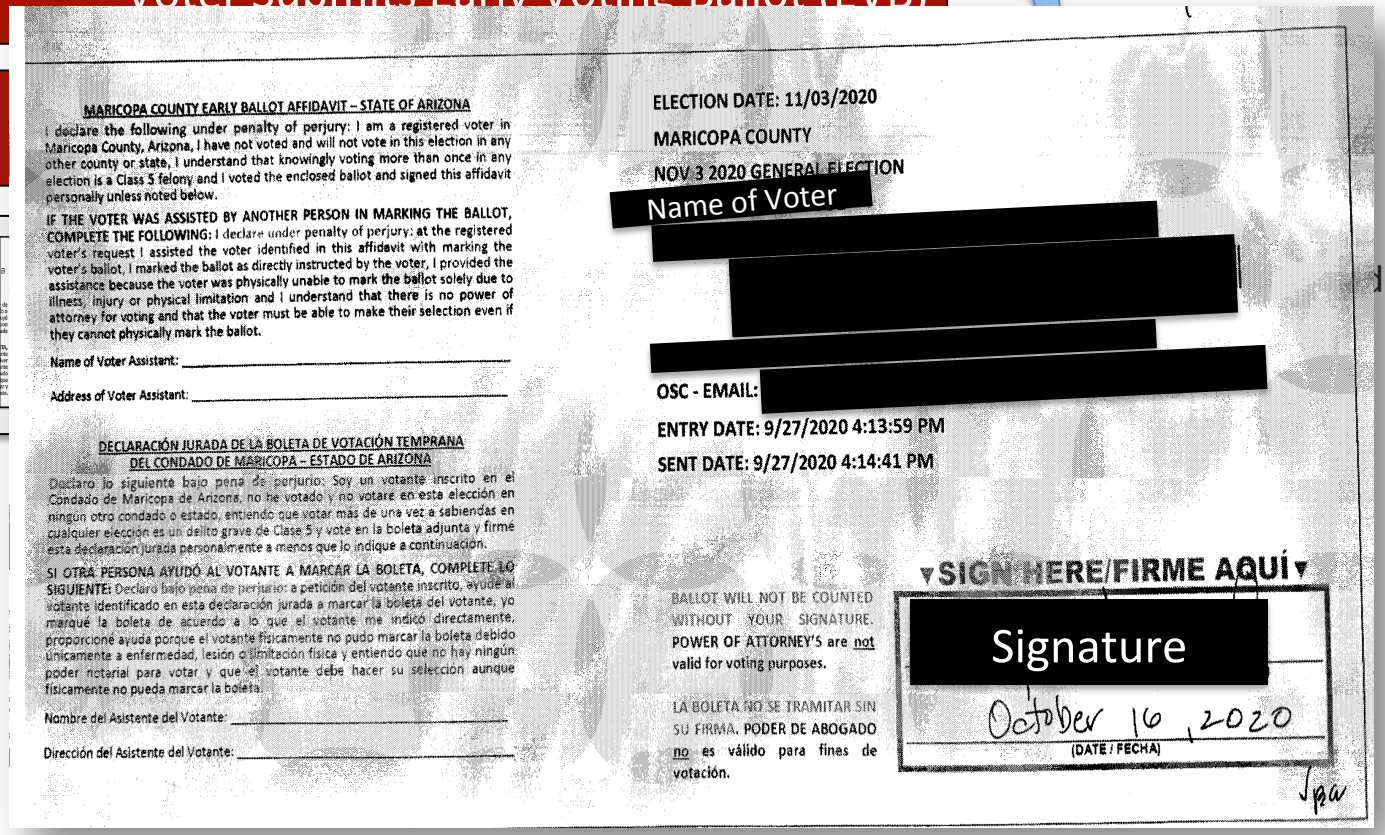
Systems Process for Early Voting Ballot Return Envelope Processing



Standard Image File (SIF)

Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

Voter Submits Early Voting Ballot (EVB)



MARICOPA COUNTY EARLY BALLOT AFFIDAVIT – STATE OF ARIZONA

I declare the following under penalty of perjury: I am a registered voter in Maricopa County, Arizona, I have not voted and will not vote in this election in any other county or state, I understand that knowingly voting more than once in any election is a Class 5 felony and I voted the enclosed ballot and signed this affidavit personally unless noted below.

IF THE VOTER WAS ASSISTED BY ANOTHER PERSON IN MARKING THE BALLOT, COMPLETE THE FOLLOWING: I declare under penalty of perjury: at the registered voter's request I assisted the voter identified in this affidavit with marking the voter's ballot, I marked the ballot as directly instructed by the voter, I provided the assistance because the voter was physically unable to mark the ballot solely due to illness, injury or physical limitation and I understand that there is no power of attorney for voting and that the voter must be able to make their selection even if they cannot physically mark the ballot.

Name of Voter Assistant: _____

Address of Voter Assistant: _____

DECLARACIÓN JURADA DE LA BOLETA DE VOTACIÓN TEMPRANA DEL CONDADO DE MARICOPA – ESTADO DE ARIZONA

Declaro lo siguiente bajo pena de perjurio: Soy un votante inscrito en el Condado de Maricopa de Arizona, no he votado y no votaré en esta elección en ningún otro condado o estado, entiendo que votar más de una vez a sabiendas en cualquier elección es un delito grave de Clase 5 y voté en la boleta adjunta y firmé esta declaración jurada personalmente a menos que lo indique a continuación.

SI OTRA PERSONA AYUDÓ AL VOTANTE A MARCAR LA BOLETA, COMPLETE LO SIGUIENTE: Declaro bajo pena de perjurio: a petición del votante inscrito, ayudé al votante identificado en esta declaración jurada a marcar la boleta del votante, yo marqué la boleta de acuerdo a lo que el votante me indicó directamente, proporcioné ayuda porque el votante físicamente no pudo marcar la boleta debido únicamente a enfermedad, lesión o limitación física y entiendo que no hay ningún poder notarial para votar y que el votante debe hacer su selección aunque físicamente no pueda marcar la boleta.

Nombre del Asistente del Votante: _____

Dirección del Asistente del Votante: _____

ELECTION DATE: 11/03/2020

MARICOPA COUNTY

NOV 3 2020 GENERAL ELECTION

Name of Voter

[redacted]

OSC - EMAIL: [redacted]

ENTRY DATE: 9/27/2020 4:13:59 PM

SENT DATE: 9/27/2020 4:14:41 PM

BALLOT WILL NOT BE COUNTED WITHOUT YOUR SIGNATURE. POWER OF ATTORNEY'S are not valid for voting purposes.

LA BOLETA NO SE TRAMITAR SIN SU FIRMA. PODER DE ABOGADO no es válido para fines de votación.

▼SIGN HERE/FIRME AQUÍ▼

Signature

October 16, 2020

(DATE / FECHA)

Jpa

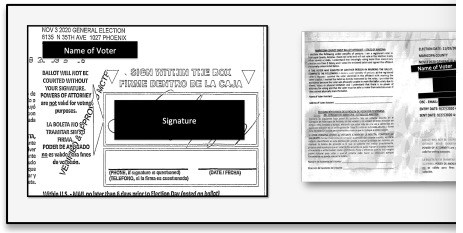
different EVB return envelope formats

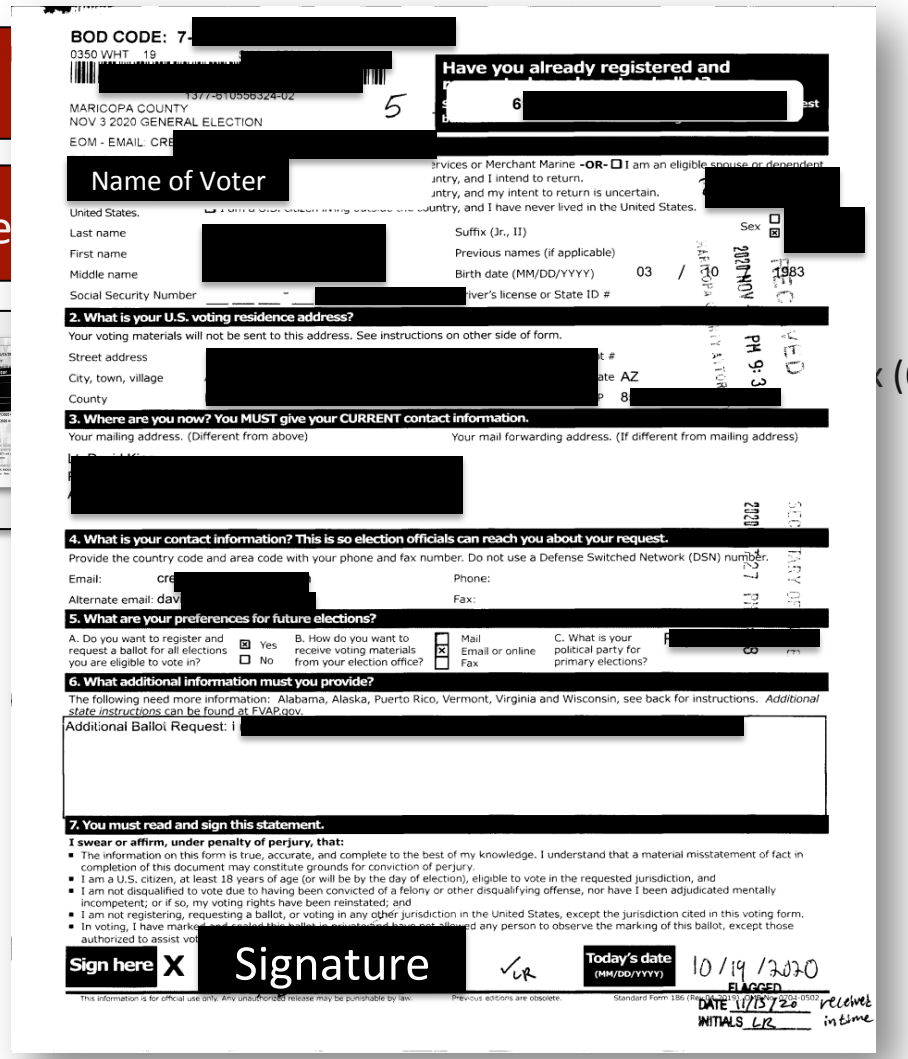
UOCAVA Image File, Type A (UIF-A)

Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

Voter Submits

EVB Return Enve





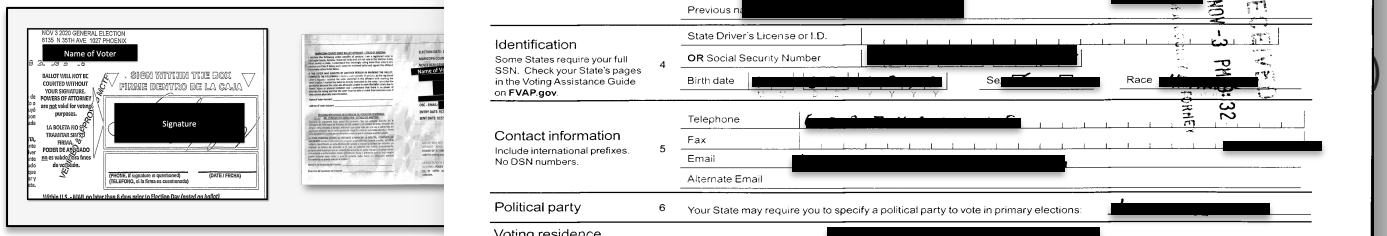
(6) different EVB return envelope formats

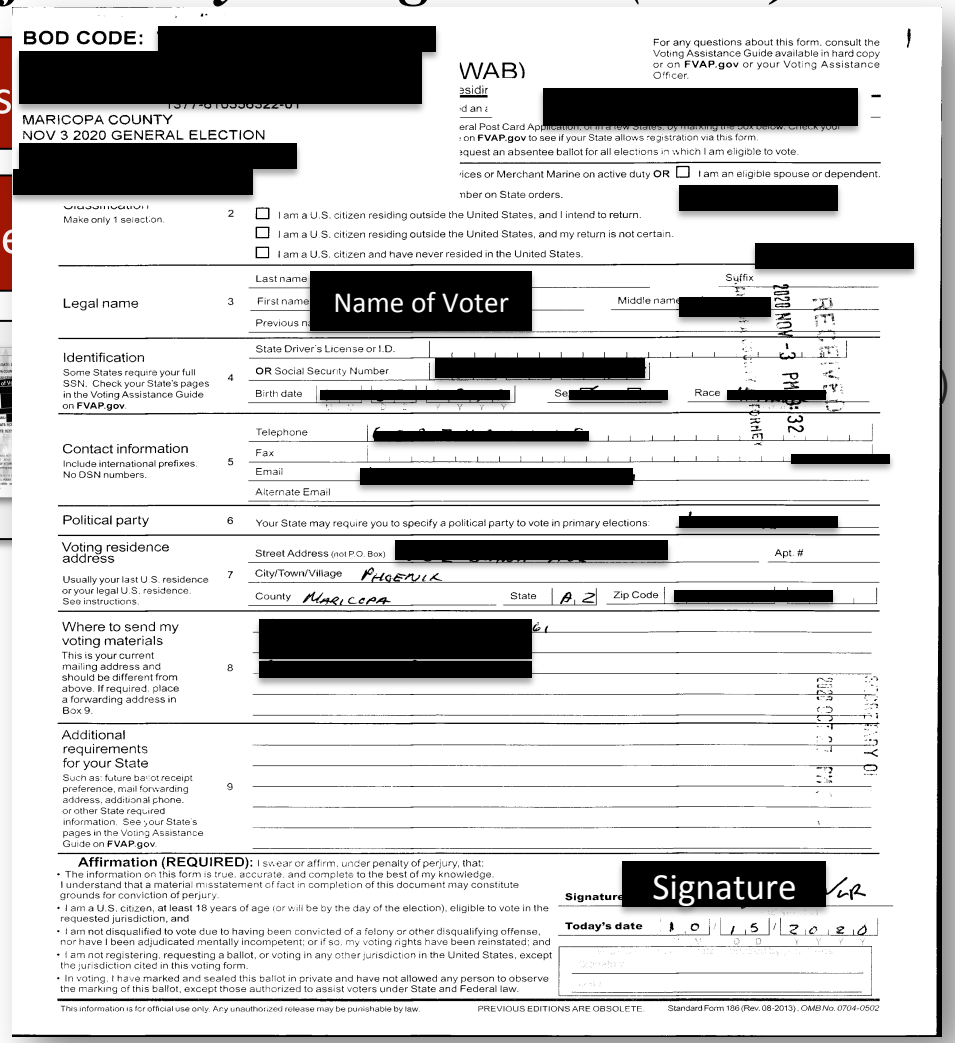
UOCAVA Image File, Type B (UIF-B)

Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

Voter Submits

EVB Return Enve





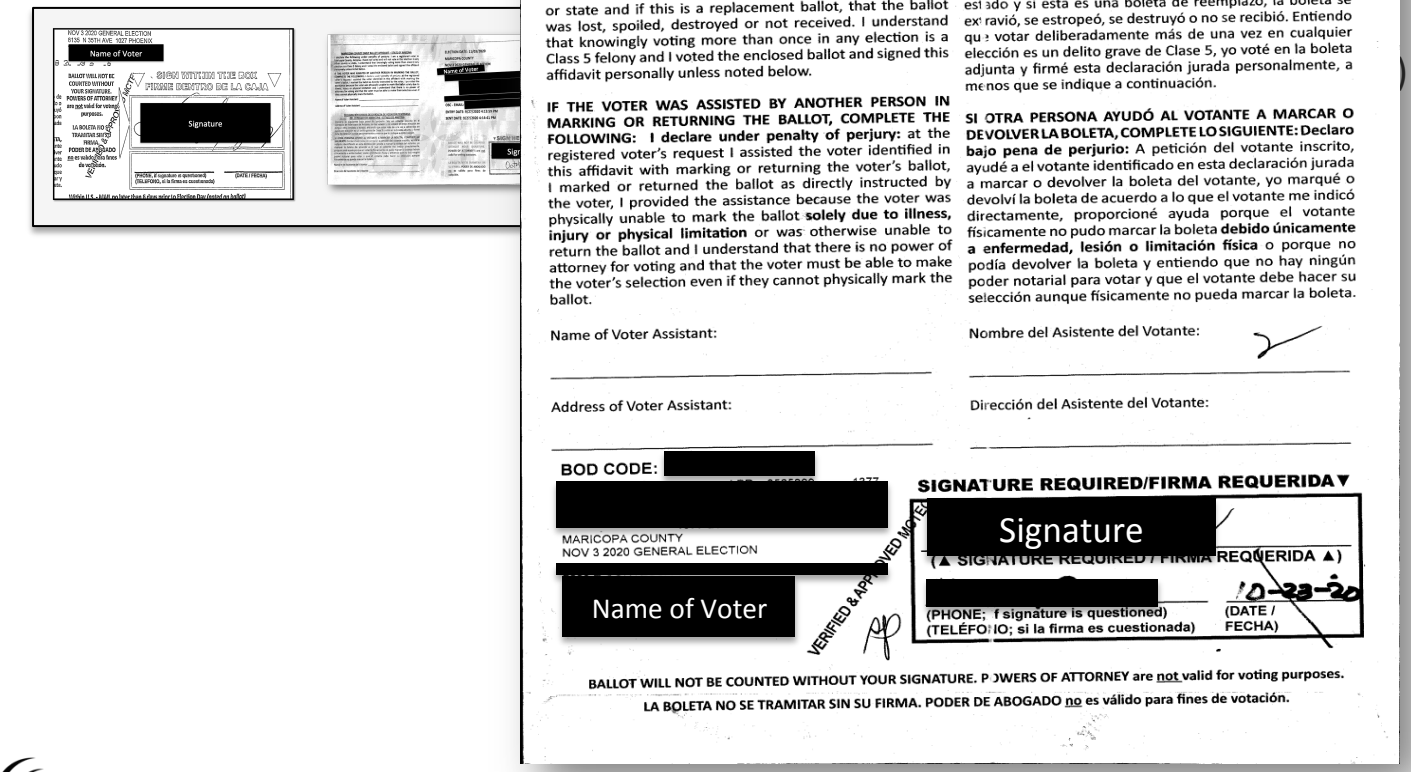
) different EVB return envelope formats

UOCAVA Image File, Type C (UIF-C)

Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

Voter Submits Ea

EVB Return Envelo



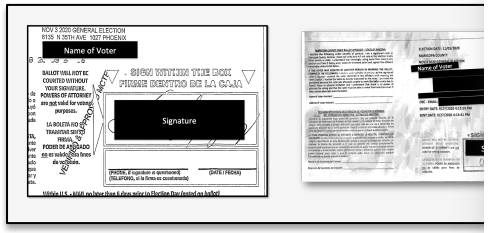
) different EVB return envelope formats

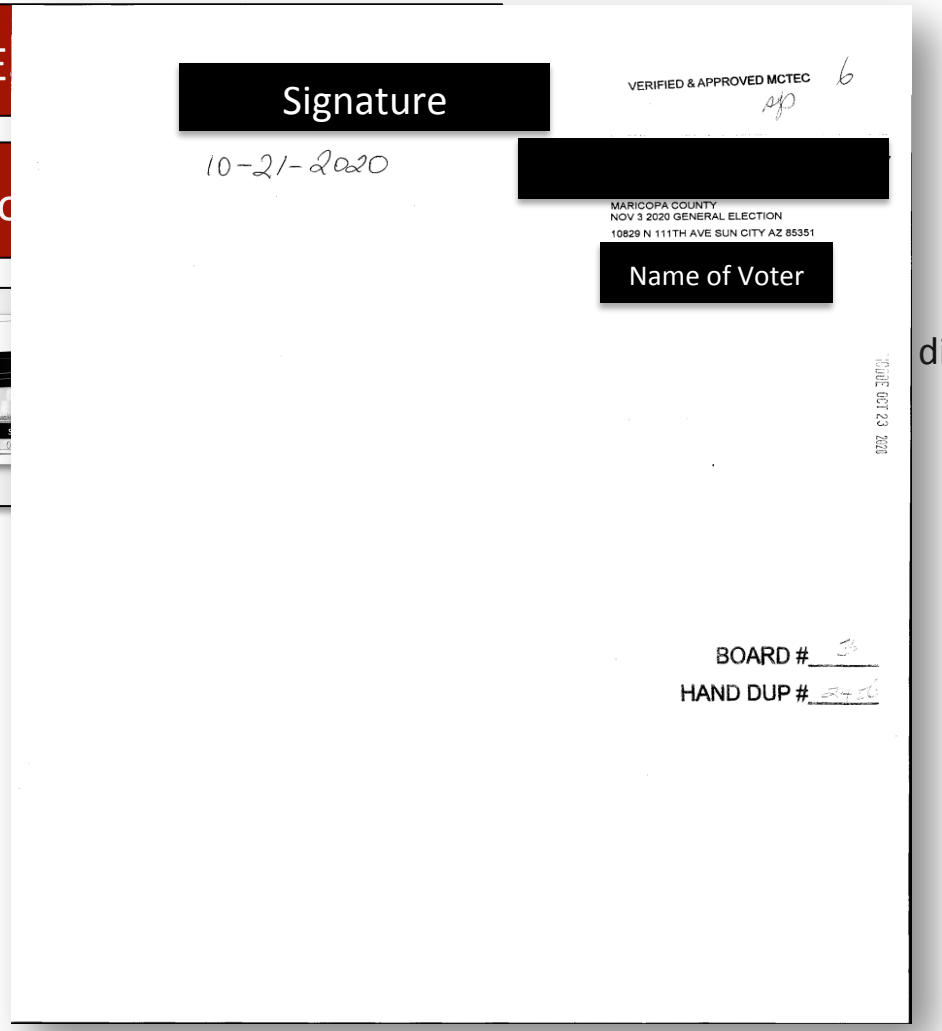
Large Print Image File, (LIF)

Systems Process for Early Voting Ballot (EVB) Return Envelope Processing

Voter Submits E

EVB Return Envelo





different EVB return envelope formats

Braille Image File, (BIF)

Total Count of EVB Return Envelope Image Files Received by EchoMail: 1,929,240

Breakdown by type of images

Type of Image	Count	Percent
SIF	1,919,598	99.5%

Total Count of EVB Return Envelope Image Files Received by EchoMail: 1,929,240

Breakdown by type of images

Type of Image	Count	Percent
SIF	1,919,598	99.5%
UIF-A	8,849	0.459%

Total Count of EVB Return Envelope Image Files Received by EchoMail: 1,929,240

Breakdown by type of images

Type of Image	Count	Percent
SIF	1,919,598	99.5%
UIF-A	8,849	0.459%
UIF-B	277	0.014%

Total Count of EVB Return Envelope Image Files Received by EchoMail: 1,929,240

Breakdown by type of images

Type of Image	Count	Percent
SIF	1,919,598	99.5%
UIF-A	8,849	0.459%
UIF-B	277	0.014%
UIF-C	12	0.001%

Total Count of EVB Return Envelope Image Files Received by EchoMail: 1,929,240

Breakdown by type of images

Type of Image	Count	Percent
SIF	1,919,598	99.5%
UIF-A	8,849	0.459%
UIF-B	277	0.014%
UIF-C	12	0.001%
LIF	475	0.024%

Total Count of EVB Return Envelope Image Files Received by EchoMail: 1,929,240

Breakdown by type of images

Type of Image	Count	Percent
SIF	1,919,598	99.5%
UIF-A	8,849	0.459%
UIF-B	277	0.014%
UIF-C	12	0.001%
LIF	475	0.024%
BIF	29	0.002%

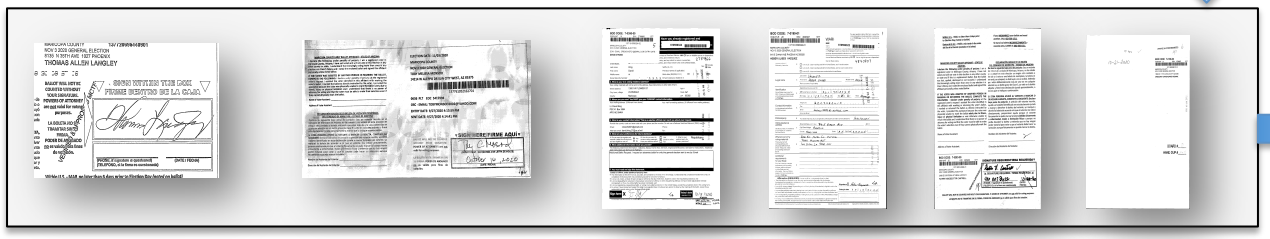
Total Count of EVB Return Envelope Image Files Received by EchoMail: 1,929,240

Type of Image	Count	Percent
SIF	1,919,598	99.5%
UIF-A	8,849	0.459%
UIF-B	277	0.014%
UIF-C	12	0.001%
LIF	475	0.024%
BIF	29	0.002%
TOTAL	**1,929,240**	**100%**

Systems Process for Early Voting Ballot Return Envelope Processing

Voter Submits Early Voting Ballot (EVB)

EVB Return Envelopes Are Scanned into Images



Six (6) different EVB return envelope formats

Removal of Duplicates

Duplicates Analysis

Type	Total Images	Duplicates	Unique Voters
2-Copy Duplicates	33,868	16,934	16,934

Duplicates Analysis

Type	Total Images	Duplicates	Unique Voters
2-Copy Duplicates	33,868	16,934	16,934
3-Copy Duplicates	564	376	188

Duplicates Analysis

Type	Total Images	Duplicates	Unique Voters
2-Copy Duplicates	33,868	16,934	16,934
3-Copy Duplicates	564	376	188
4-Copy Duplicates	16	12	4

Duplicates Analysis

Type	Total Images	Duplicates	Unique Voters
2-Copy Duplicates	33,868	16,934	16,934
3-Copy Duplicates	564	376	188
4-Copy Duplicates	16	12	4
Total	**34,448**	**17,322**	**17,126**

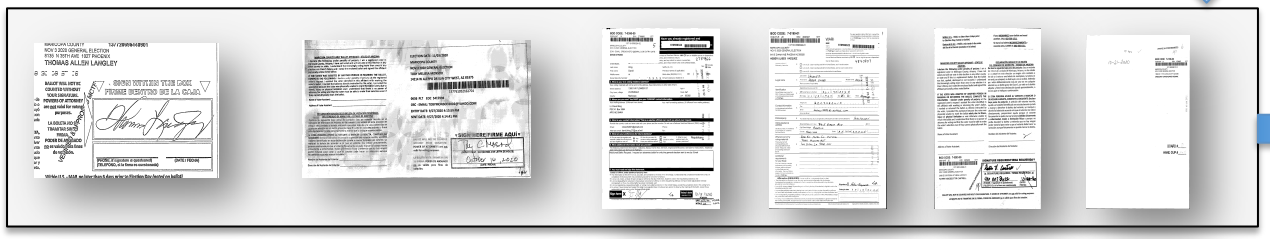
EchoMail: Total Unique EVB Return Envelopes

	EchoMail Analysis
EVB Return Envelopes Received	1,929,240
Duplicate Analysis	
Duplicates	(17,322)
Total Unique EVB Return Envelopes	1,911,918

Systems Process for Early Voting Ballot Return Envelope Processing

Voter Submits Early Voting Ballot (EVB)

EVB Return Envelopes Are Scanned into Images



Six (6) different EVB return envelope formats

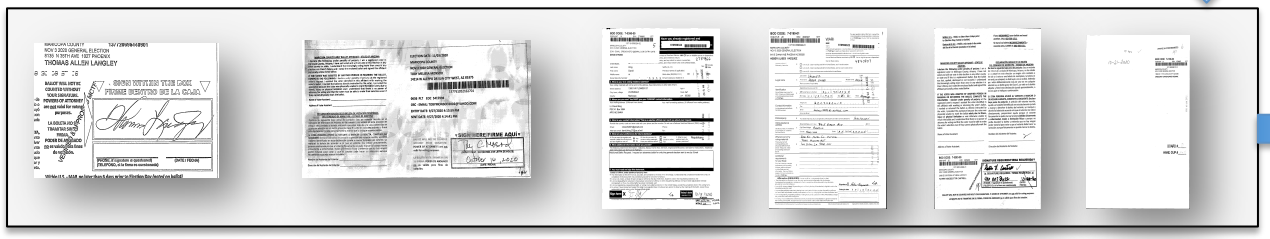
Removal of Duplicates

Signature Presence Detection

Systems Process for Early Voting Ballot Return Envelope Processing

Voter Submits Early Voting Ballot (EVB)

EVB Return Envelopes Are Scanned into Images



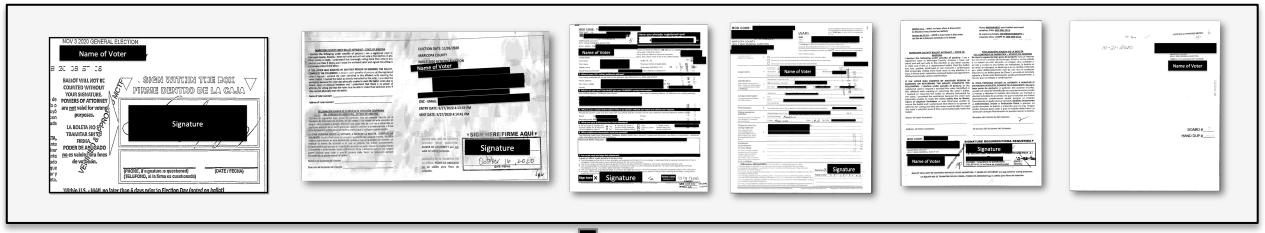
Six (6) different EVB return envelope formats

Removal of Duplicates

Signature Presence Detection

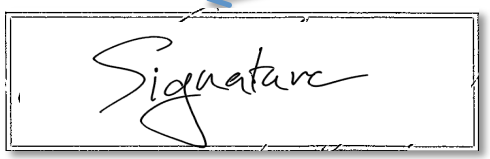
Determination of those EVBs **WITH** Signatures in the Signature Region of Return Envelope

Pattern Recognition Classification of Signature Region on Early Voting Ballot (EVB) Return Envelope Images as Blank, Likely Blank, Scribble, or Signature

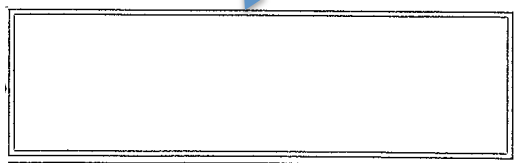


Signature Presence Detection and Classification

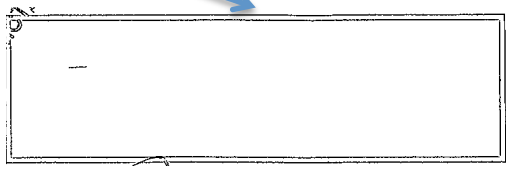
Duplicates



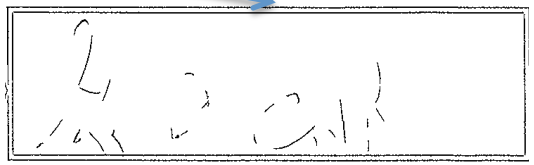
Signature



Blank

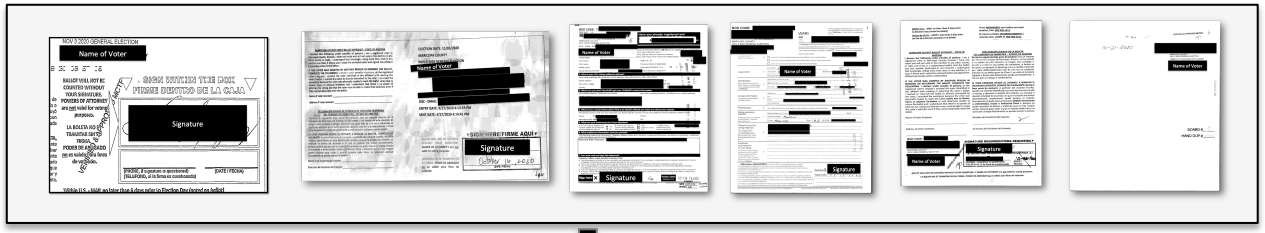


Likely Blank



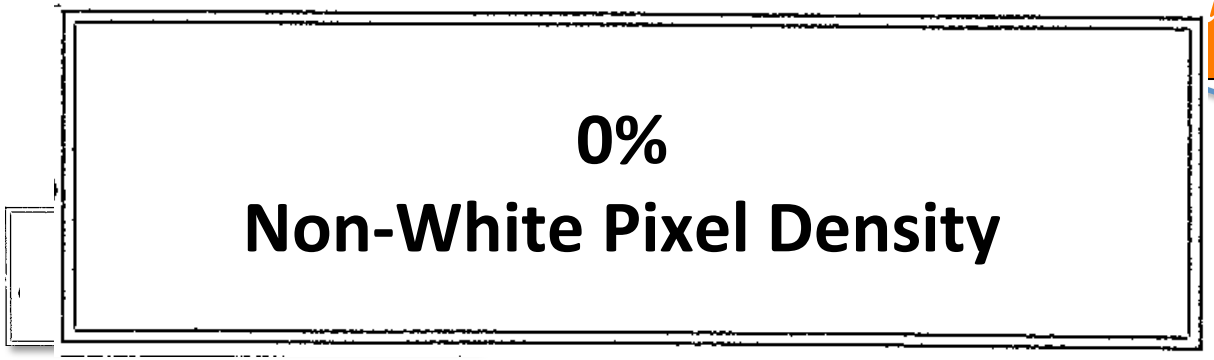
Scribble

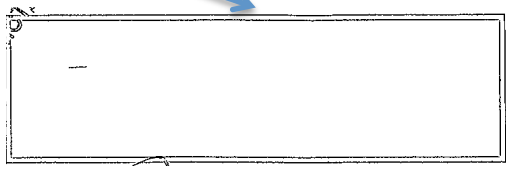
Pattern Recognition Classification of Signature Region on Early Voting Ballot (EVB) Return Envelope Images as Blank, Likely Blank, Scribble, or Signature

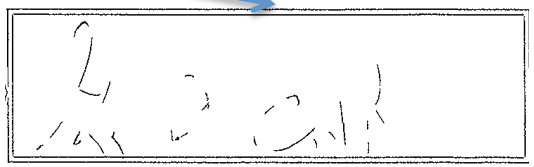


Signature Presence Detection and Classification

Duplicates







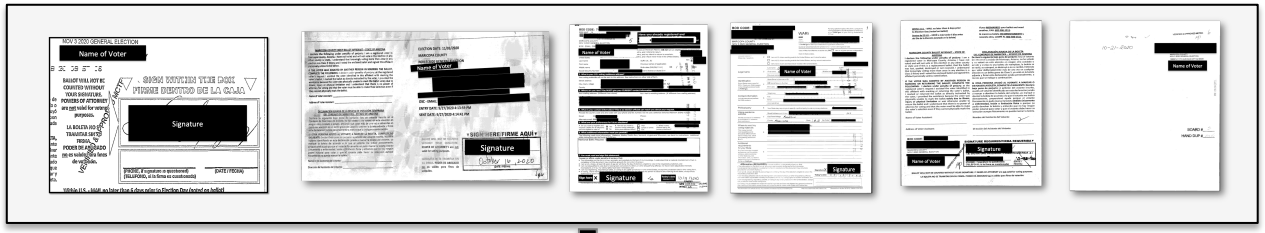
Signature

Blank

Likely Blank

Scribble

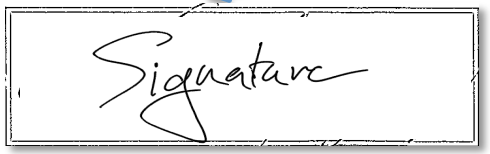
Pattern Recognition Classification of Signature Region on Early Voting Ballot (EVB) Return Envelope Images as Blank, Likely Blank, Scribble, or Signature



Signature Presence Detection

Duplicates

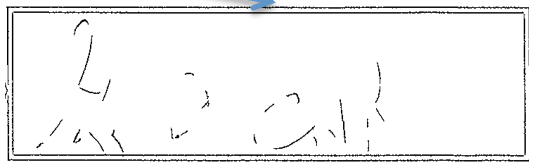
0%+ to 0.1%
Non-White Pixel Density



Signature

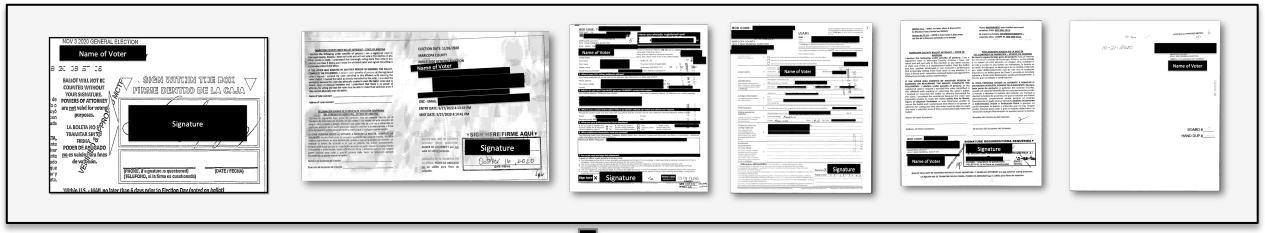
Blank

Likely Blank



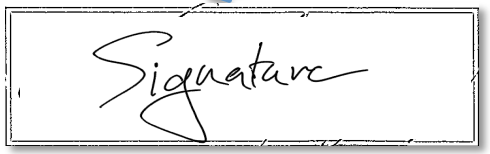
Scribble

Pattern Recognition Classification of Signature Region on Early Voting Ballot (EVB) Return Envelope Images as Blank, Likely Blank, Scribble, or Signature



Signature Presence Detection and Classific

Duplicates



Signature

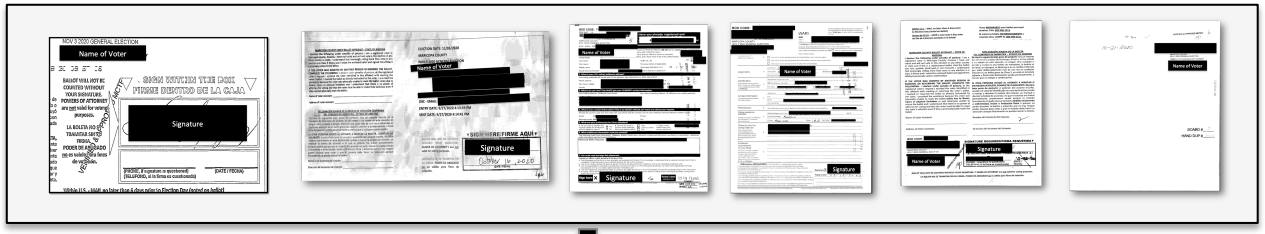
Blank

>0.1%+ to 1%
Non-White Pixel Density

Likely Blank

Scribble

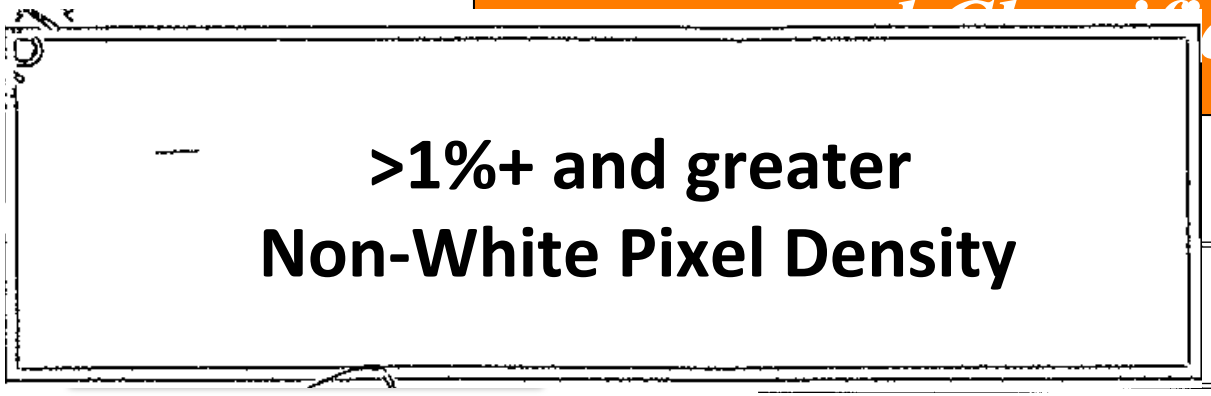
Pattern Recognition Classification of Signature Region on Early Voting Ballot (EVB) Return Envelope Images as Blank, Likely Blank, Scribble, or Signature



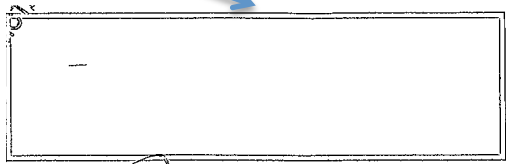
Signature Presence Detection

Duplicates

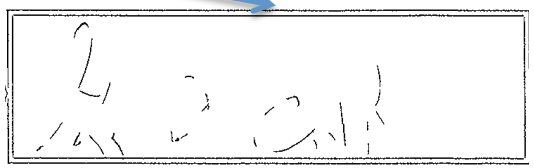
>1%+ and greater
Non-White Pixel Density



Signature



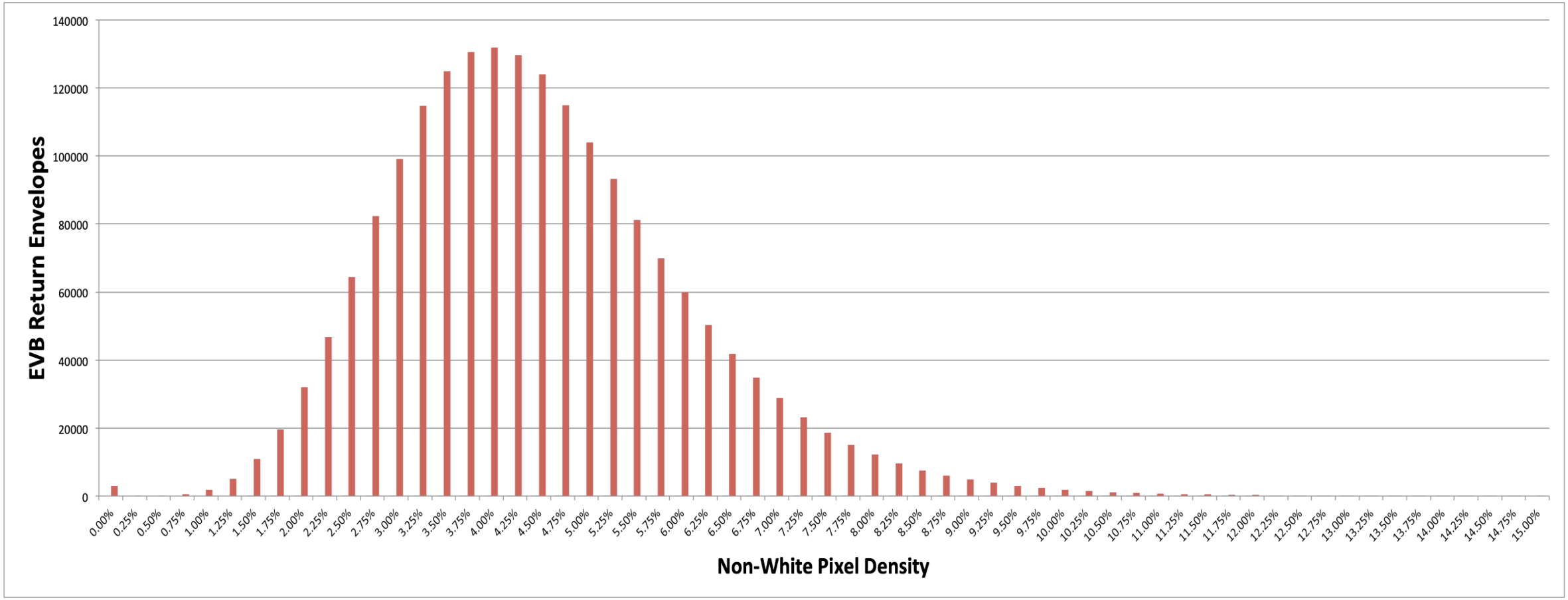
Blank



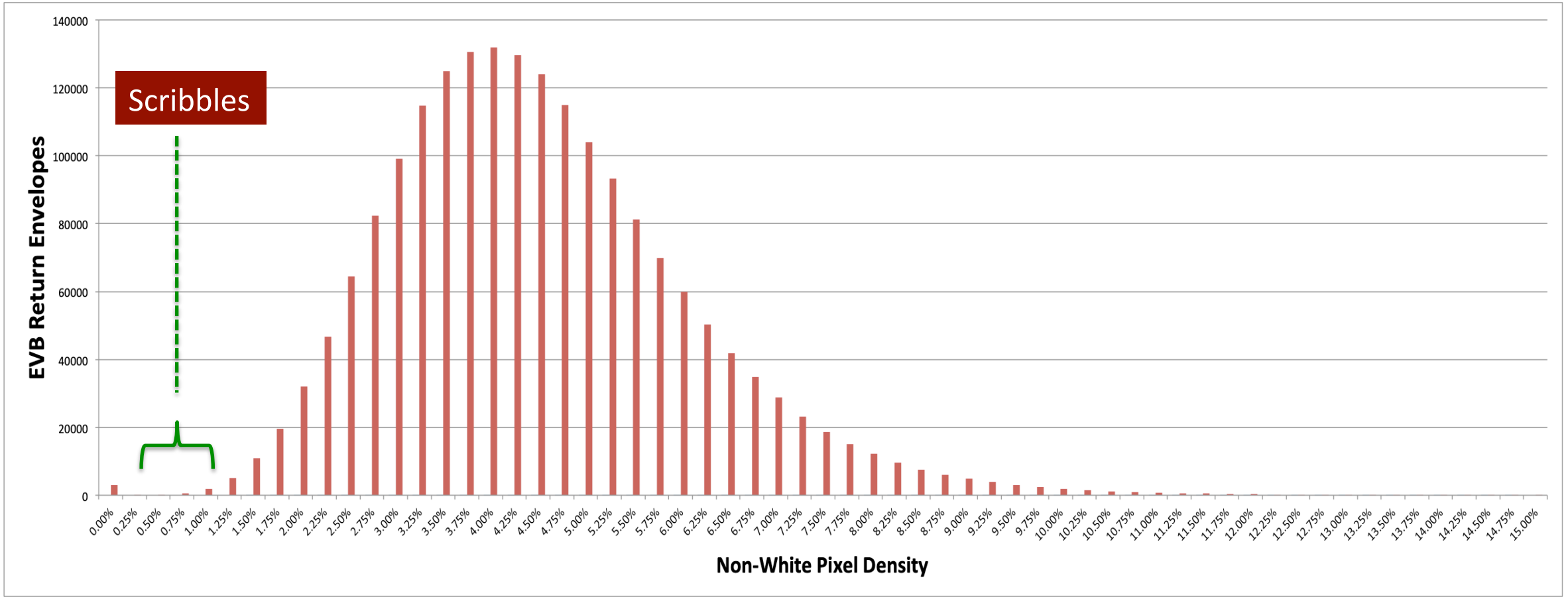
Likely Blank

Scribble

%Non-White Pixel Density vs. EVB Return Envelope Volume



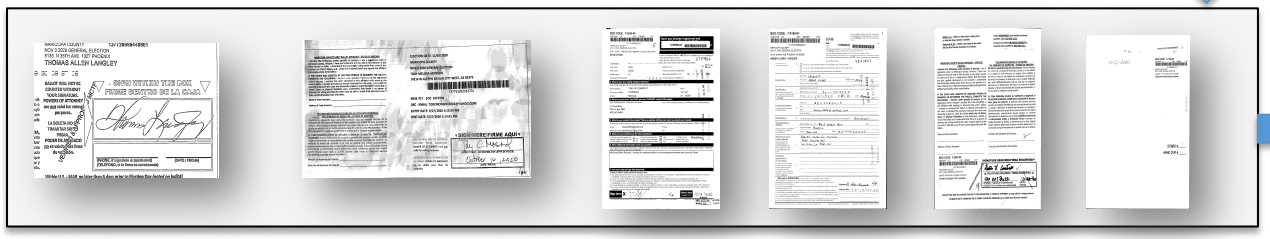
%Non-White Pixel Density vs. EVB Return Envelope Volume



Systems Process for Early Voting Ballot Return Envelope Processing

Voter Submits Early Voting Ballot (EVB)

EVB Return Envelopes Are Scanned into Images



Six (6) different EVB return envelope formats

Removal of Duplicates

Signature Presence Detection

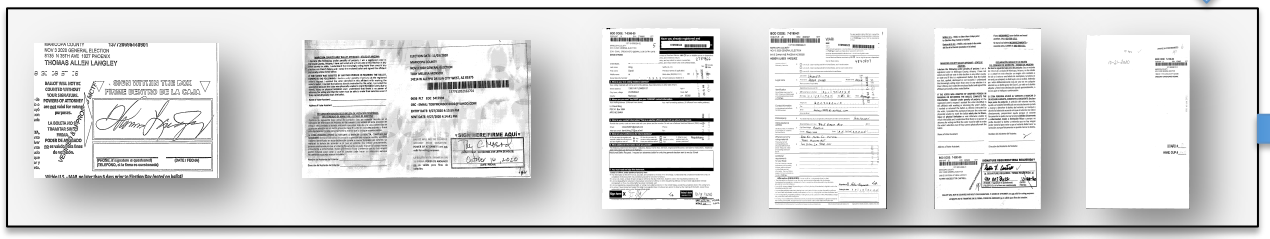
Determination of those EVBs **WITH** Signatures in the Signature Region of Return Envelope

Signature Verification

Systems Process for Early Voting Ballot Return Envelope Processing

Voter Submits Early Voting Ballot (EVB)

EVB Return Envelopes Are Scanned into Images



Six (6) different EVB return envelope formats

Removal of Duplicates

Signature Presence Detection

Determination of those EVBs **WITH** Signatures in the Signature Region of Return Envelope

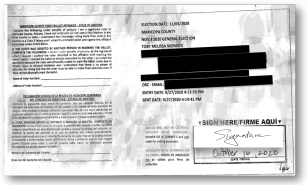
Signature Verification

Validate Signatures on EVB Return Envelopes

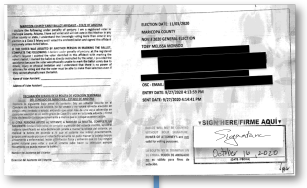
Opening of EVB Return Envelopes and Tabulation of EVBs

Signature Presence Detection

EVB Return Envelope Image

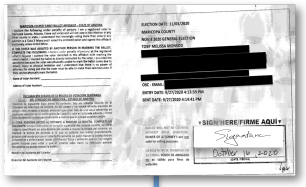


EVB Return Envelope Image

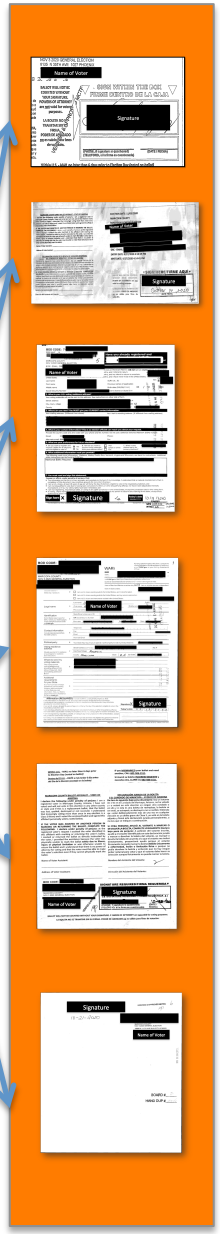


Automatic EVB Envelope Classification

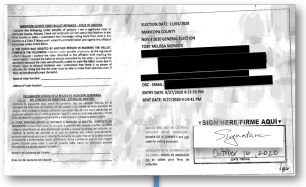
EVB Return Envelope Image



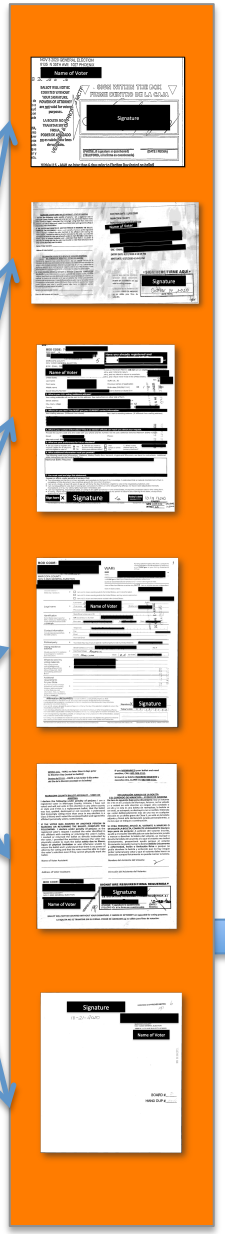
Automatic EVB Envelope Classification



EVB Return Envelope Image



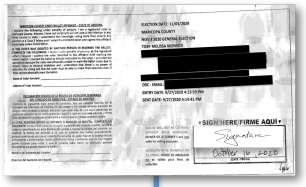
Automatic EVB Envelope Classification



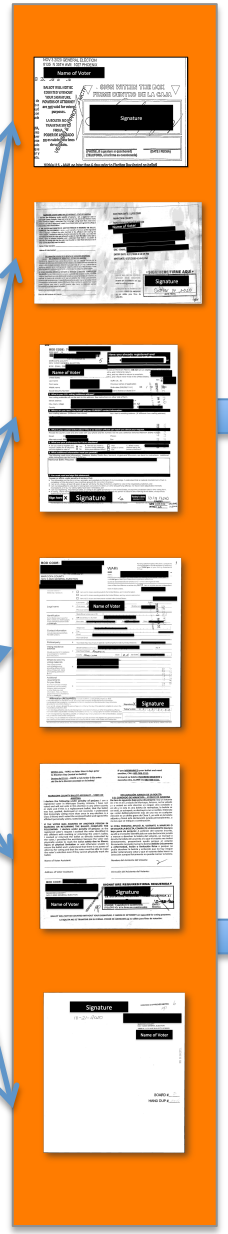
Duplicate Recognition

Duplicates

EVB Return Envelope Image



Automatic EVB Envelope Classification



Detection of Signature Region

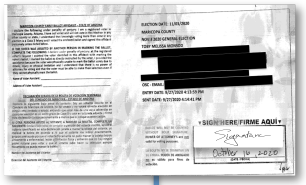
&

OCR of Name

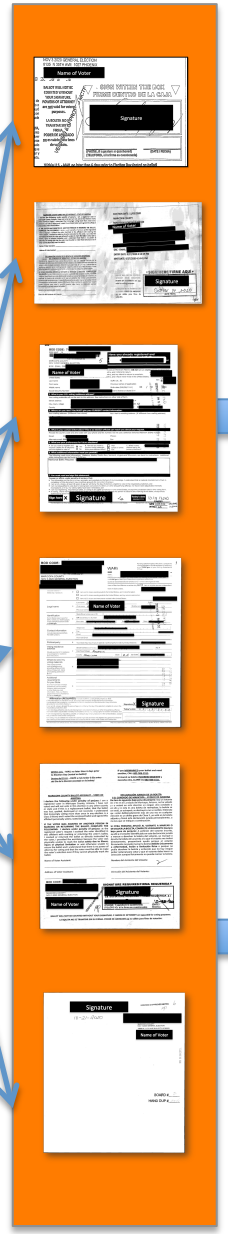
Duplicate Recognition

Duplicates

EVB Return Envelope Image



Automatic EVB Envelope Classification



Detection of Signature Region

&

OCR of Name

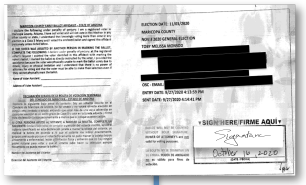
Duplicate Recognition

Duplicates

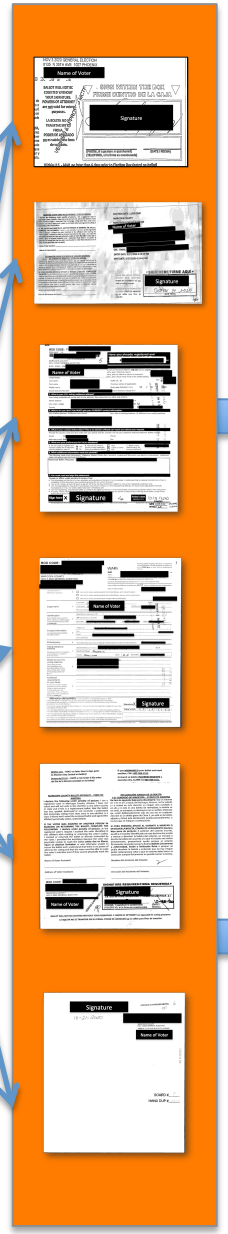
Pattern Recognition Classification of Signature Region

- EchoMail SIF Classifier
- EchoMail UIF-A Classifier
- EchoMail UIF-B Classifier
- EchoMail MIF-C Classifier
- EchoMail LIF Classifier
- EchoMail BIF Classifier

EVB Return Envelope Image



Automatic EVB Envelope Classification



Detection of Signature Region

&

OCR of Name

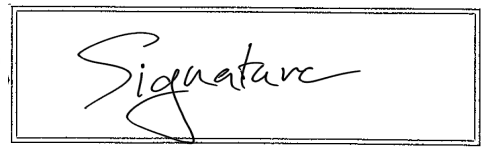
Duplicate Recognition

Duplicates

Pattern Recognition Classification of Signature Region

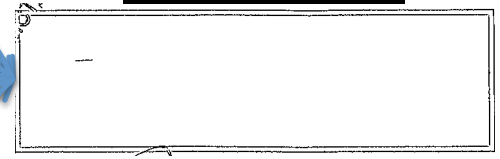
- EchoMail SIF Classifier
- EchoMail UIF-A Classifier
- EchoMail UIF-B Classifier
- EchoMail MIF-C Classifier
- EchoMail LIF Classifier
- EchoMail BIF Classifier

Signature

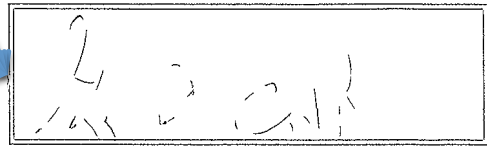


Blank

Likely Blank



Scribble



Non-Duplicate Signature Presence Detection Results

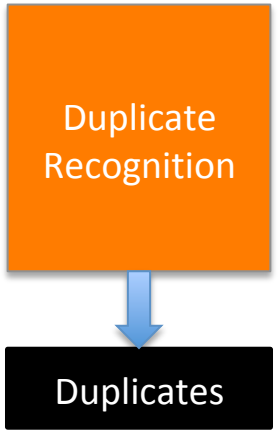
Classification of Non-Duplicate EVB Return Envelope Images	Count	Percentage
Signature	1,890,500	99.77%
Scribble	2,420	0.13%
Blank	1,771	0.09%
Likely Blank	101	0.01%
TOTAL	**1,894,792**	**100.00%**

Non-Duplicate Signature Presence Detection Results

- Scribbles
  - **2,420 Scribbles**
- Blanks i.e. “No Signatures”
  - **1,771**
  - **101**
  - **1,872 Blanks**

Non-Duplicate Image Classification	Count
Signature	1,890,500
Scribble	2,420
Blank	1,771
Likely Blank	101
TOTAL	**1,894,792**

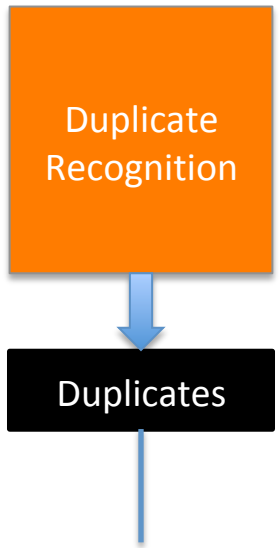
EchoMail Pattern Recognition Methodology & Process for 2-Copy Duplicate Classification



LEGEND

Signature/Signature	(SS)
Signature/Blank	(SB)
Signature/Likely Blank	(SL)
Signature/Scribble	(SC)
Scribble/Blank	(CB)
Scribble/Likely Blank	(CL)
Scribble/Scribble	(CC)
Blank/Blank	(BB)
Blank/Likely Blank	(BL)
Likely Blank/Likely Blank	(LL)

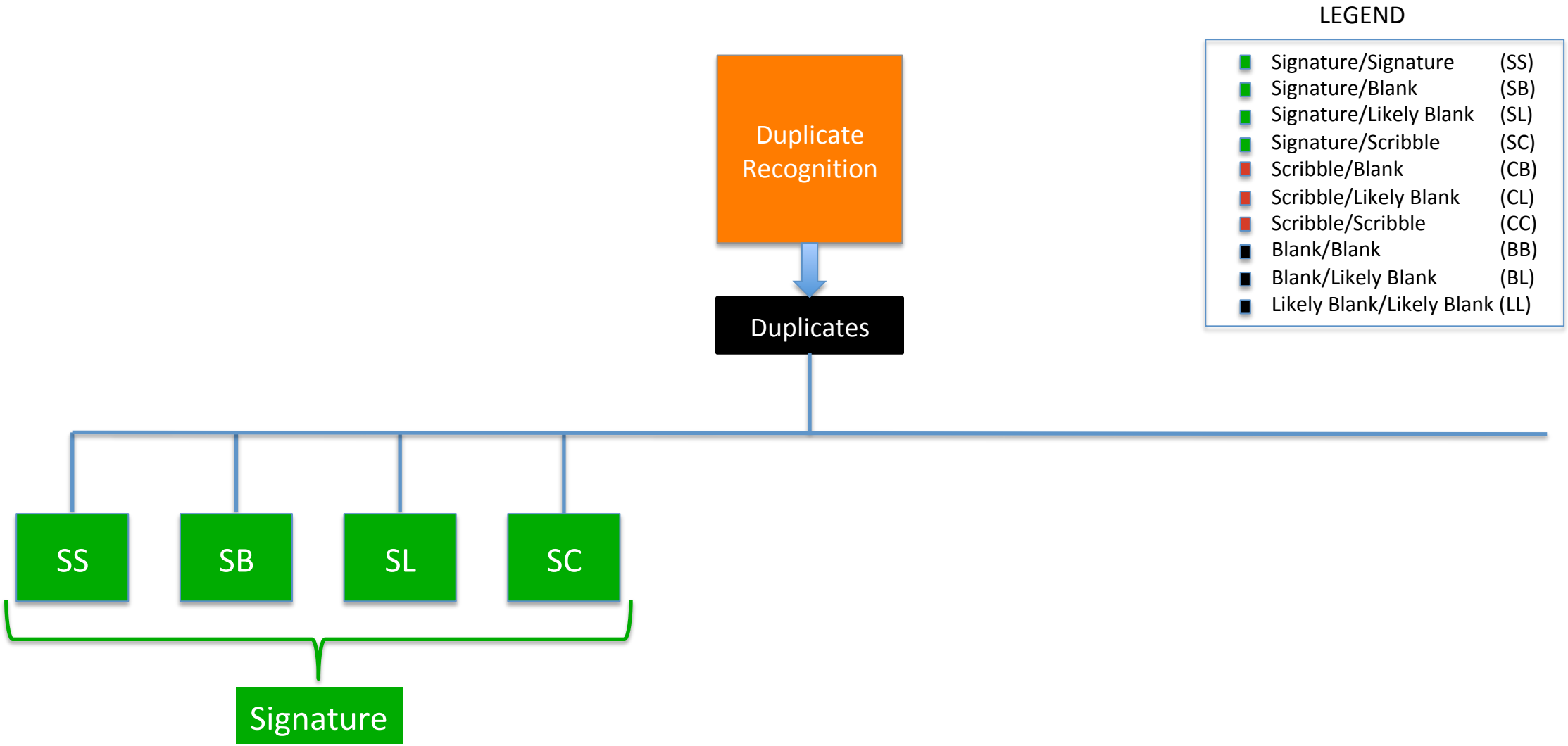
EchoMail Pattern Recognition Methodology & Process for 2-Copy Duplicate Classification



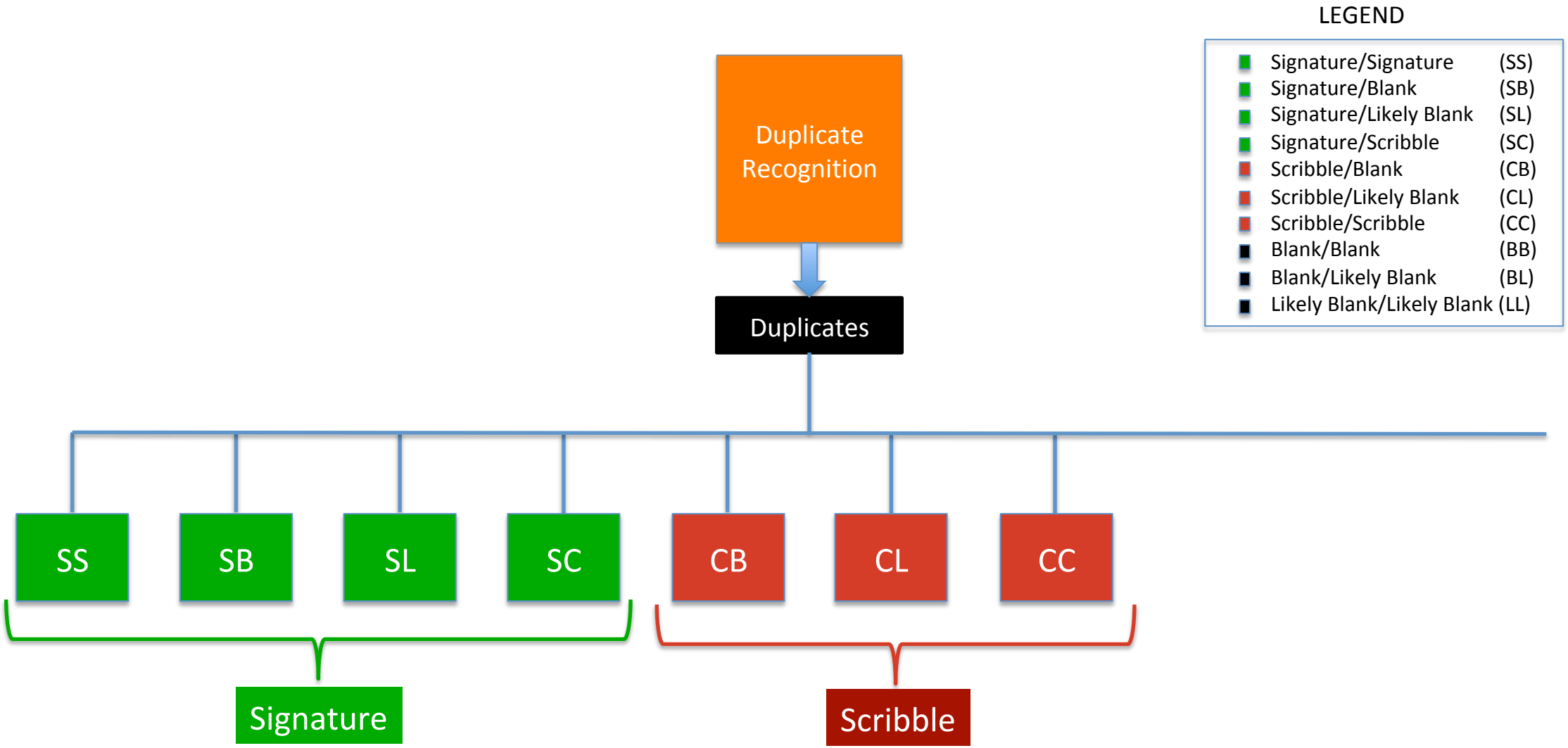
LEGEND

Signature/Signature	(SS)
Signature/Blank	(SB)
Signature/Likely Blank	(SL)
Signature/Scribble	(SC)
Scribble/Blank	(CB)
Scribble/Likely Blank	(CL)
Scribble/Scribble	(CC)
Blank/Blank	(BB)
Blank/Likely Blank	(BL)
Likely Blank/Likely Blank	(LL)

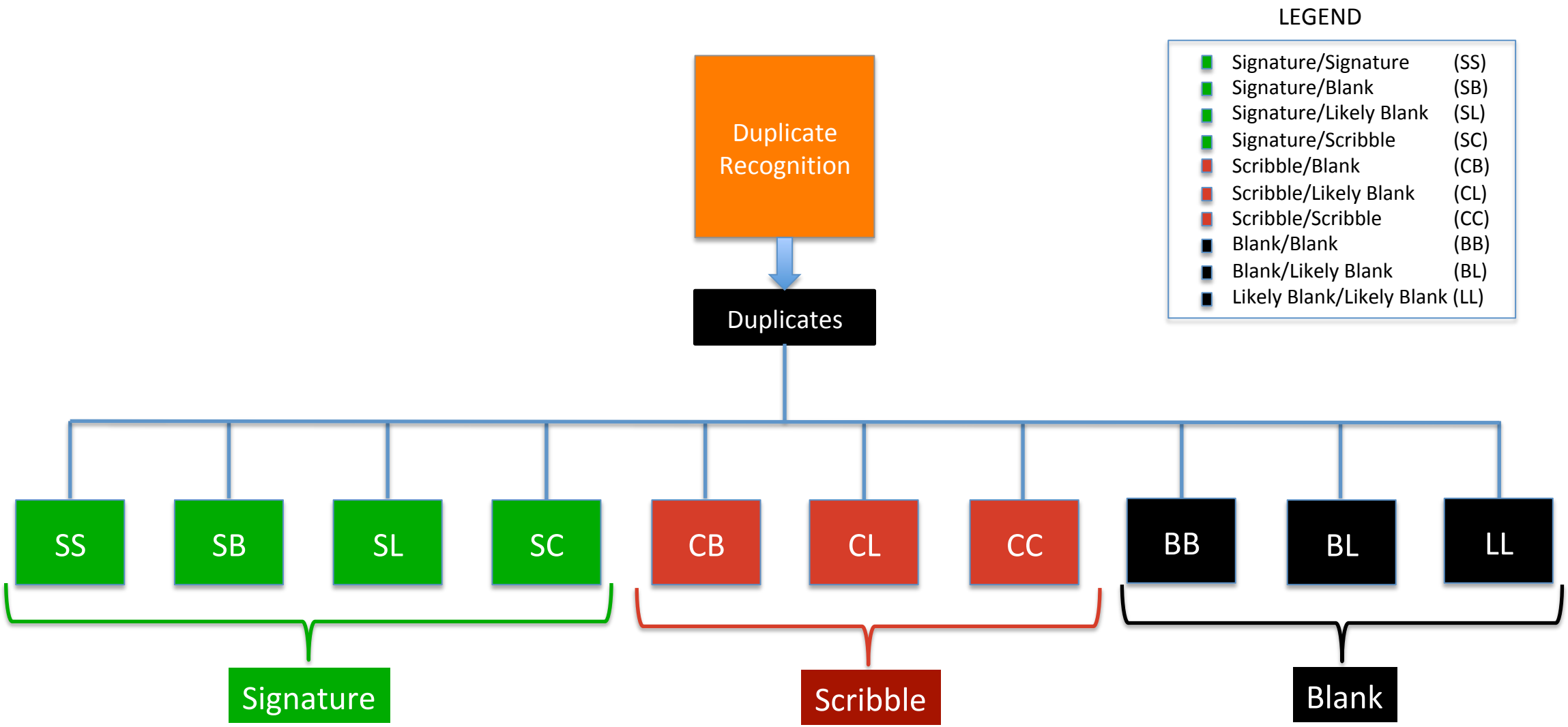
EchoMail Pattern Recognition Methodology & Process for 2-Copy Duplicate Classification



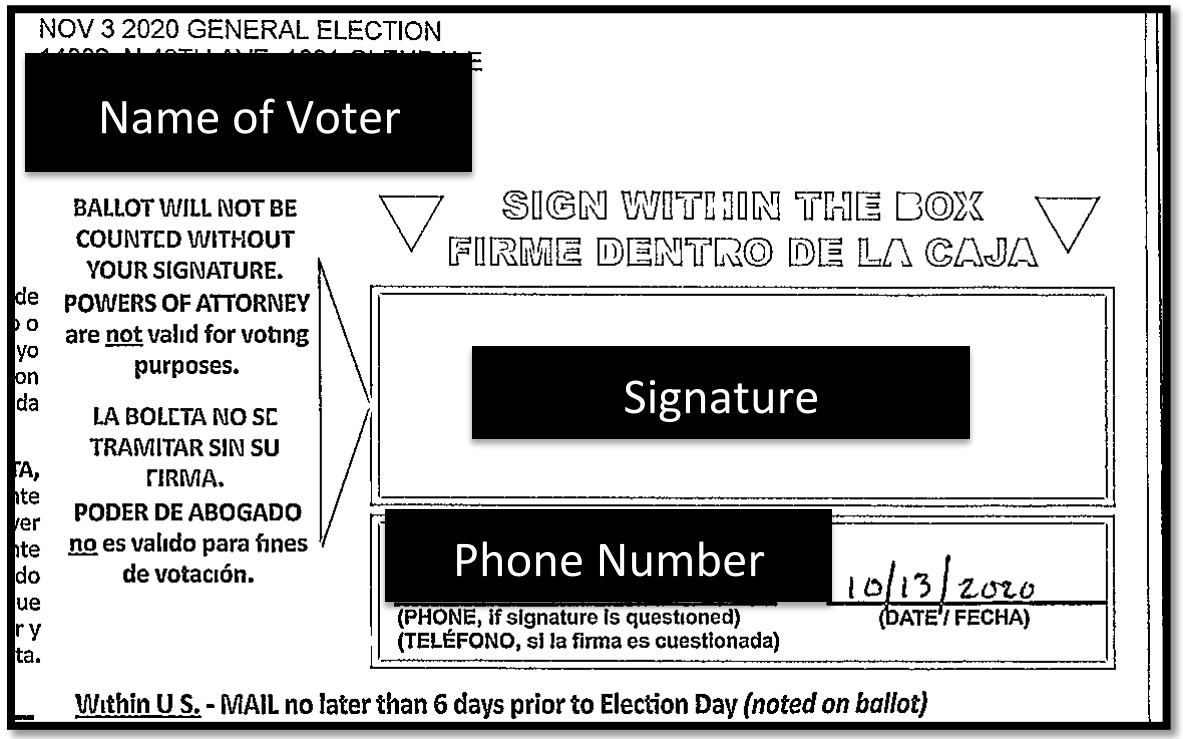
EchoMail Pattern Recognition Methodology & Process for 2-Copy Duplicate Classification

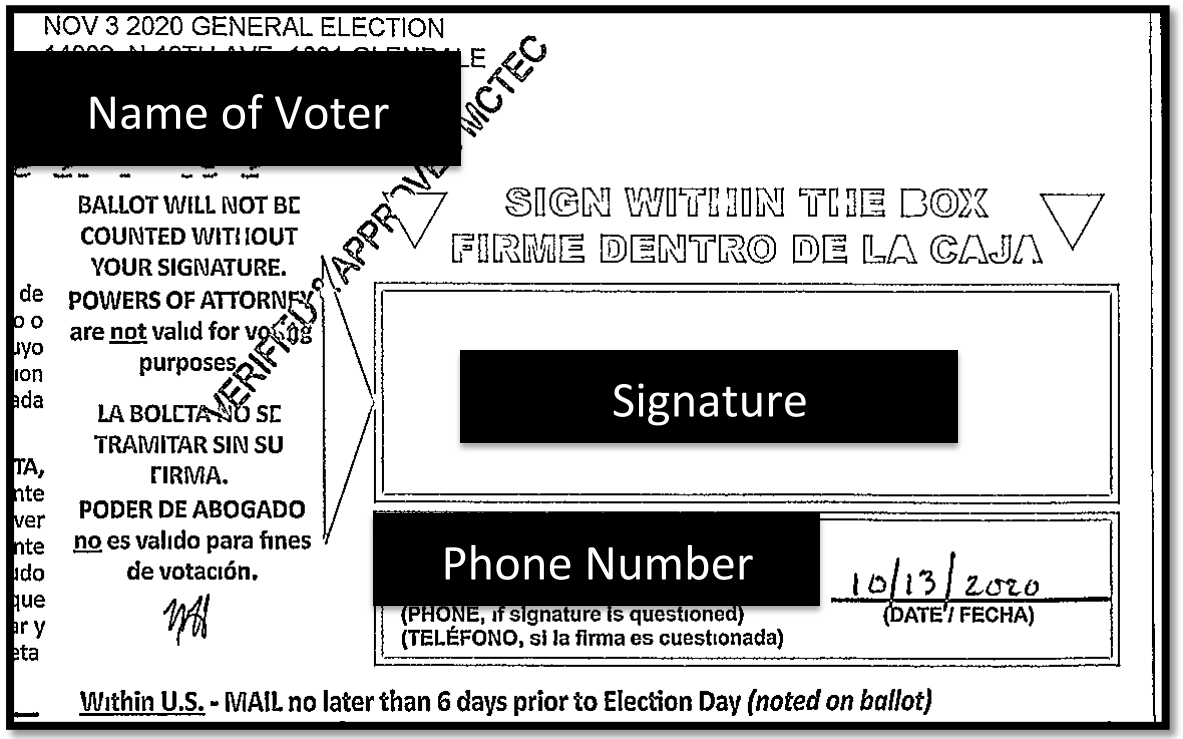


EchoMail Pattern Recognition Methodology & Process for 2-Copy Duplicate Classification

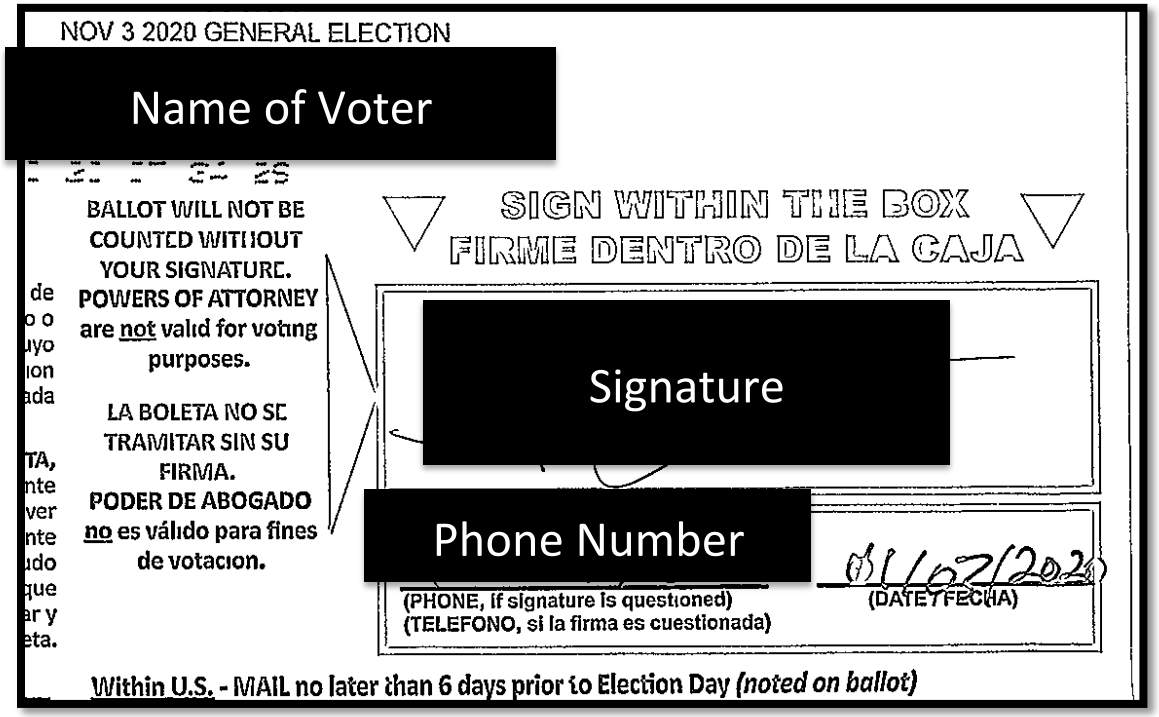


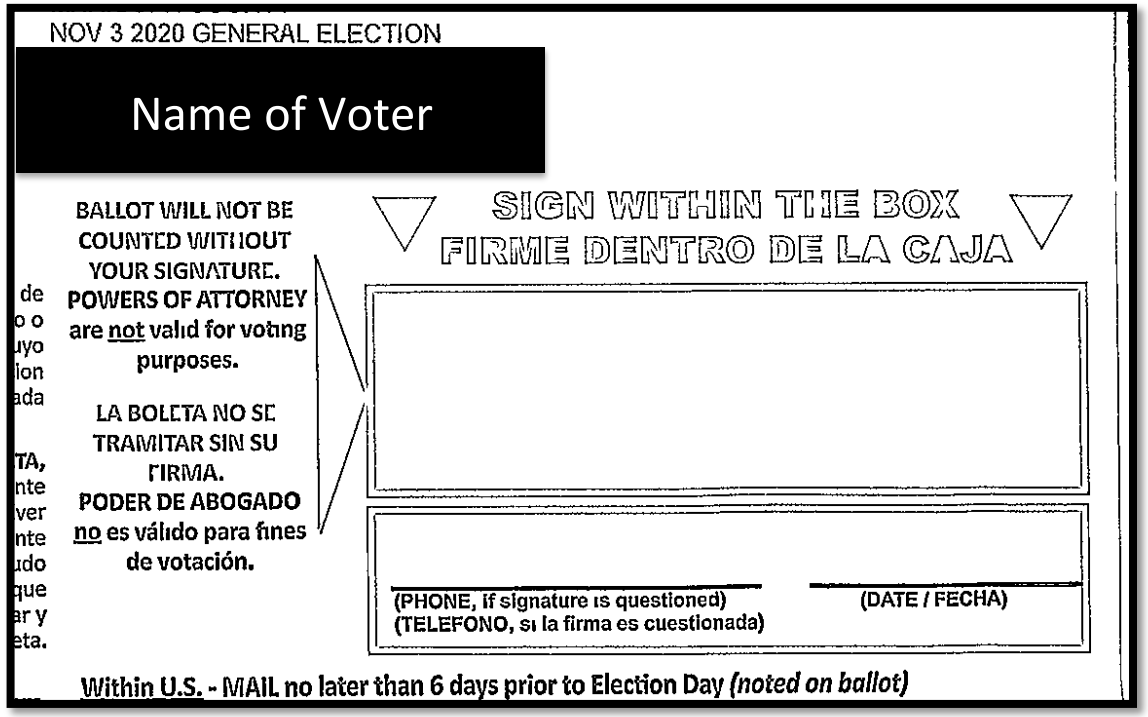
Duplicate (Signed & Signed - SS)



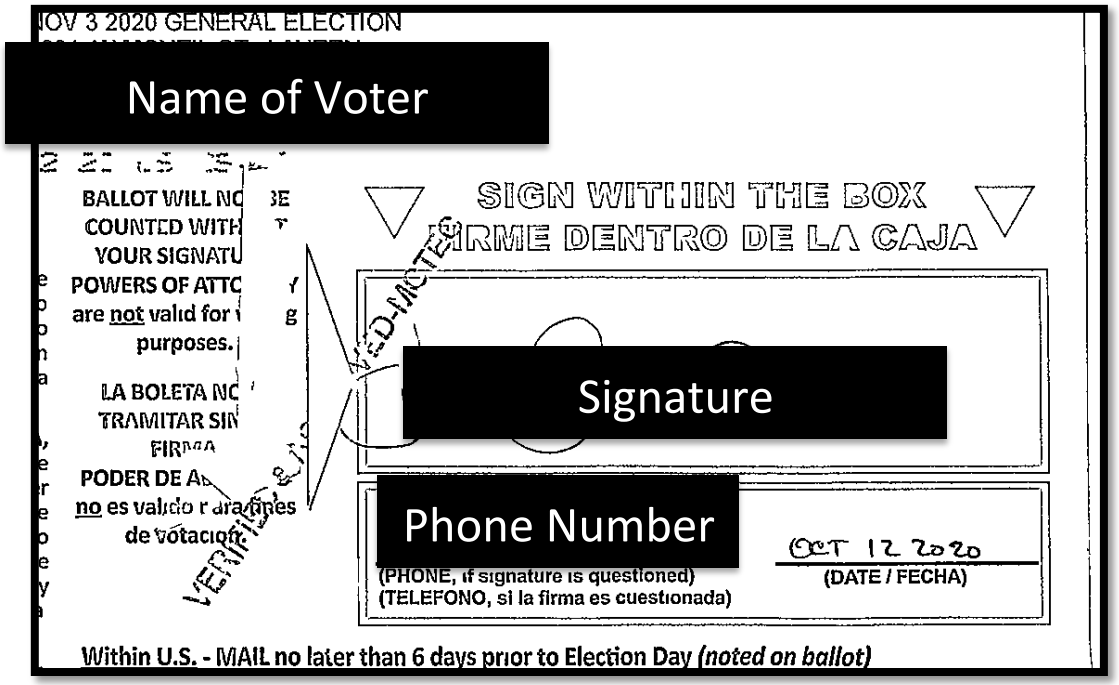


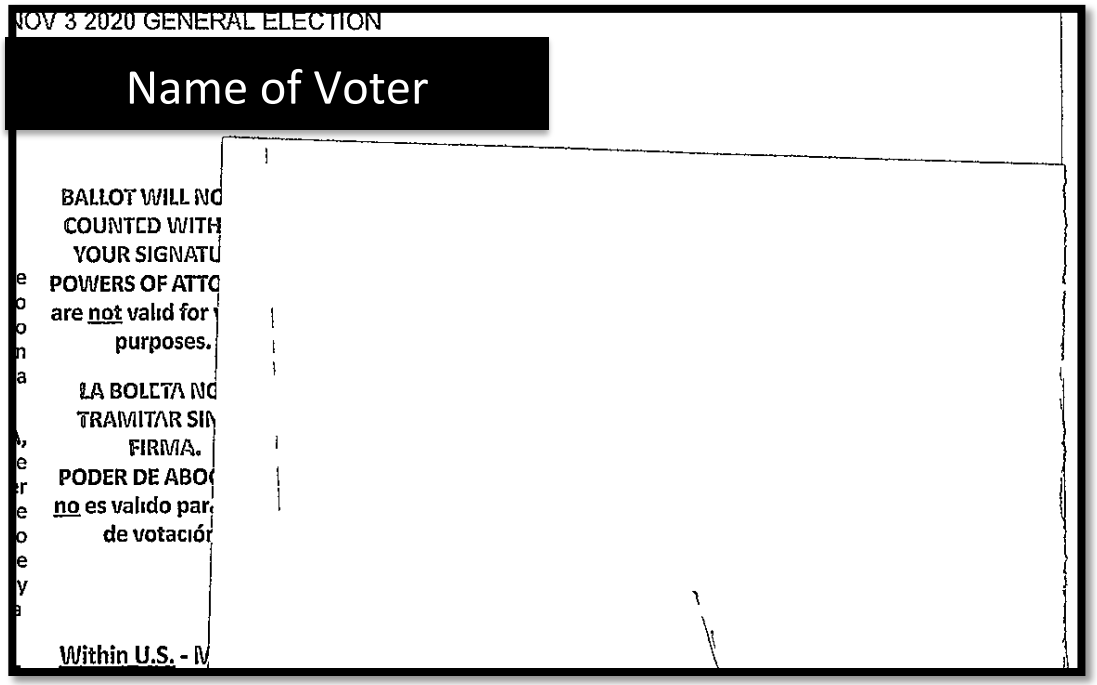
Duplicate (Signed & Blank - SB)



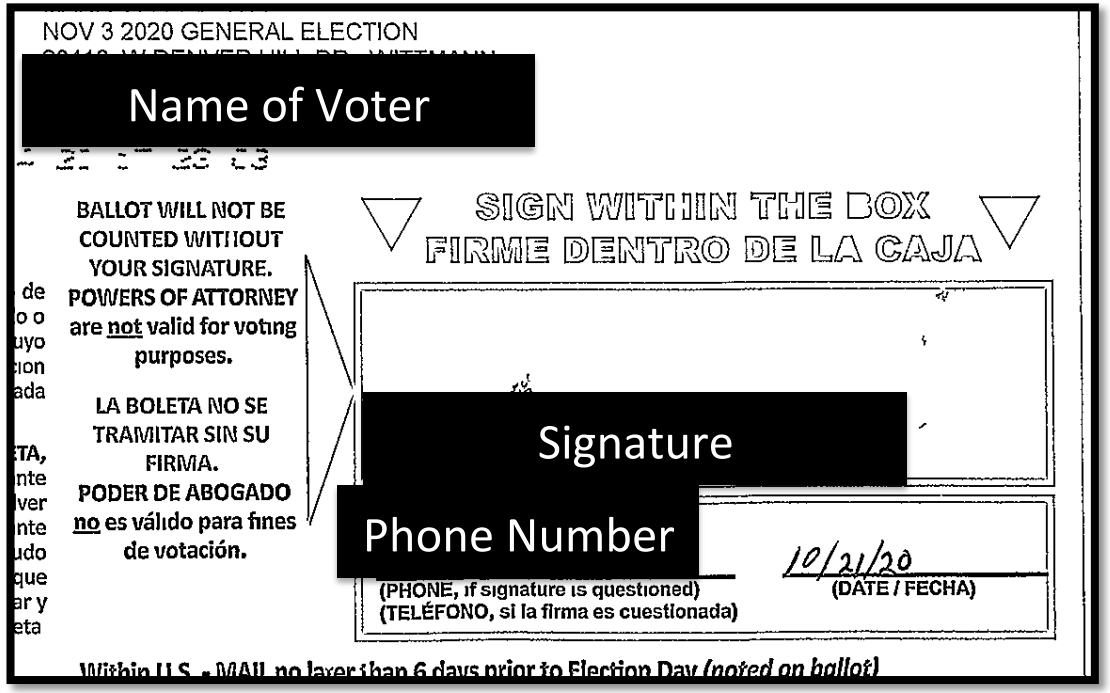


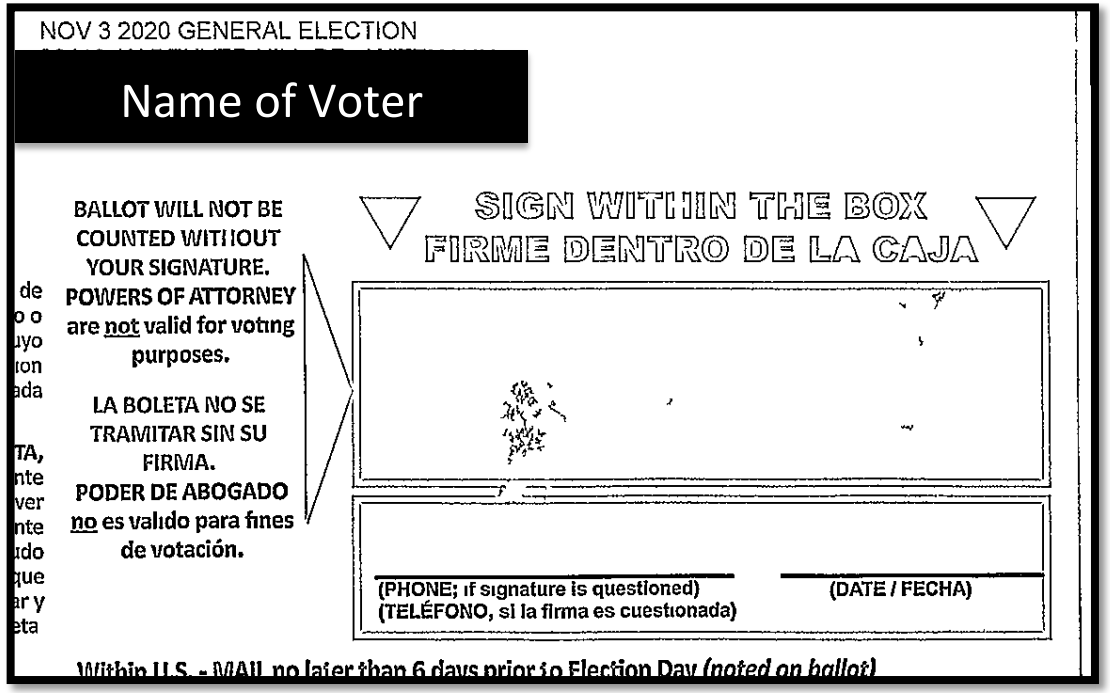
Duplicate (Signed & Likely Blank - SL)





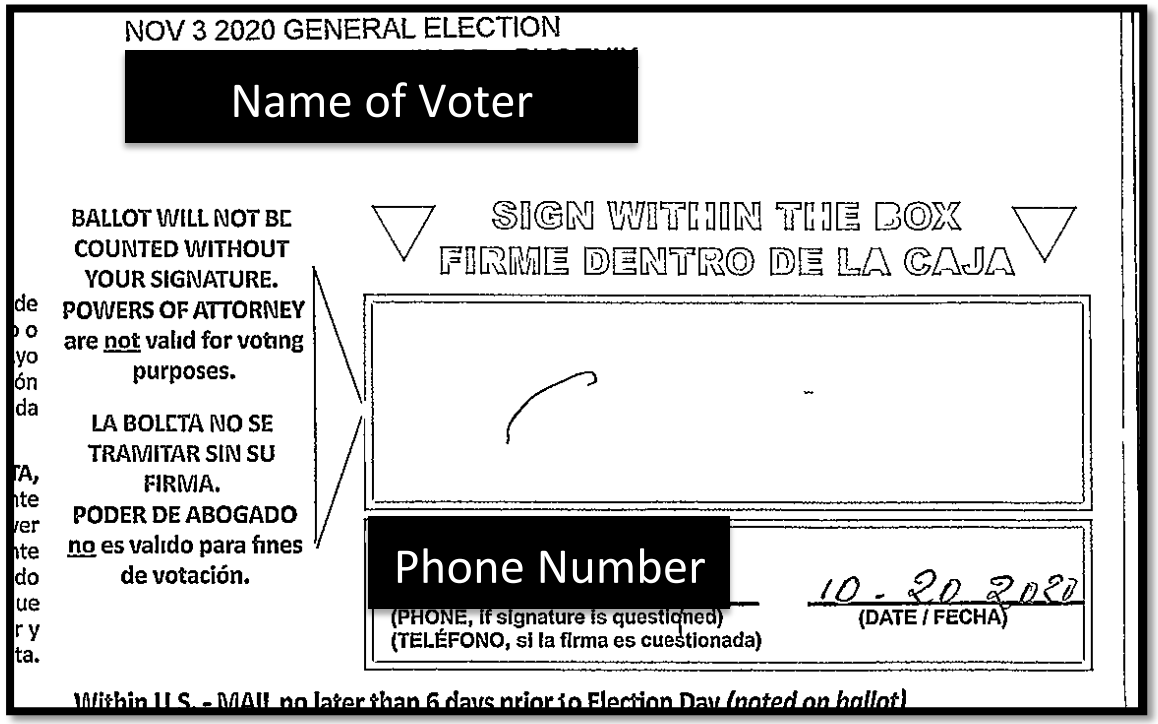
Duplicate (Signed & Scribble - SC)

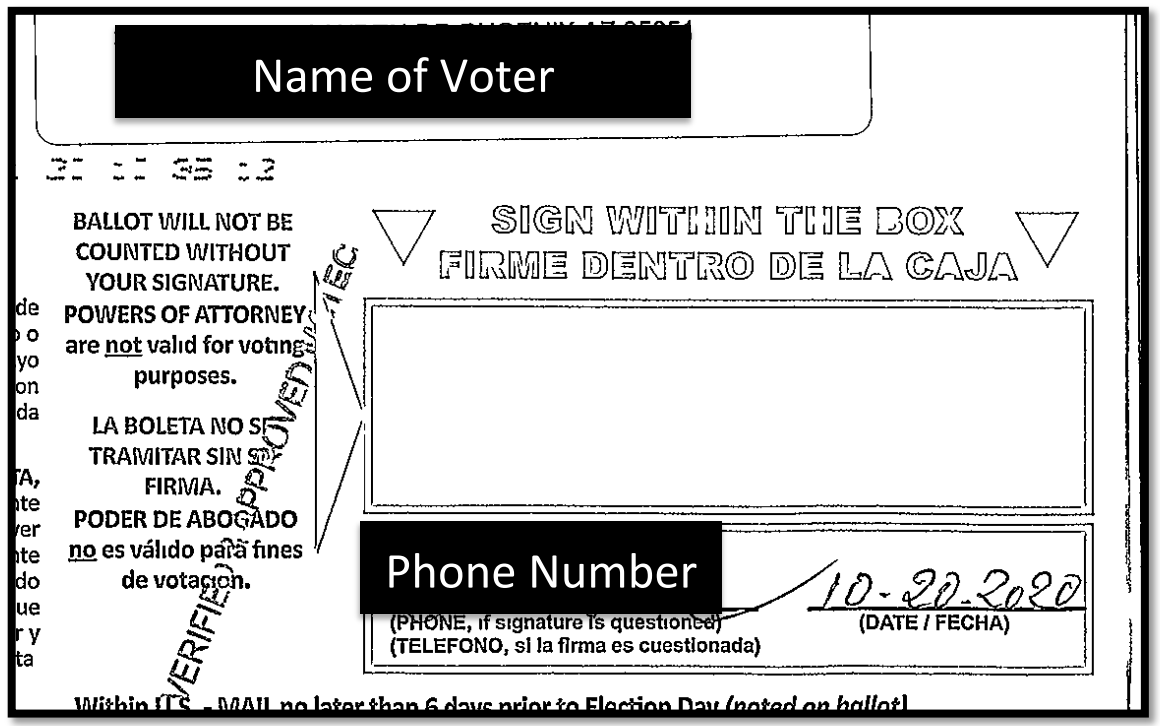




Duplicate (Scribble & Blank - CB)

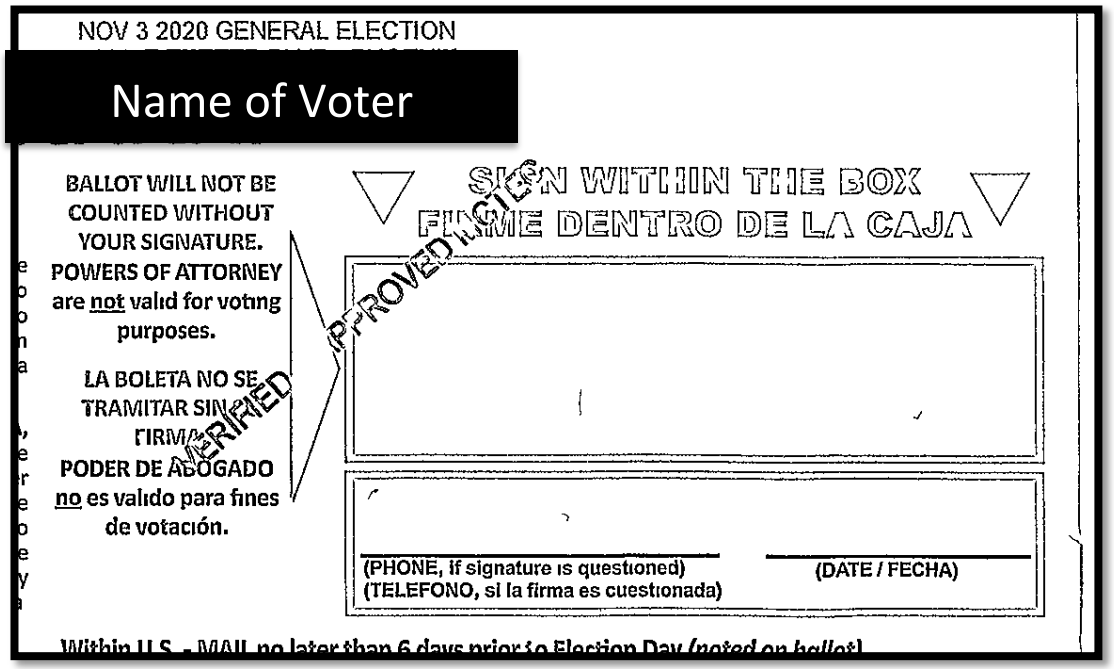
Signature Region with Blank is Being Approved

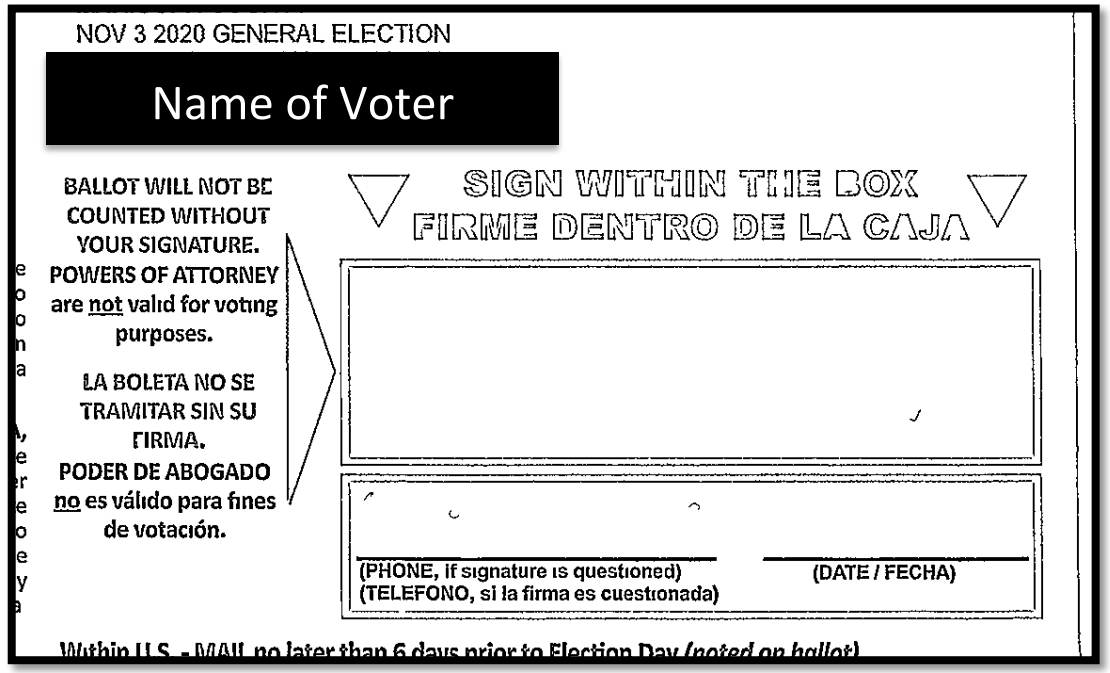




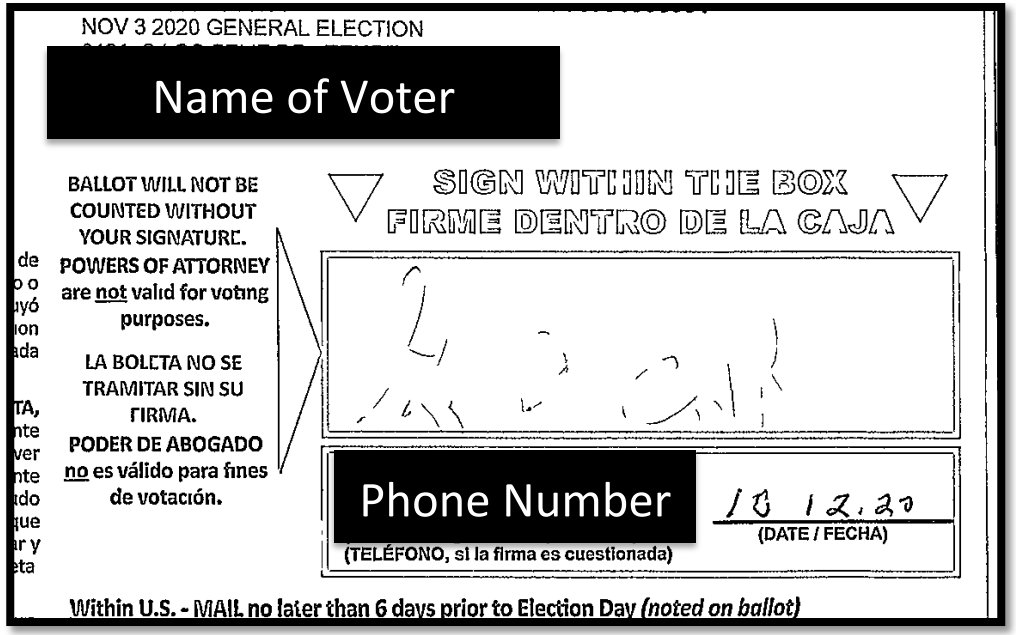
Duplicate (Scribble & Likely Blank - CL)

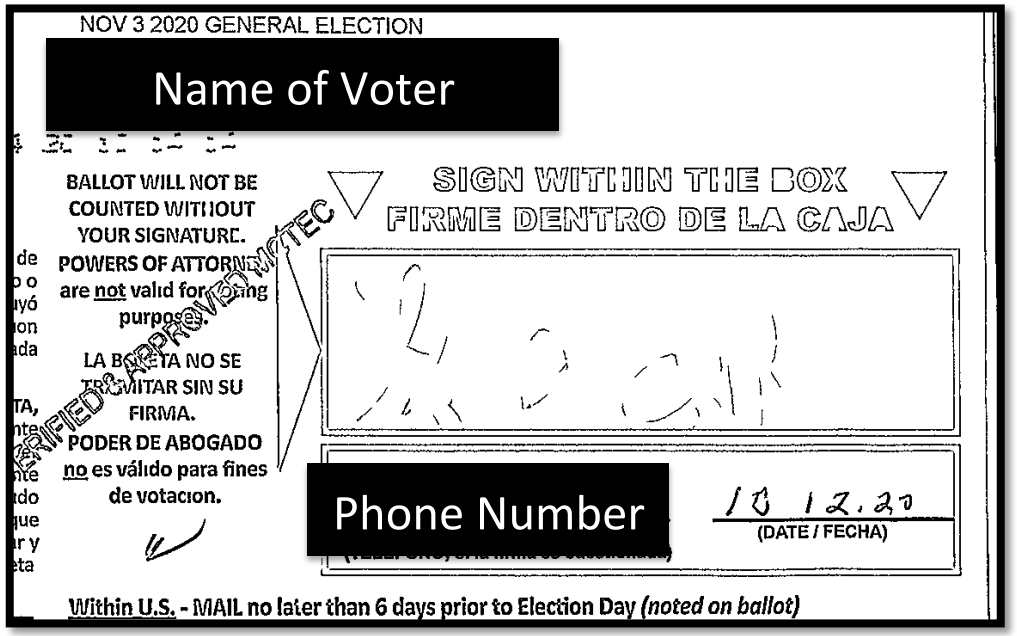
Signature Region with Scribble is Being Approved





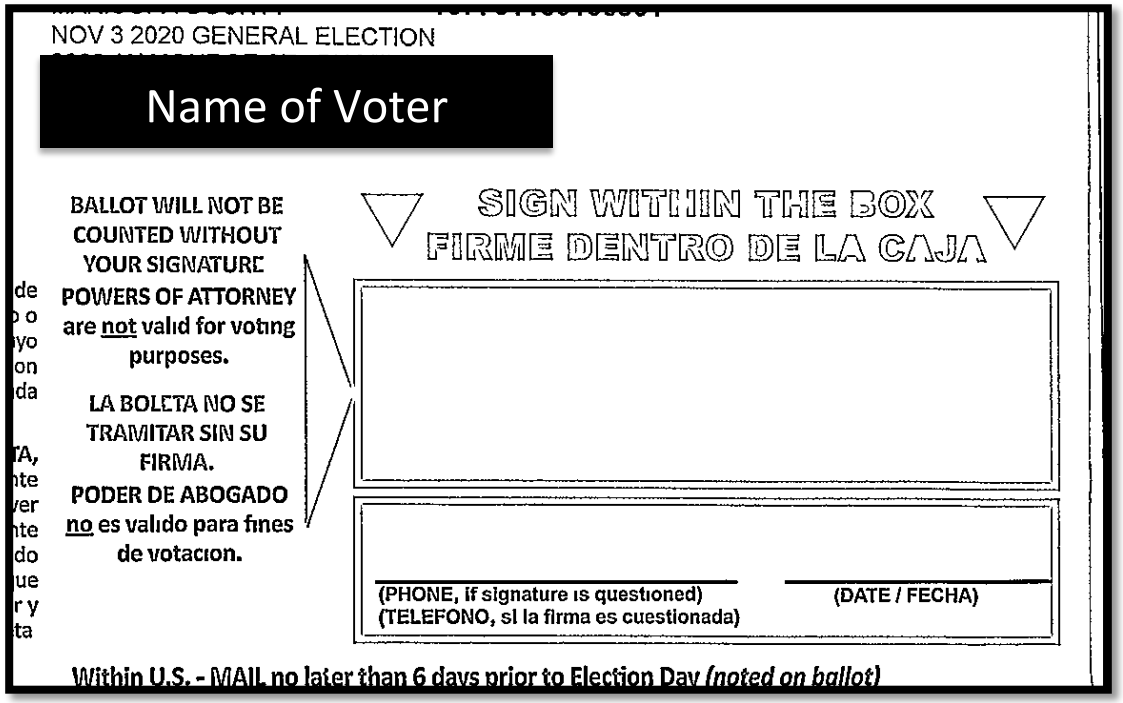
Duplicate (Scribble & Scribble - CC)

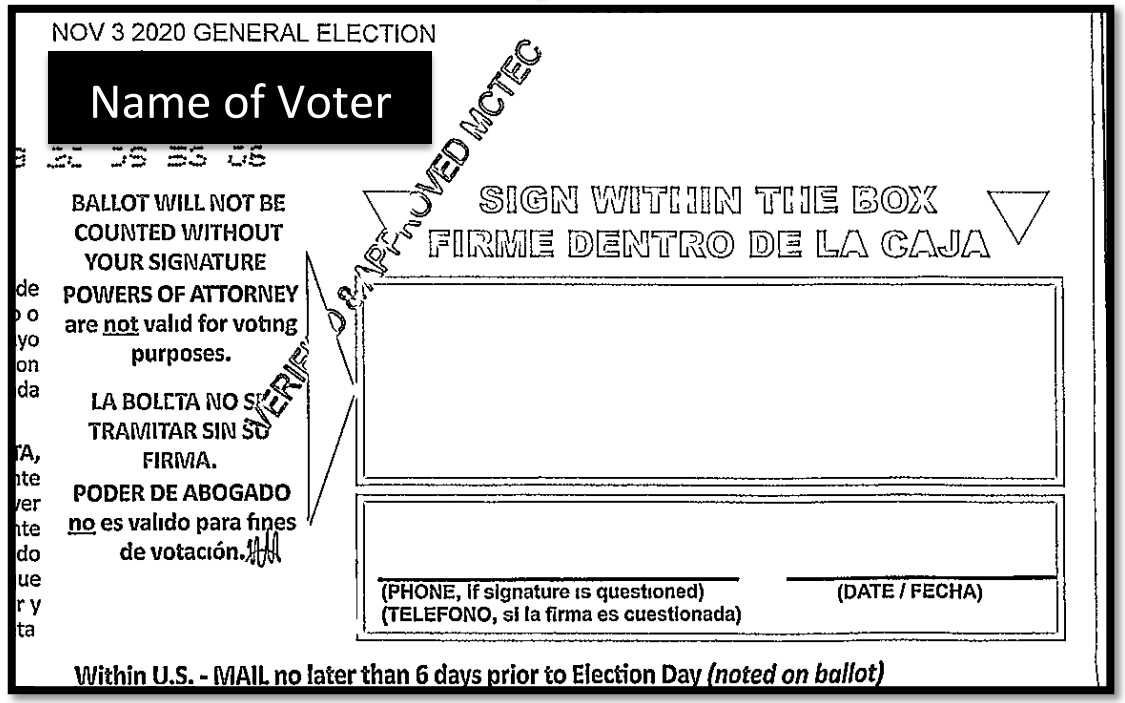




Duplicate (Blank & Blank - BB)

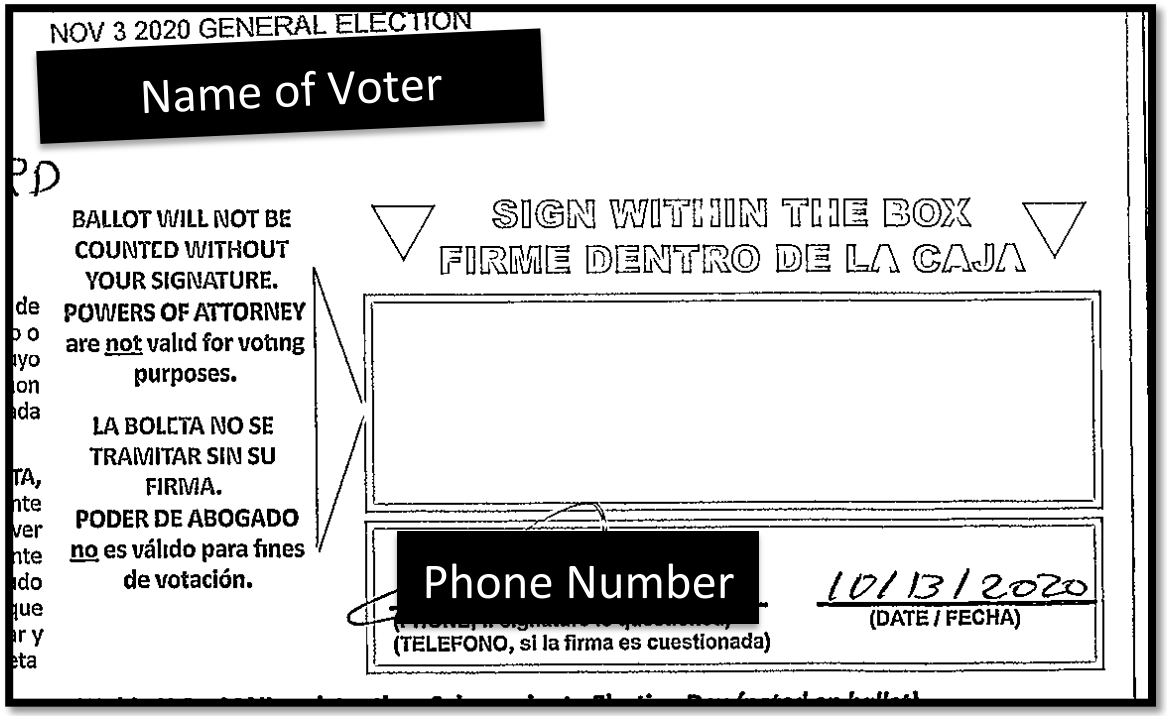
Signature Region with Blank is Being Approved

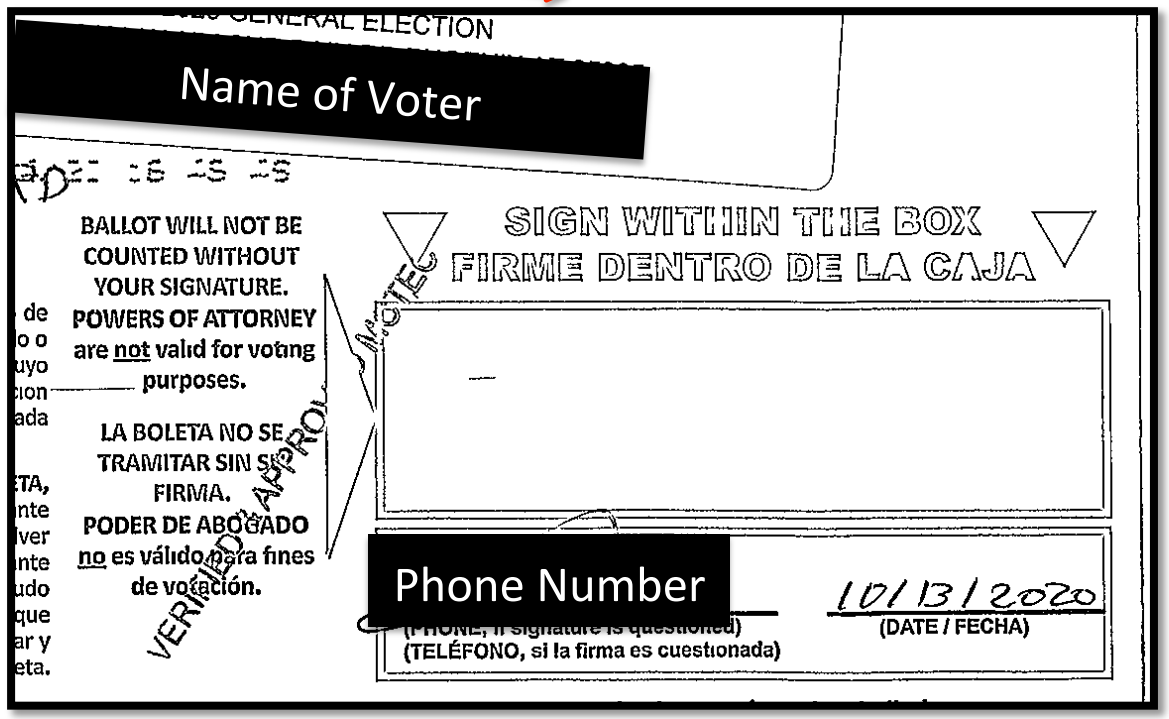




Duplicate (Blank & Likely Blank - BL)

Signature Region with Likely Blank is Being Approved

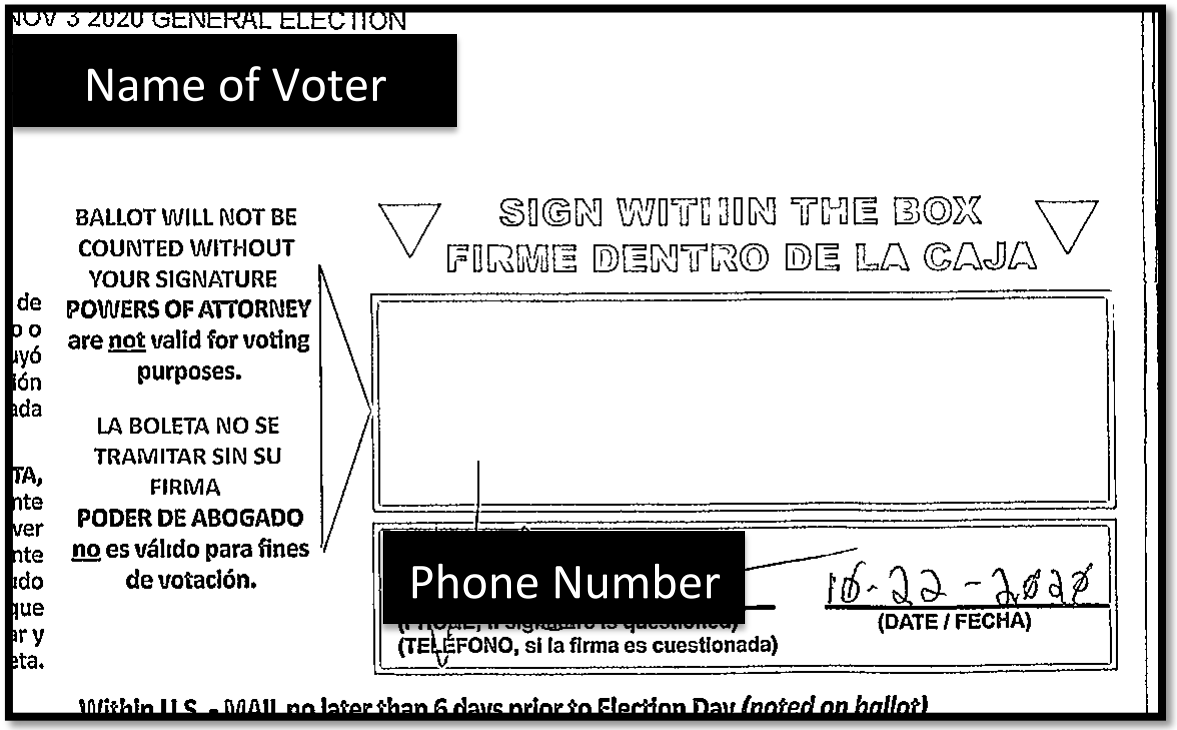


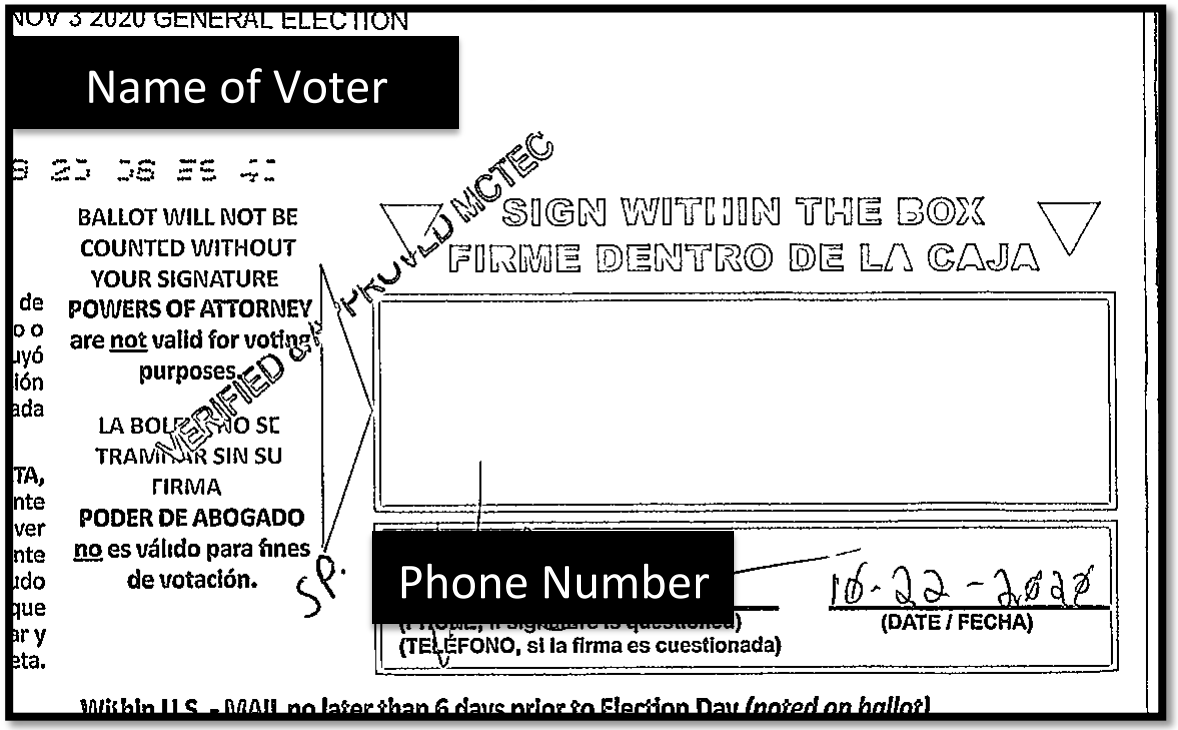


*Orientation of Name of Voter varies between the two duplicates, thought the exact same image. Appears as if name was overlaid differently from one image to another.

Duplicate (Likely Blank & Likely Blank - LL)

Signature Region with Likely Blank is Being Approved





2-Copy Duplicate Signature Presence Detection Results

Image Copy I	Image Copy II	Classification	Count
Signature	Signature	SS	15,288
Signature	Blank	SB	1,348
Signature	Likely Blank	SL	26
Signature	Scribble	SC	72
Scribble	Blank	CB	6
Scribble	Likely Blank	CL	7
Scribble	Scribble	CC	142
Blank	Blank	BB	36
Blank	Likely Blank	BL	5
Likely Blank	Likely Blank	LL	4
		TOTAL	**16,934**

Signatures for Verification

Scribbles

Blanks "No Signatures"

2-Copy Duplicate Signature Presence Detection Results

- Scribbles
  - **CB + CL + CC**
  - **6 + 7+ 142**
  - **155 Scribbles**
- Blanks i.e. “No Signatures”
  - **BB + BL + LL**
  - **36 + 5 + 4**
  - **45 Blanks**

Image Copy I	Image Copy II	Classification	Count
Signature	Signature	SS	15,288
Signature	Blank	SB	1,348
Signature	Likely Blank	SL	26
Signature	Scribble	SC	72
Scribble	Blank	CB	6
Scribble	Likely Blank	CL	7
Scribble	Scribble	CC	142
Blank	Blank	BB	36
Blank	Likely Blank	BL	5
Likely Blank	Likely Blank	LL	4
		TOTAL	**16,934**

3-Copy, and 4-Copy Duplicate Signature Presence Detection Results

Type	Definitive Blanks	Likely Blanks	Scribbles	Signatures	Totals
3-Copy	40	2	16	506	**564**
4-Copy	2	0	0	14	**16**

Table 9: Three- & Four-Copy Duplicate Signature Presence Detection Results.

Three-Copy Duplicate Blank

4338895.tiff

PBSigVar_1377_RTNIMAGOUT_10142020_0024/4338895.tiff

PBSigVar_1377_RTNIMAGOUT_10242020_0100/4338895.tiff

PBSigVar_1377_RTNIMAGOUT_10282020_0129/4338895.tiff

Three-Copy Duplicate Scribble

459562.tiff

PBSigVar_1377_RTNIMAGOUT_10122020_0007/459562.tiff

PBSigVar_1377_RTNIMAGOUT_10152020_0037/459562.tiff

PBSigVar_1377_RTNIMAGOUT_10262020_0107/459562.tiff

EchoMail Results

Total Number of Blanks Calculation

	Blanks
Non-Duplicate Blanks	1,872
2-Copy Duplicate Blanks	45
3-Copy Duplicate Blanks	2
Total	1,919

Total Number of Scribbles Calculation

	Scribbles
Non-Duplicate Scribbles	2,420
2-Copy Duplicate Scribbles	155
3-Copy Duplicate Scribbles	5
Total	2,580

EchoMail Results Summary

	EchoMail Analysis
EVB Return Envelopes Received	1,929,240*
Duplicate Analysis	
Duplicates[1]	(17,322)
Unique EVB Return Envelopes	1,911,918
Signature Presence Detection	
No Signature Ballots[2]	(1,919)
Scribbles[3]	(2,580)
EVBs Ready for Signature Verification	1,907,419

Comparative Analysis

Comparative Analysis of EchoMail and Maricopa Reported

	EchoMail Analysis	Maricopa Reported	Variance
EVB Return Envelopes Received	**1,929,240***	***Unknown***	**NA**
Duplicate Analysis			
Duplicates[7]	(17,322)	*Un-reported*	NA
Unique EVB Return Envelopes	**1,911,918**	**1,918,463****	**(6,545)**
Signature Presence Detection			
No Signature Ballots[8]	(1,919)	(1,455)	(464)
Scribbles[9]	(2,580)	NA	(2580)
EVBs Ready for Signature Verification	**1,907,419**	**1,917,008**	**(9,589)**
Signature Verification			
"Bad Signatures"	NA	(587)	NA
"Late Returns"	NA	(934)	NA
Total EVBs Verified and Counted	**NA**	**1,915,487**	**NA**

Key Findings and Anomalies

EchoMail Key Findings

- Unknown how many EVB return envelopes were **originally** received by Maricopa
- 34,448 Duplicates from 17,126 Unique Voters. Maricopa reported NO Duplicates in *CANVASS report.*
- 464 ***more*** "No Signature" EVB Return Envelopes Identified by EchoMail
- 6,545 ***more*** unique EVB Return Envelopes processed by Maricopa
- 2,580 Scribbles in Signature Region i.e. "Bad Signatures"
  - Maricopa reported 587 "Bad Signatures" that is 0.031% of total EVBs received
- 9,589 ***more*** net EVBs submitted for Signature Verification by Maricopa versus EchoMail EVB return envelope images
- 25% Surge of Duplicates in Last Six Days
- Blanks of Duplicates being stamped ***"VERIFIED & APPROVED MCTEC"***
- Stamps of **"VERIFIED & APPROVED MCTEC"** in Blank Signature Regions
- **"VERIFIED & APPROVED MCTEC"** Stamps Appearing "BEHIND" Envelope Triangle
- Two Different Voter-IDs, having Same Address/Phone/Name, with Matching Signatures

Anomaly #1

Anomaly #1

Maricopa Reported Only 587 "Bad Signatures" Out of 1,918,463 (0.031%)

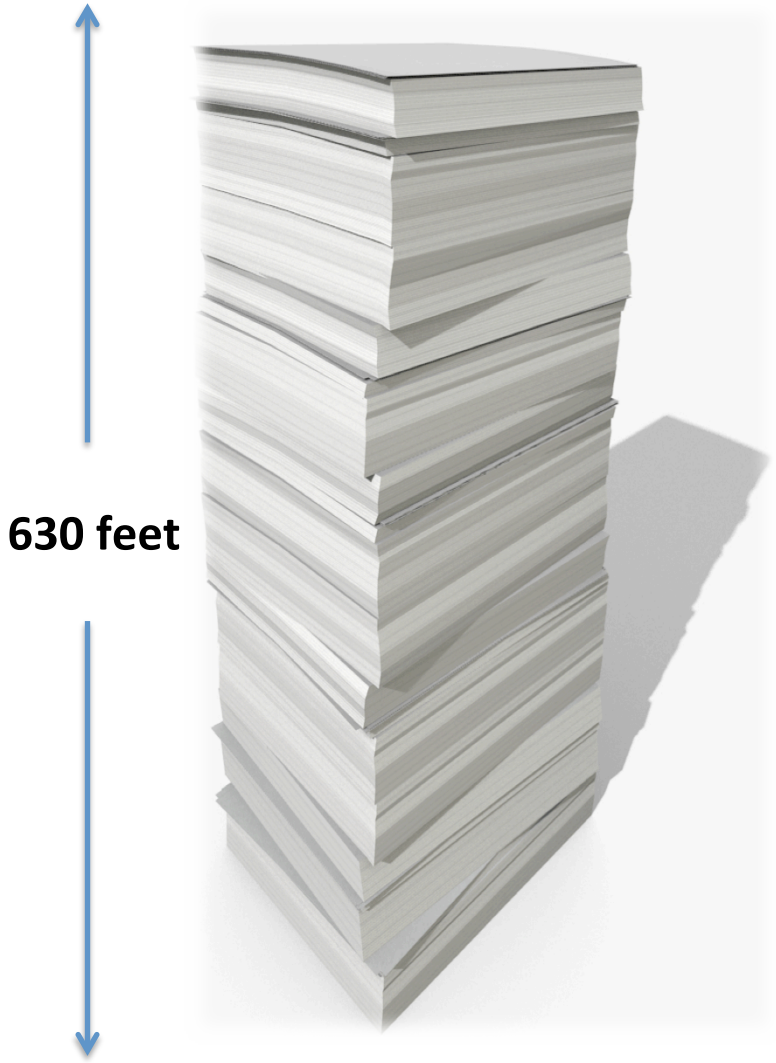
Anomaly #1

ONE “Bad Signature” for EVERY 3,268 EVBs

Anomaly #1

ONE “Bad Signature”
for EVERY 3,268 EVBs

1,918,463 EVBs



Anomaly #1

ONE “Bad Signature” for EVERY 3,268 EVBs

1,918,463 EVBs

630 feet

Anomaly #1

ONE "Bad Signature" for EVERY 3,268 EVBs

1,918,463 EVBs

2.31 inches

557 "Bad Signatures"

630 feet

Anomaly #1

ONE “Bad Signature” for EVERY 3,268 EVBs

0.0306% of All EVB Return Envelopes

2.31 inches

557 “Bad Signatures”

630 feet

1,918,463 EVBs

Anomaly #2

ECHOMAIL

2,580 "Bad Signatures" e.g. Scribbles Out of 1,911,918 (0.135%)

Anomaly #2

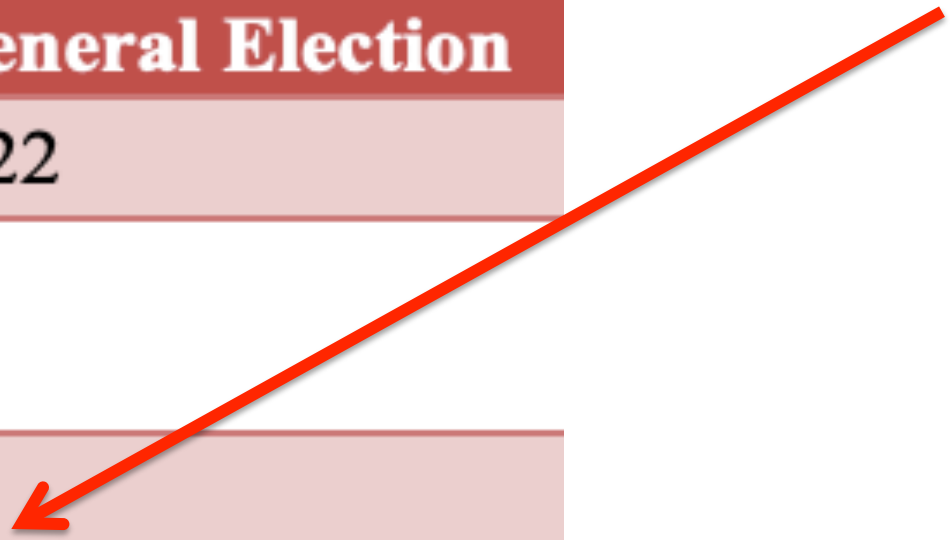
ECHOMAIL

2,580 "Bad Signatures" e.g. Scribbles Out of 1,911,918 (0.135%)

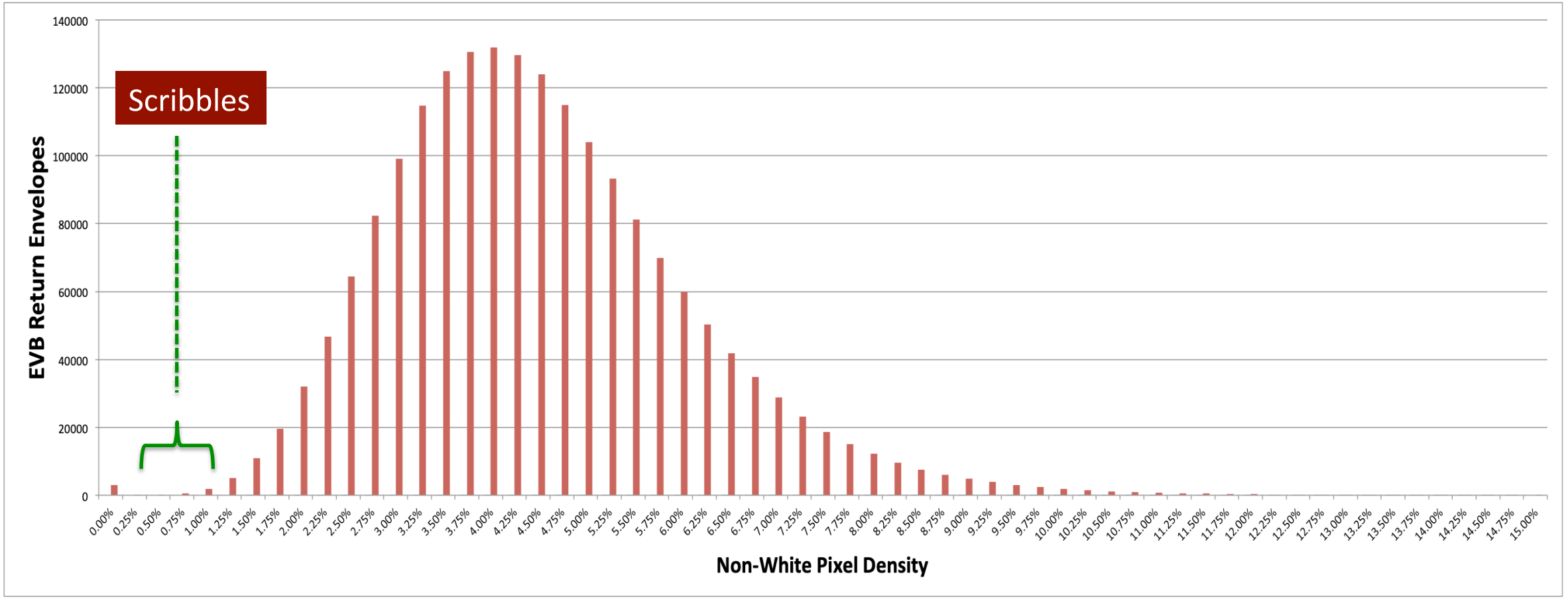
EchoMail was commissioned to identify presence of Blanks, Scribbles, Signatures in Signature Region, NOT to perform Signature Verification/Matching. If Scribbles ALONE were considered "Bad Signatures," then EchoMail ITSELF identified 335% more "Bad Signatures" than Maricopa did from its ENTIRE Signature Verification process.

State of Arizona: 2016 General Election Signature Mismatch Rejection Rate

	State of Arizona 2016 General Election
Mail-In Ballots	2,017,722
Rejection from Signature Mismatch	2,657
Signature Mismatch Rejection Rate	0.131%



%Non-White Pixel Density vs. EVB Return Envelope Volume



Anomaly #3

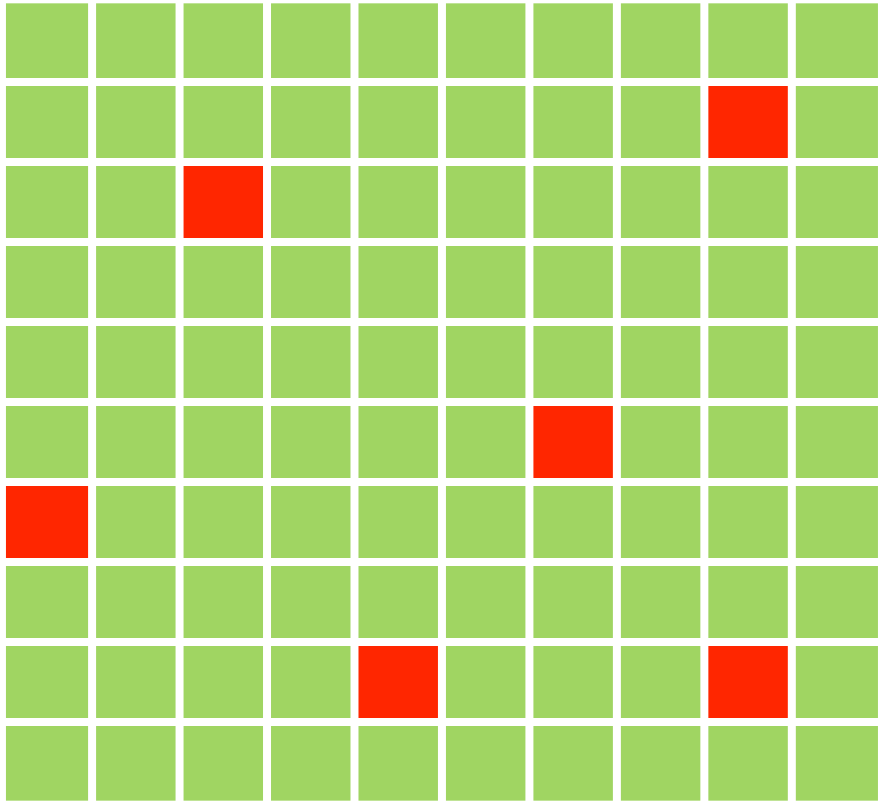
ECHOMAIL

3% to 97% Increased Illegibility Rate of Signatures 4 days After Election Day

Signatures 4-Weeks BEFORE Election Day

Signatures 4-Days AFTER Election Day

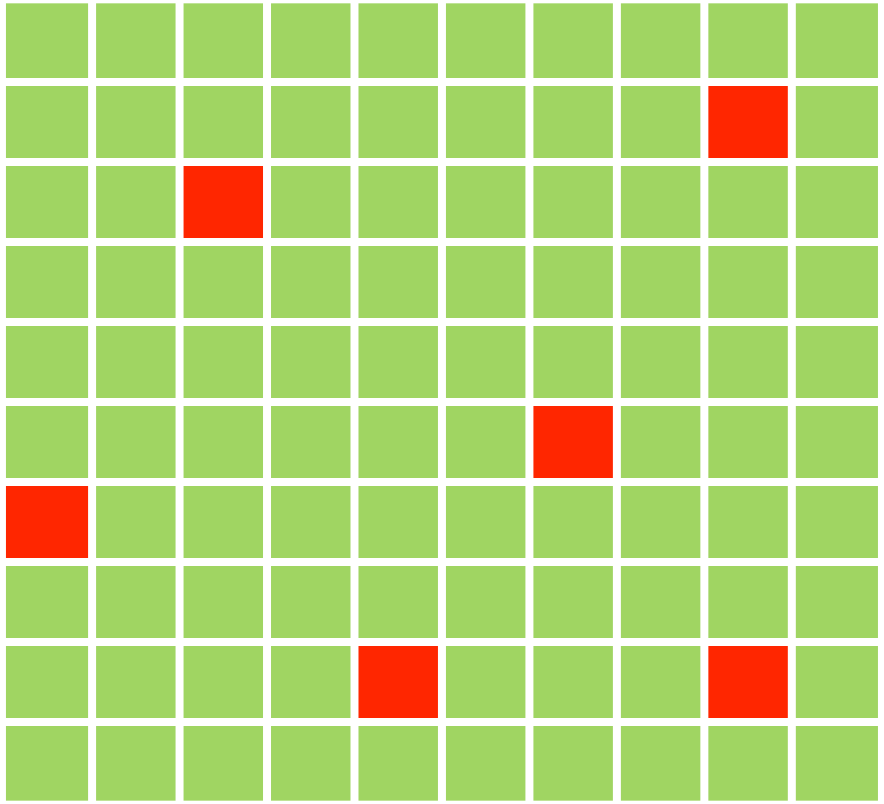
Random Sampling of Signatures:
4-Weeks Before *Election vs. 4-Days* After *Election*



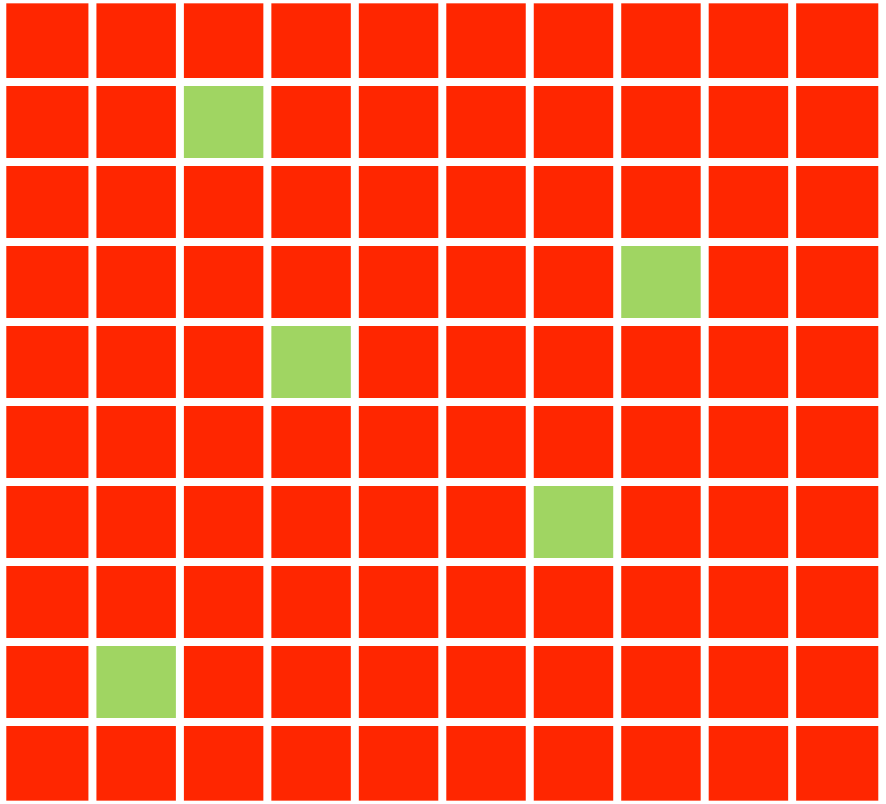
Illegible

4-Weeks Before Election

Random Sampling of Signatures:
4-Weeks Before *Election vs. 4-Days* After *Election*



4-Weeks Before Election



4-Days After Election

Illegible

Legible

Anomaly #4

ECHOMAIL

As EVBs Increased by 53% from 2016 to 2020 in Maricopa, "Bad Signatures" Decreased by 56%

Inverse Pattern: Increase in EVBs with Decrease in Signature Mismatch Rate

	Maricopa County 2016 General Election
EVB Return Envelopes	1,257,179
Rejection from Signature Mismatch	1,456
Signature Mismatch Rejection Rate	0.116%

Inverse Pattern: Increase in EVBs with Decrease in Signature Mismatch Rate

	Maricopa County, AZ 2020 General Election	Maricopa County 2016 General Election
EVB Return Envelopes	1,918,463	1,257,179
Rejection from Signature Mismatch	587	1,456
Signature Mismatch Rejection Rate	0.031%	0.116%

Inverse Pattern: Increase in EVBs with Decrease in Signature Mismatch Rate

	Maricopa County, AZ 2020 General Election	Maricopa County 2016 General Election
EVB Return Envelopes ↑	1,918,463	1,257,179
Rejection from Signature Mismatch	587	1,456
Signature Mismatch Rejection Rate	0.031%	0.116%

Inverse Pattern: Increase in EVBs with Decrease in Signature Mismatch Rate

	Maricopa County, AZ 2020 General Election	Maricopa County 2016 General Election
EVB Return Envelopes ↑	1,918,463	1,257,179
Rejection from Signature Mismatch ↓	587	1,456
Signature Mismatch Rejection Rate	0.031%	0.116%

Inverse Pattern: Increase in EVBs with Decrease in Signature Mismatch Rate

	Maricopa County, AZ 2020 General Election	Maricopa County 2016 General Election
EVB Return Envelopes ↑	1,918,463	1,257,179
Rejection from Signature Mismatch ↓	587	1,456
Signature Mismatch Rejection Rate ↓	0.031%	0.116%

Anomaly #5

Anomaly #5

MARICOPA

No Mention of Duplicates in Maricopa CANVASS Report

Anomaly #5

MARICOPA

No Mention of Duplicates in Maricopa CANVASS Report

GENERAL ELECTION

VOTER TURNOUT	2020
Voter Turnout	80.51%
Early Ballots Requested	2,160,412
Early Ballots Verified and Counted	1,915,487
Rejected Early Ballots	
Bad Signatures	587
No Signatures	1,455
Late Returns	934

Anomaly #5

MARICOPA

No Mention of Duplicates in Maricopa CANVASS Report

ECHOMAIL

17,126 Voters Sent in TWO or More Ballots ("Duplicates")

Anomaly #5

Type	Total Images	Duplicate Images	Unique # of Voters
2-Copy Duplicates	33,868	16,934	16,934
3-Copy Duplicates	564	376	188
4-Copy Duplicates	16	12	4
Total	34,448	17,322	17,126

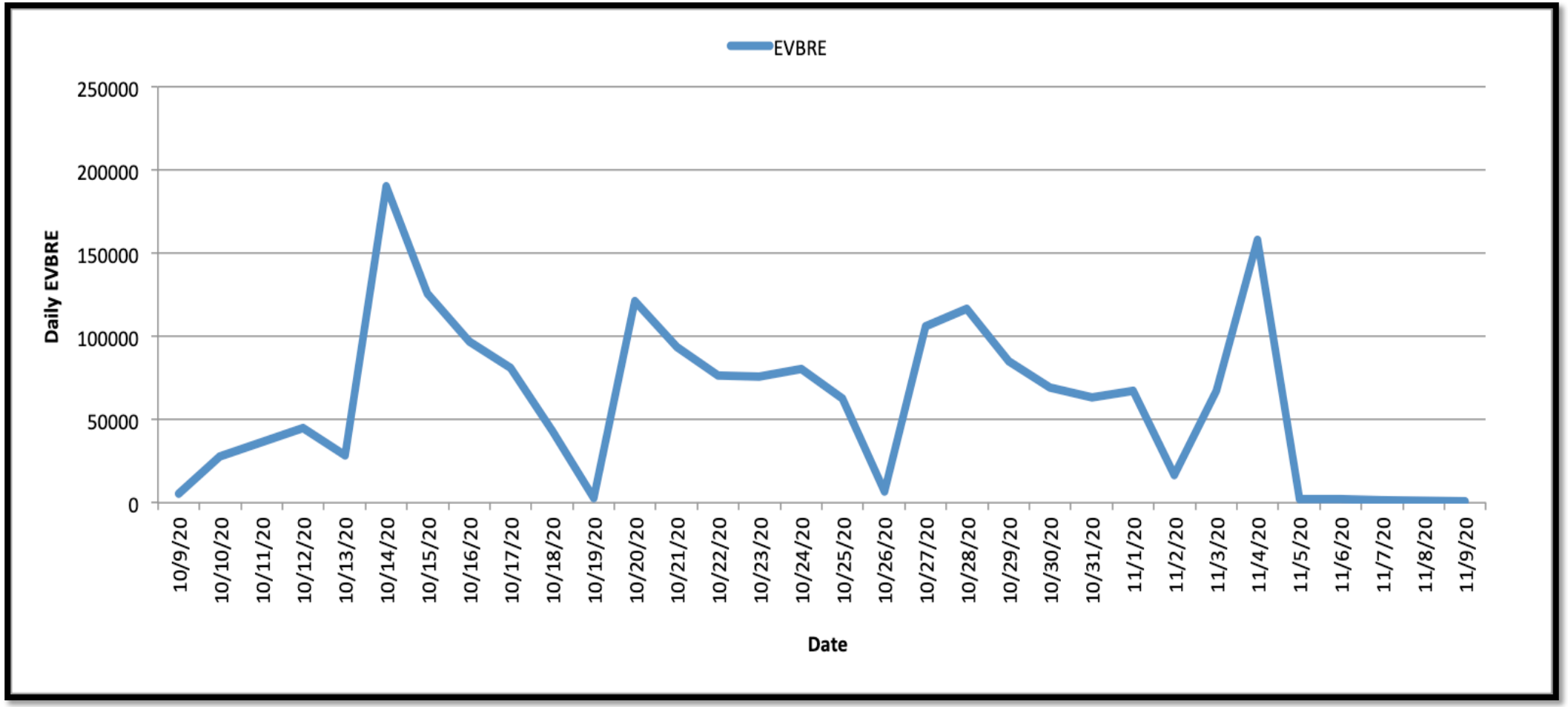
Anomaly #6

Anomaly #6

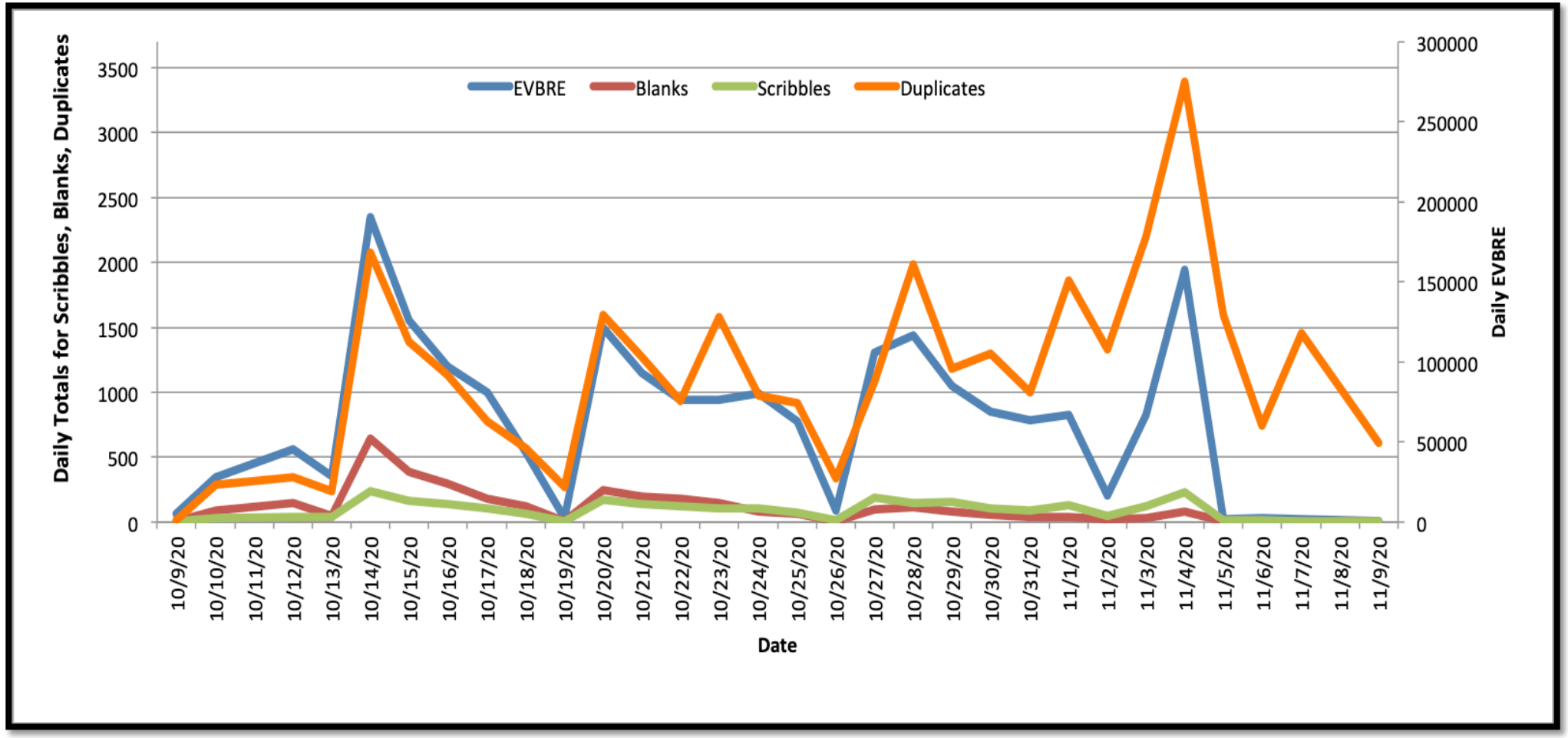
ECHOMAIL

25%+ of Duplicates Came In During Nov. 4-9, 2020

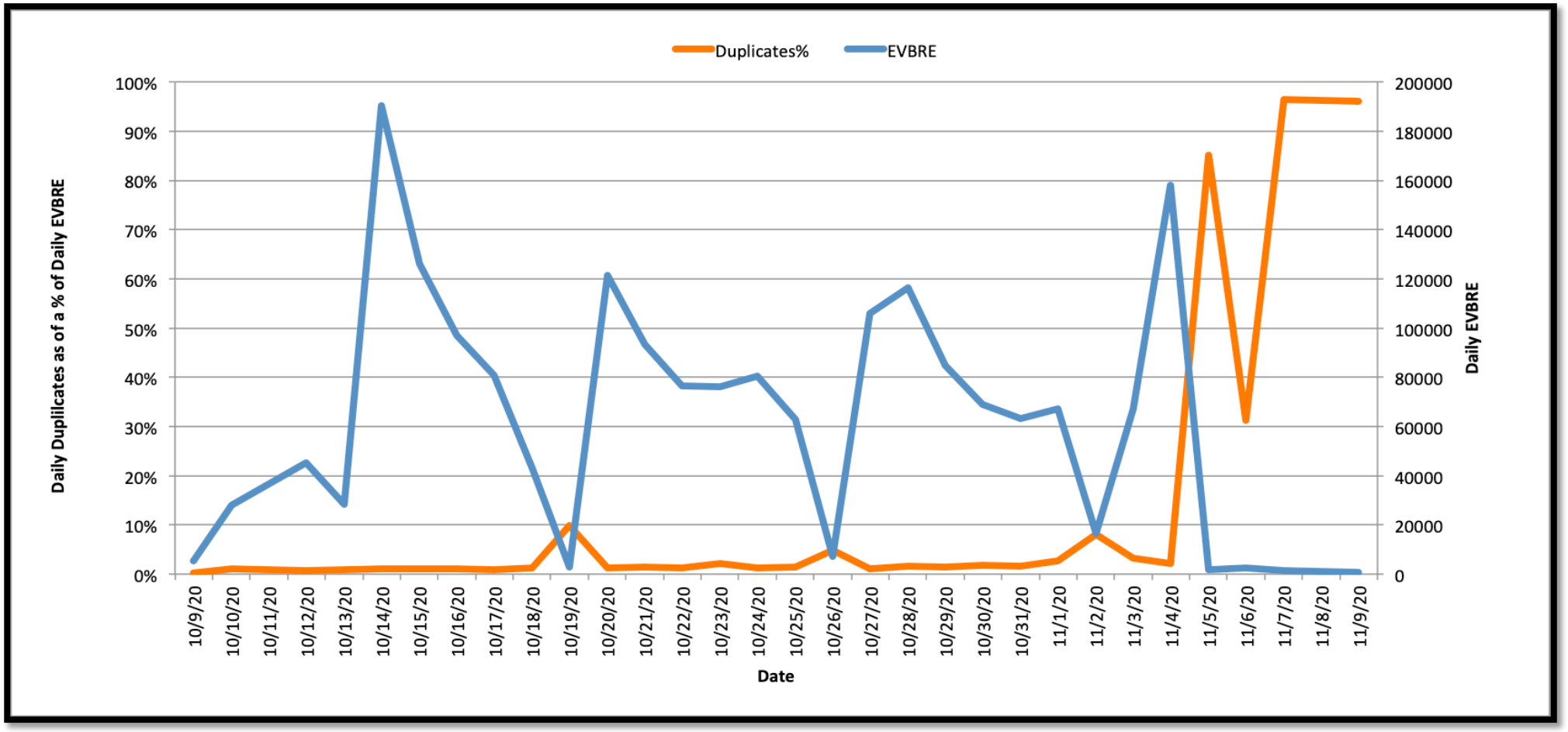
Anomaly #6



Anomaly #6



Anomaly #6



Anomaly #7

Anomaly #7

ECHOMAIL

EV33 System Had Only 9,382 Voters Who Submitted Duplicates vs. 17,126 Voters Identified by EchoMail

Anomaly #7

ECHOMAIL

EV33 System Had Only 9,382 Voters Who Submitted Duplicates vs. 17,126 Voters Identified by EchoMail

ECHOMAIL

Of the 9,382 in EV33, ONLY 2,138 Voters Matched with Voters Among the 17,126

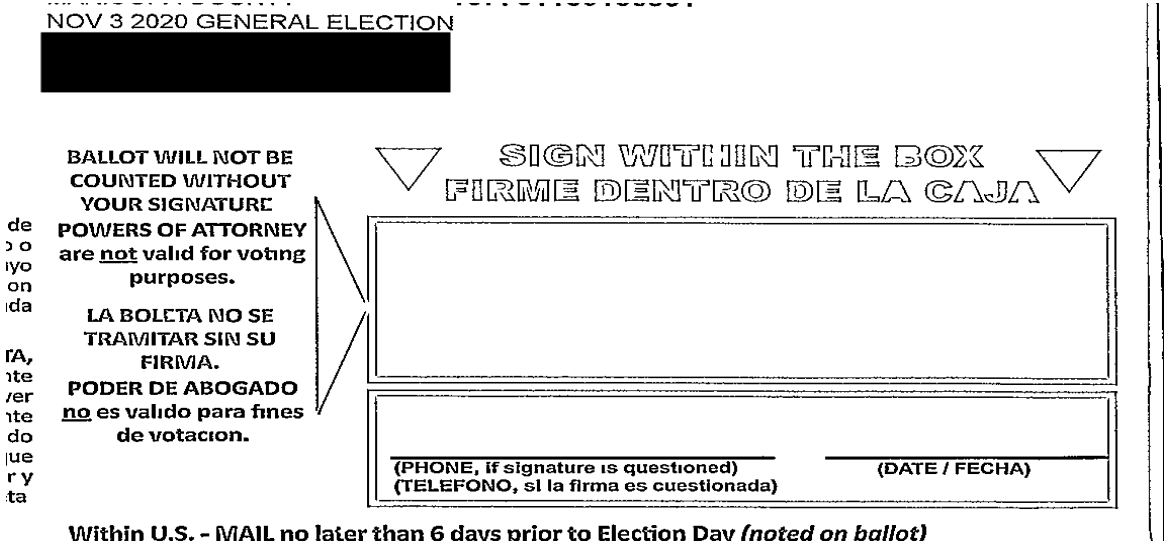
Anomaly #8

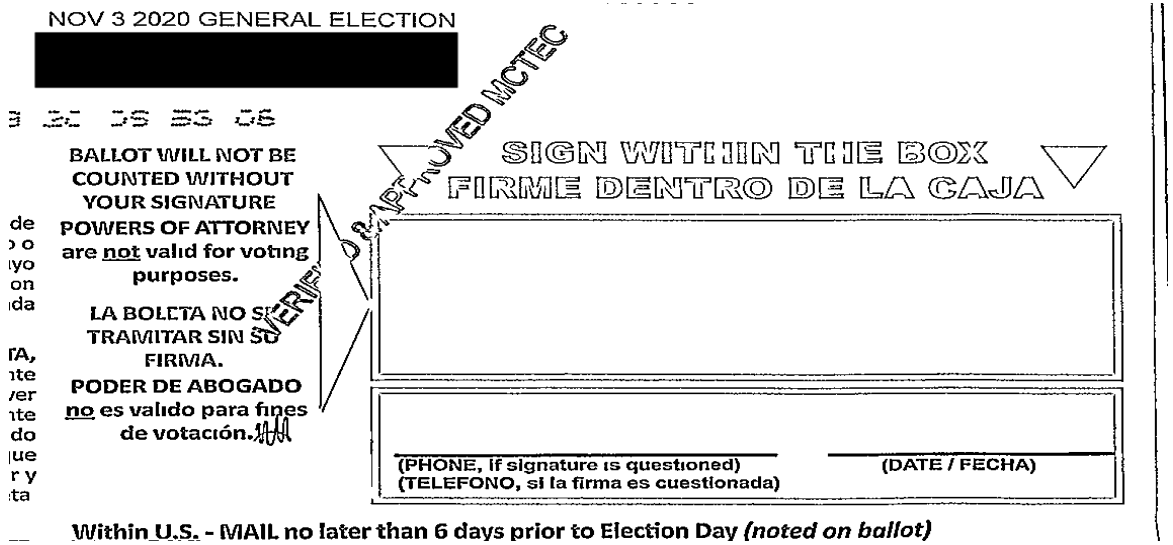
Anomaly #8

ECHOMAIL

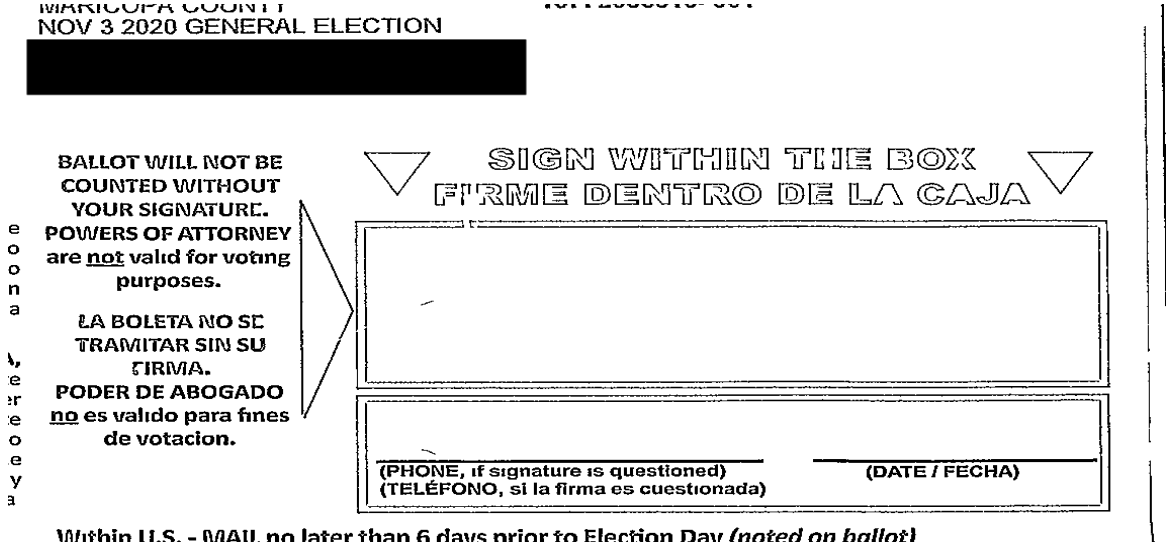
*Duplicate BLANKS **were** "VERIFIED & APPROVED"*

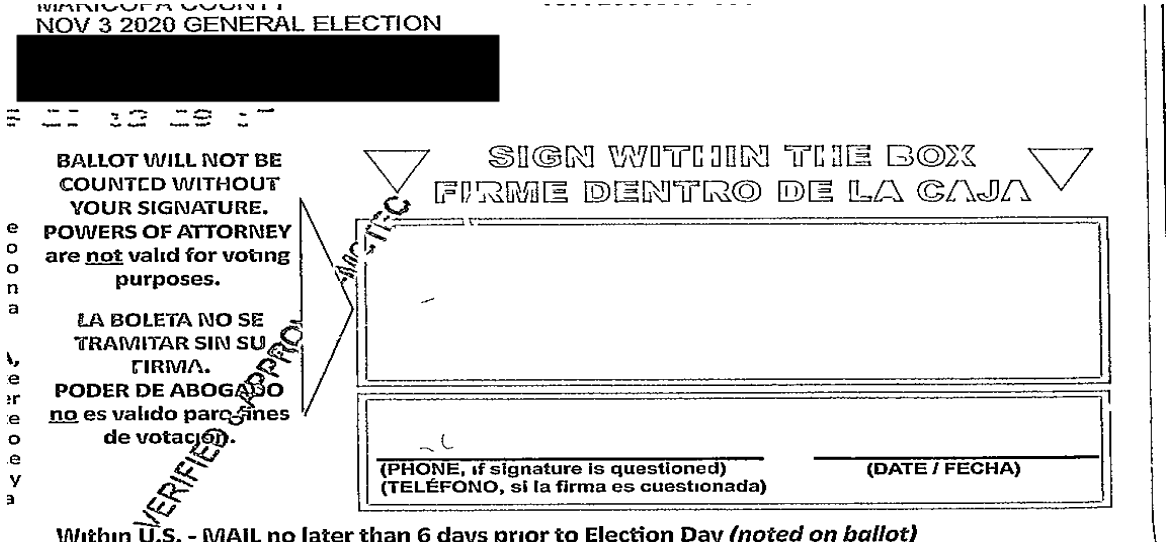
Duplicate Blanks
Stamped and Approved – Example #1



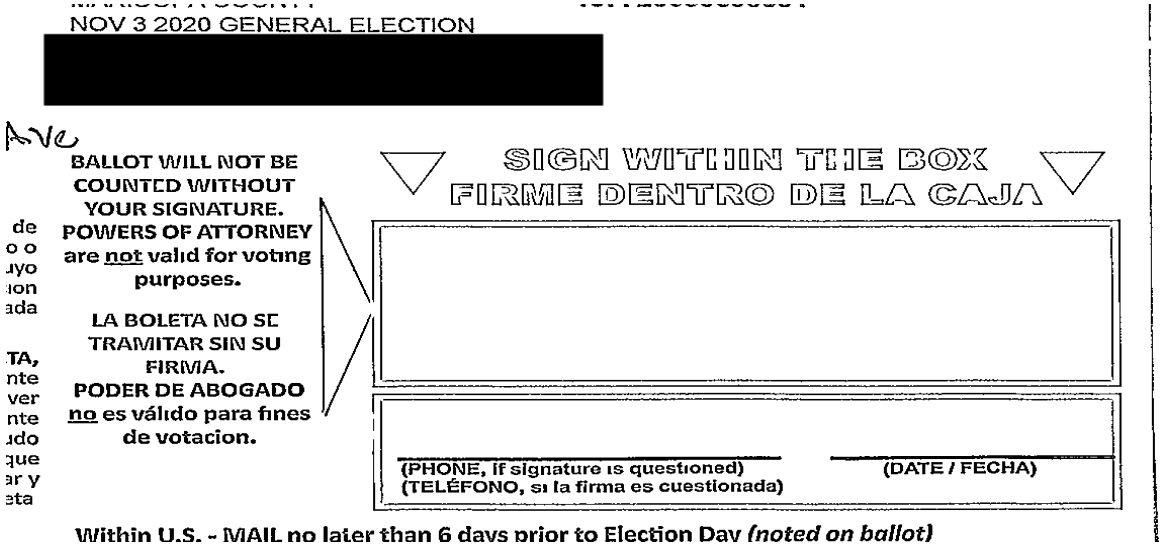


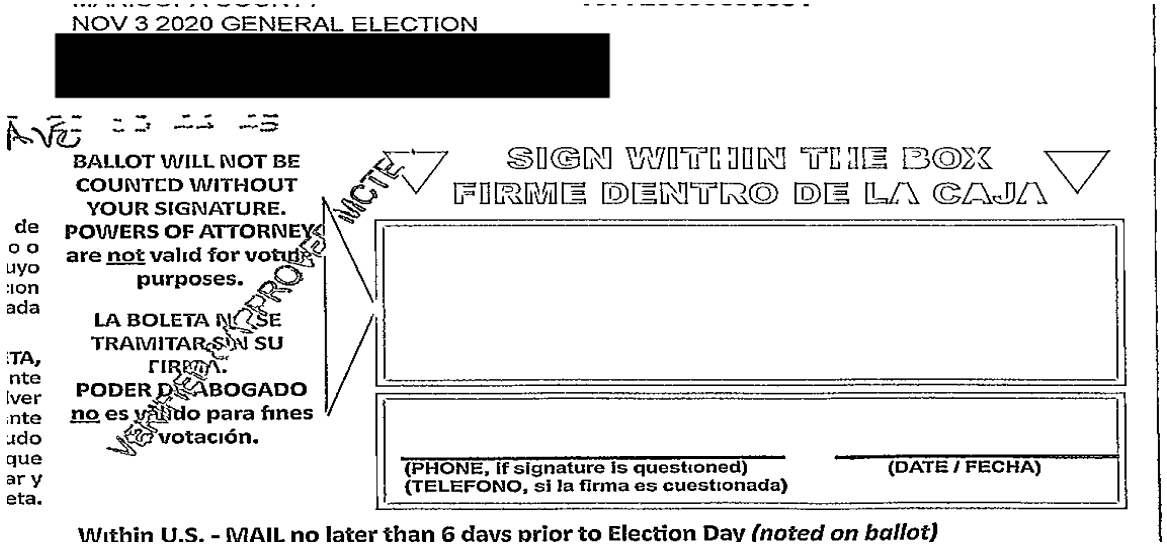
Duplicate Blanks
Stamped and Approved - Example #2



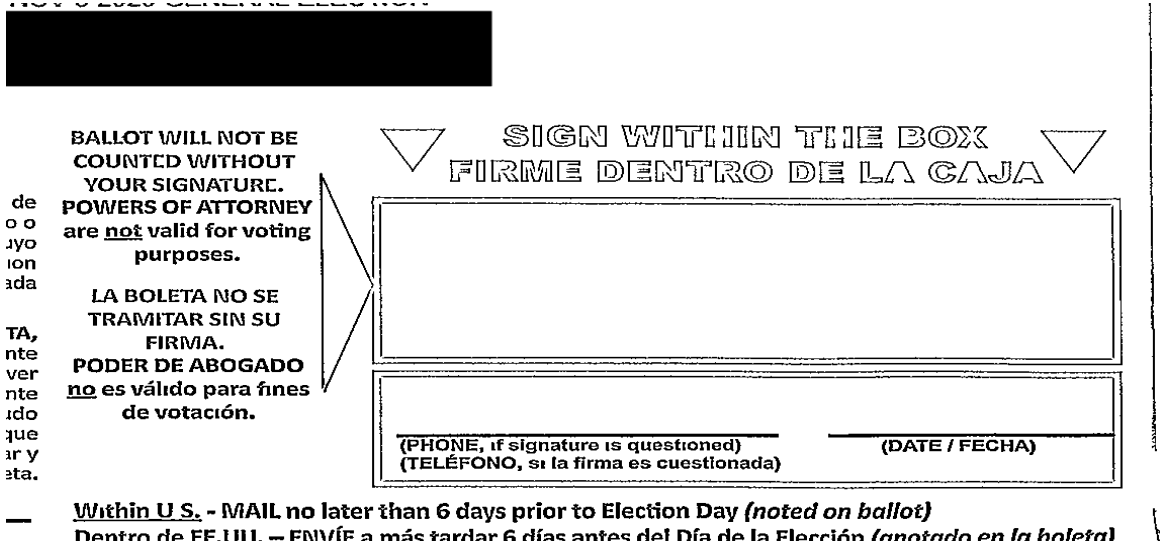


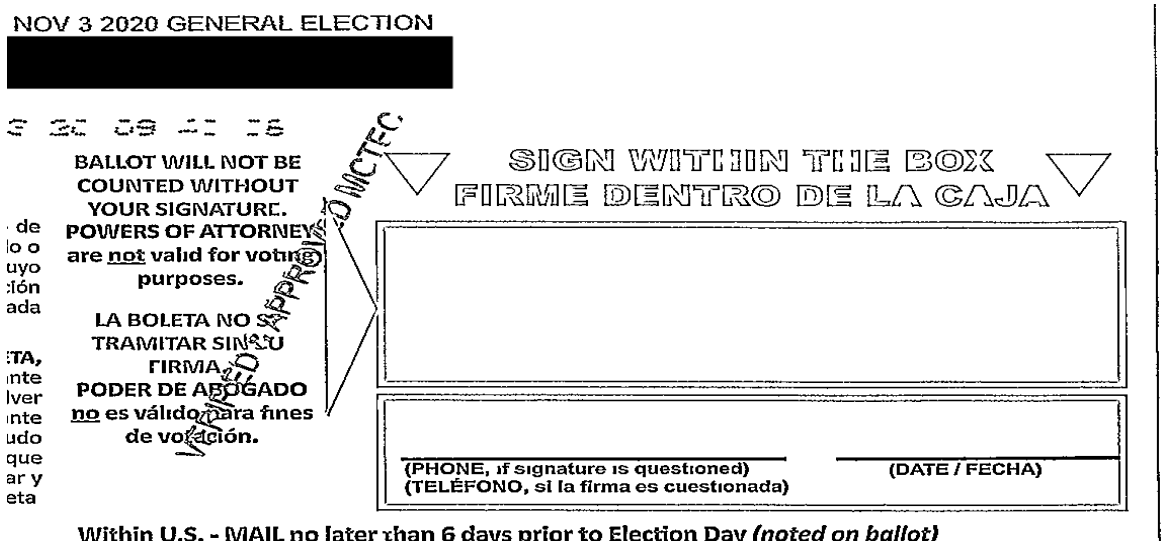
Duplicate Blanks
Stamped and Approved - Example #3



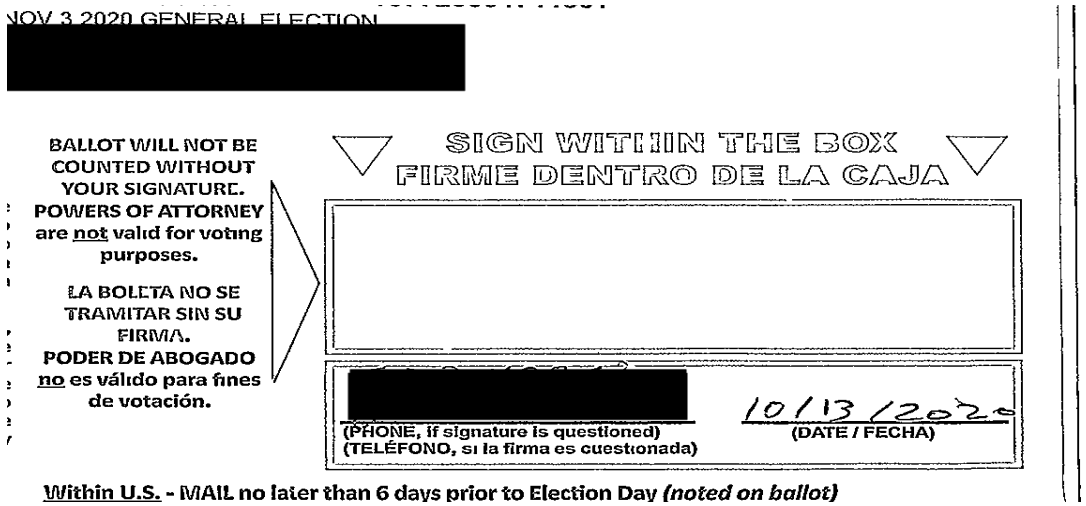


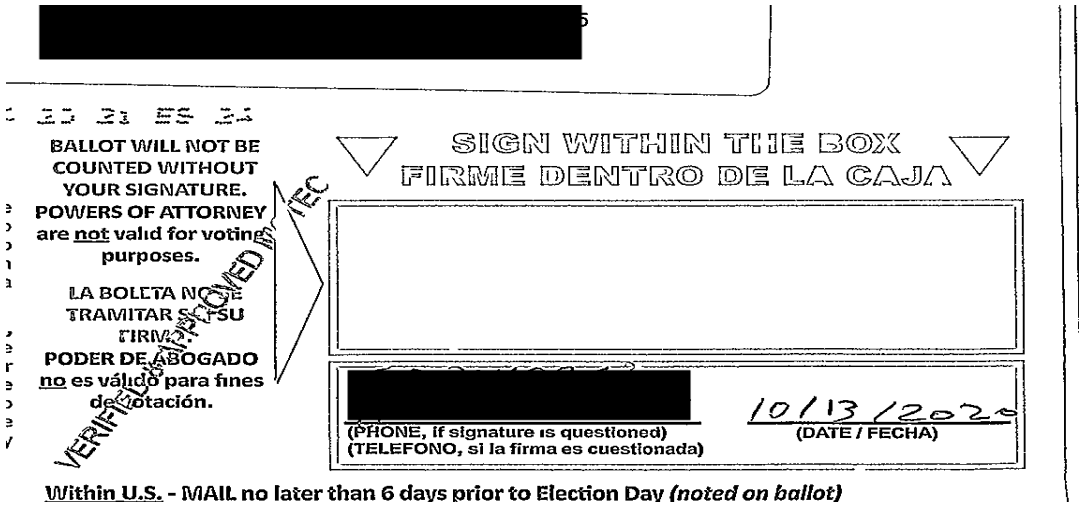
Duplicate Blanks
Stamped and Approved - Example #4

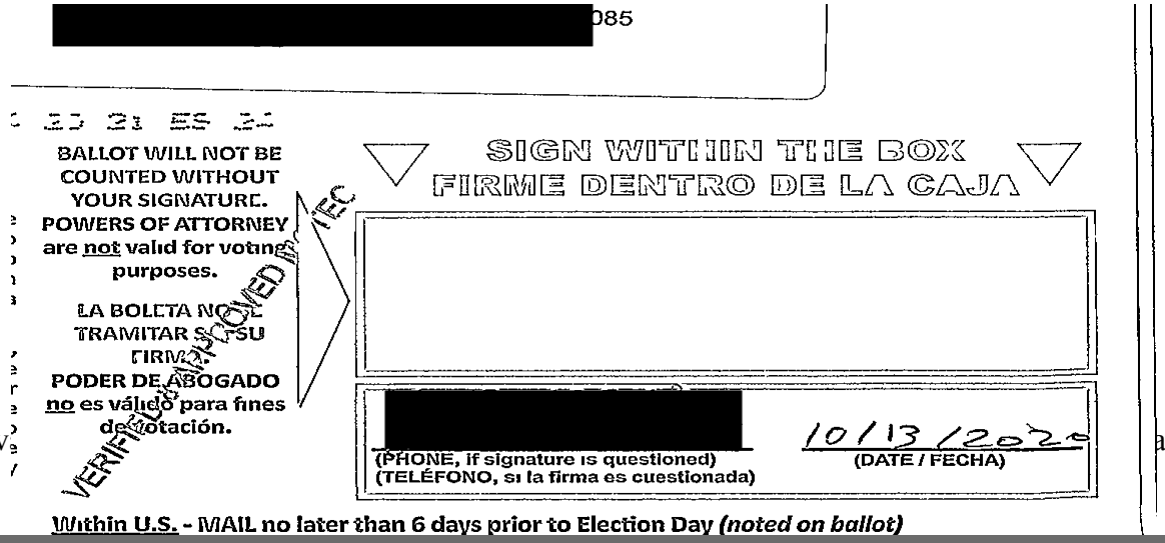




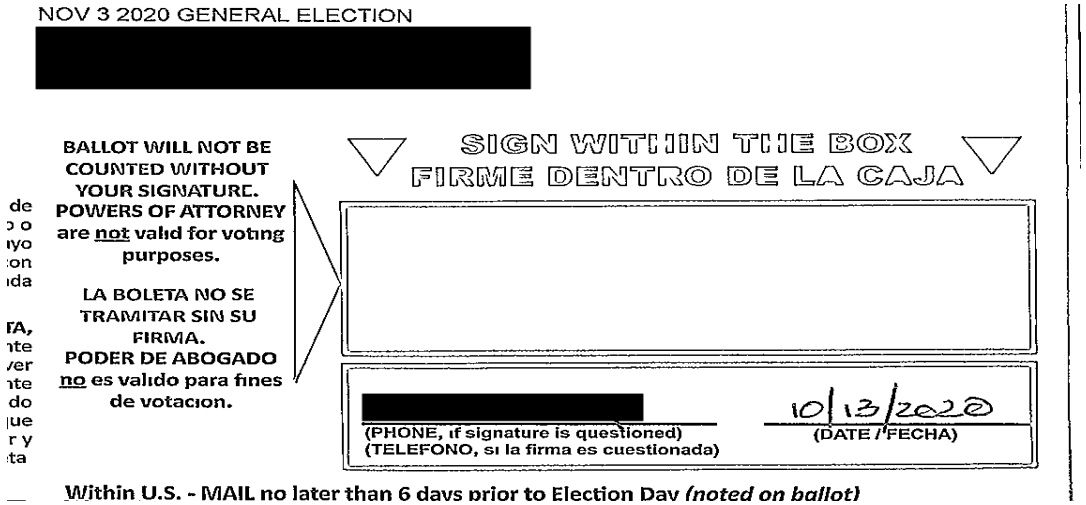
Three-Copy Duplicate Blanks (2 Approved)

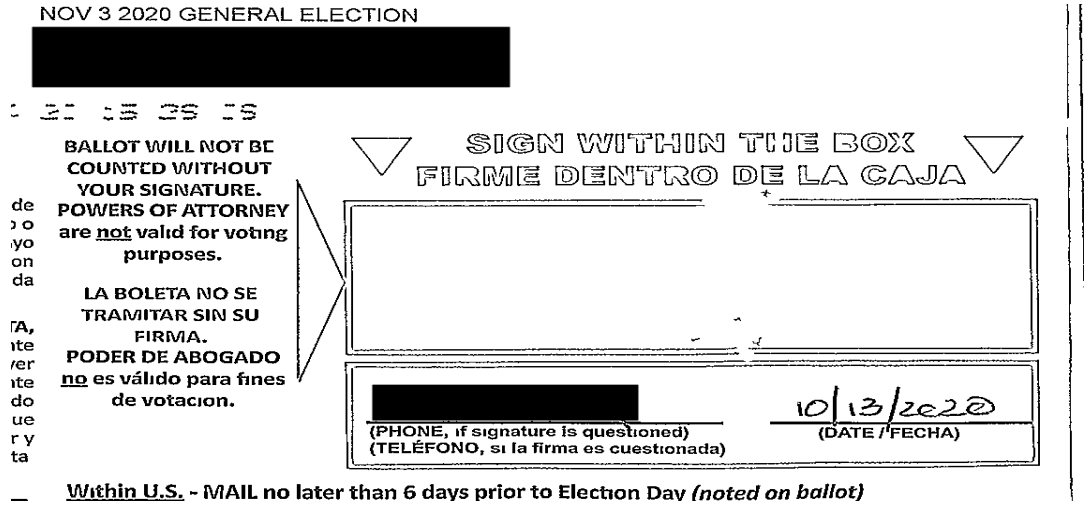


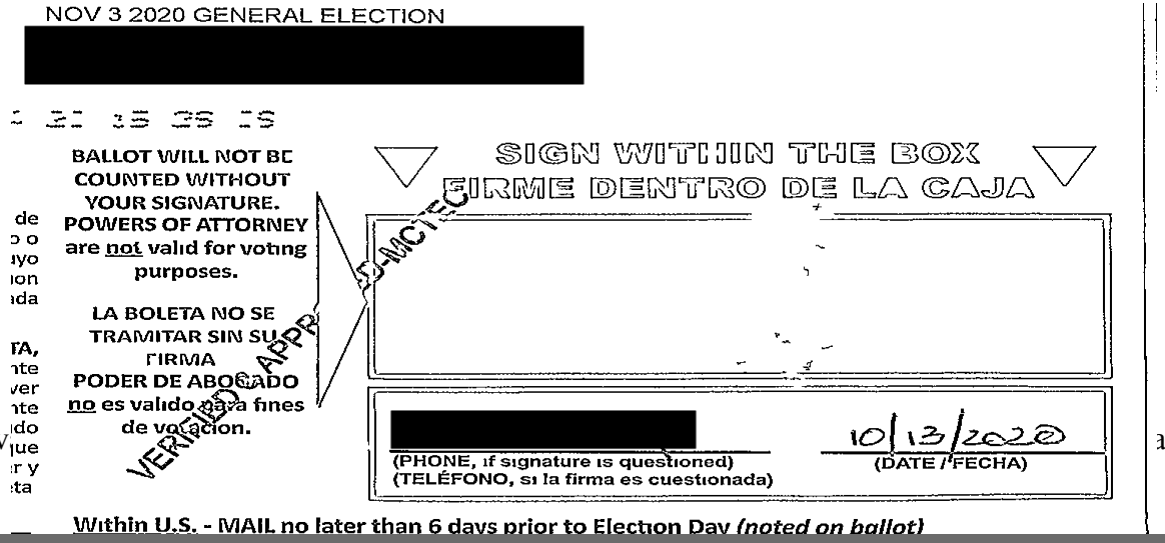




Three-Copy Duplicate Blanks





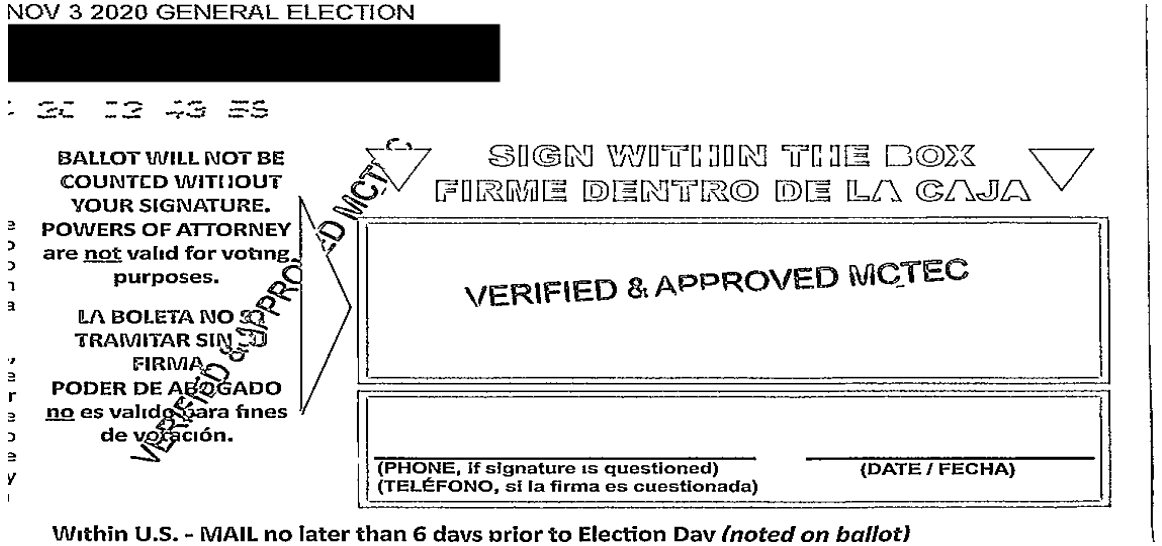


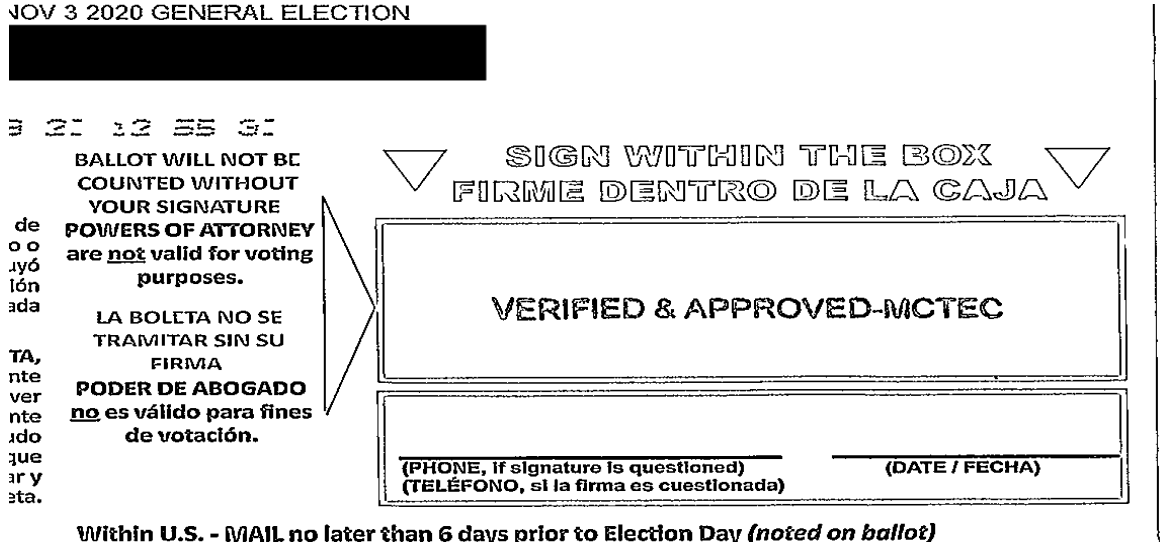
Anomaly #9

ECHOMAIL

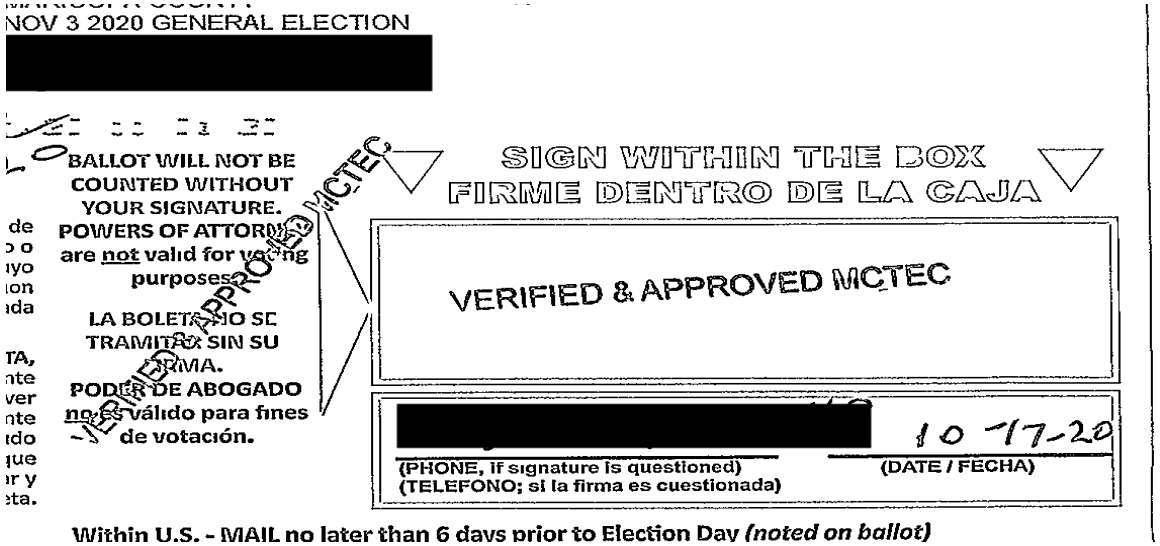
"VERIFIED & APPROVED" in Blank Signature Region

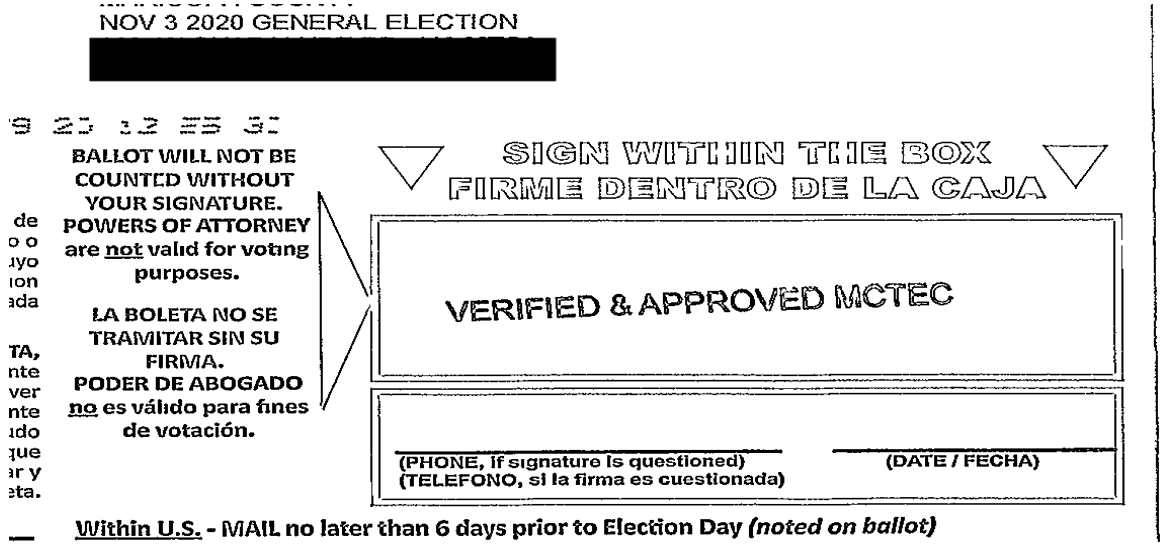
Stamped in Blank Signature Region



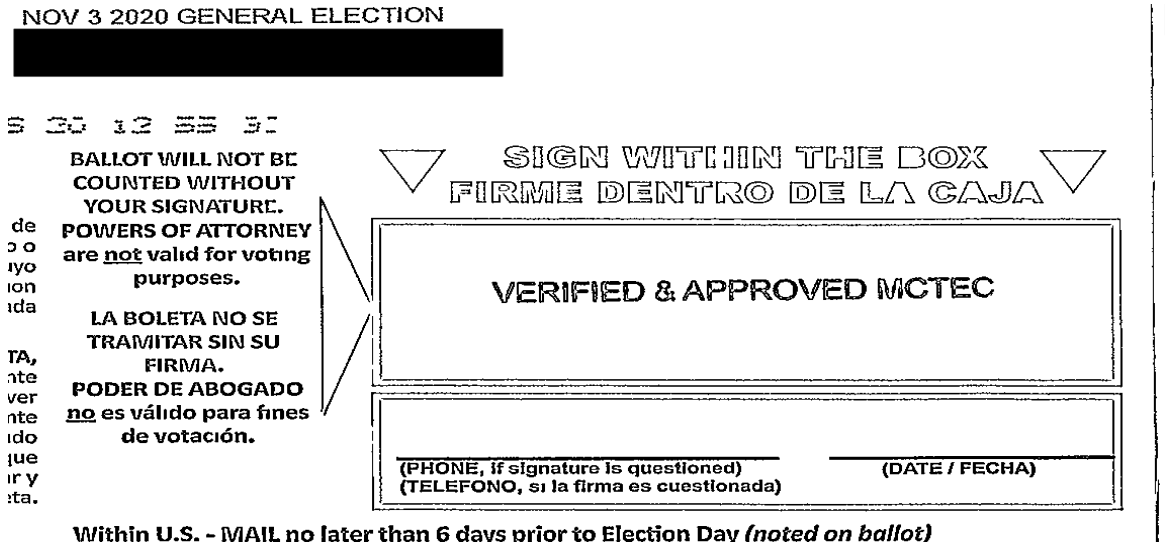


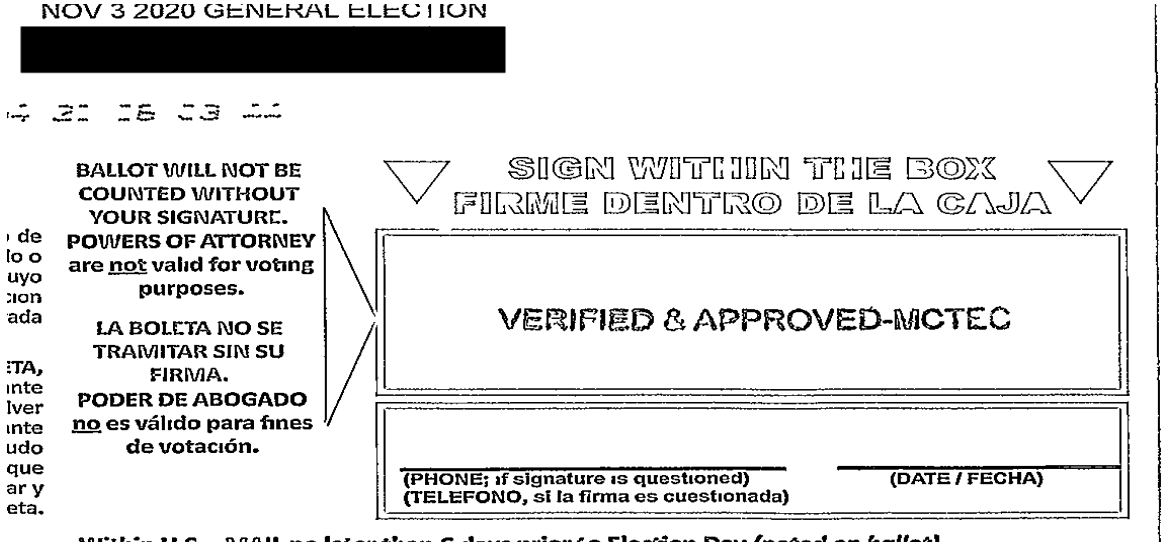
Stamped in Blank Signature Region





Stamped in Blank Signature Region



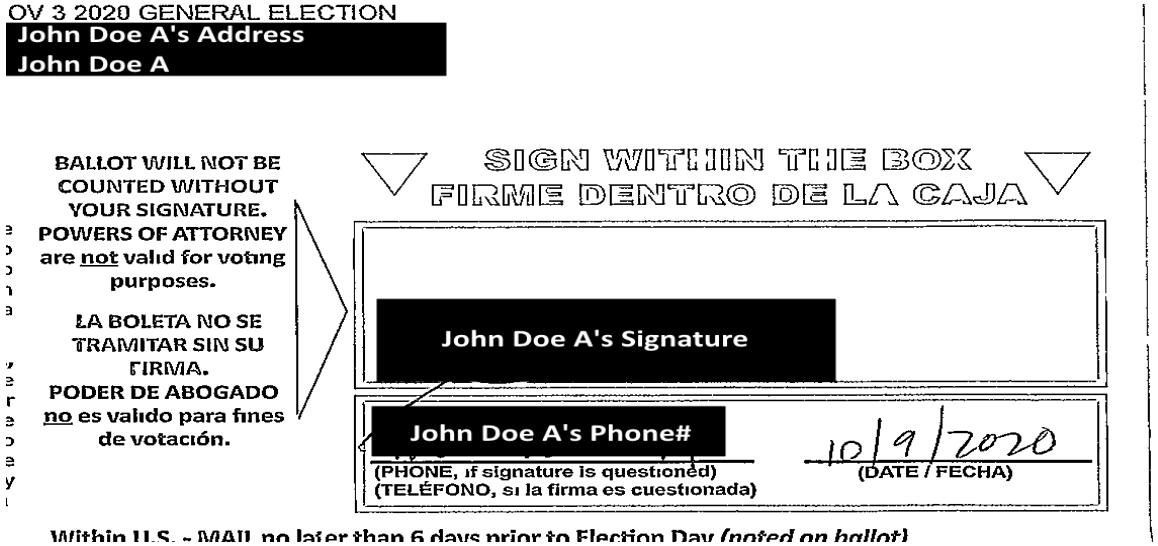


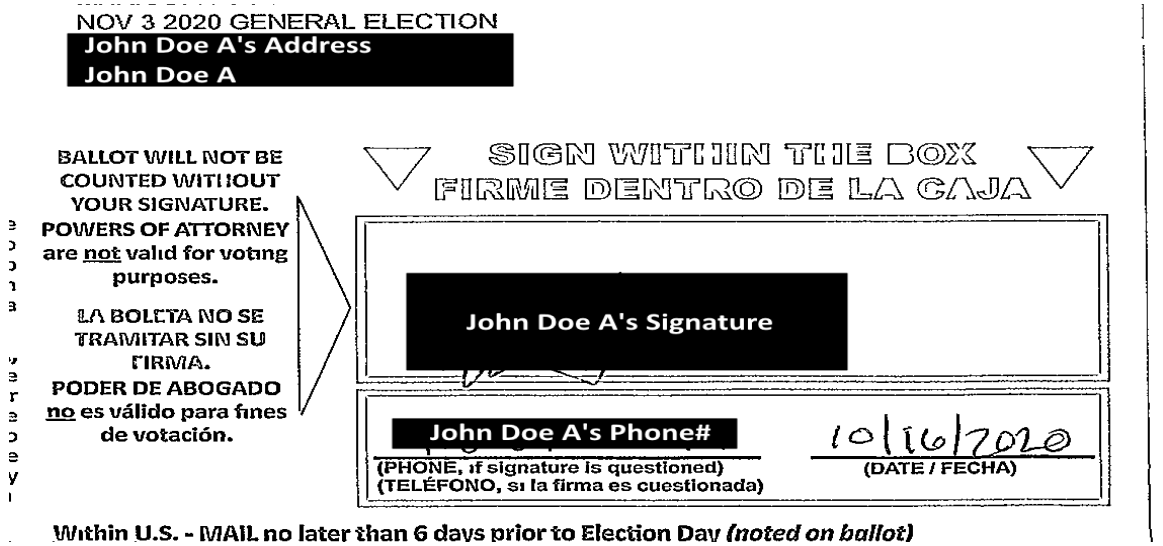
Anomaly #10

ECHOMAIL

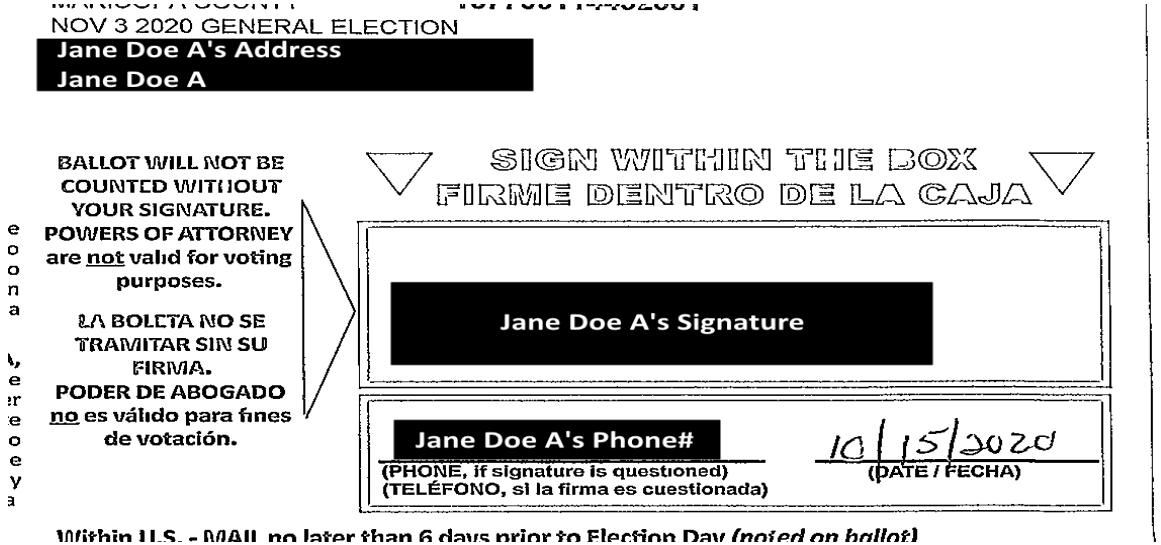
Two Different Voter-Ids with Same Name/Address Phone Number with MATCHING Signatures

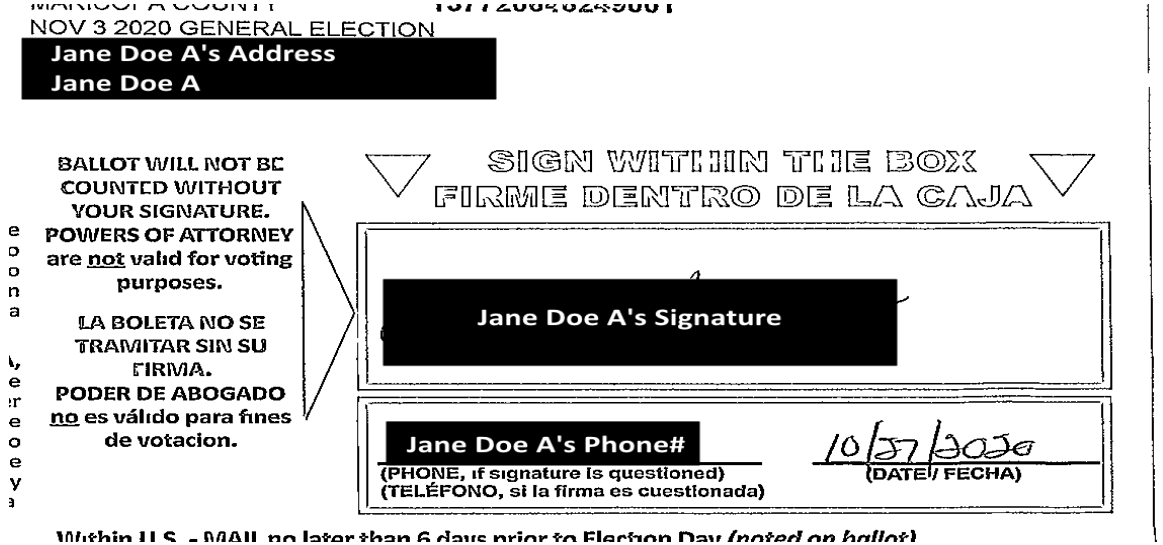
Same Name/Address/Signature/Phone, Two Different Voter IDs



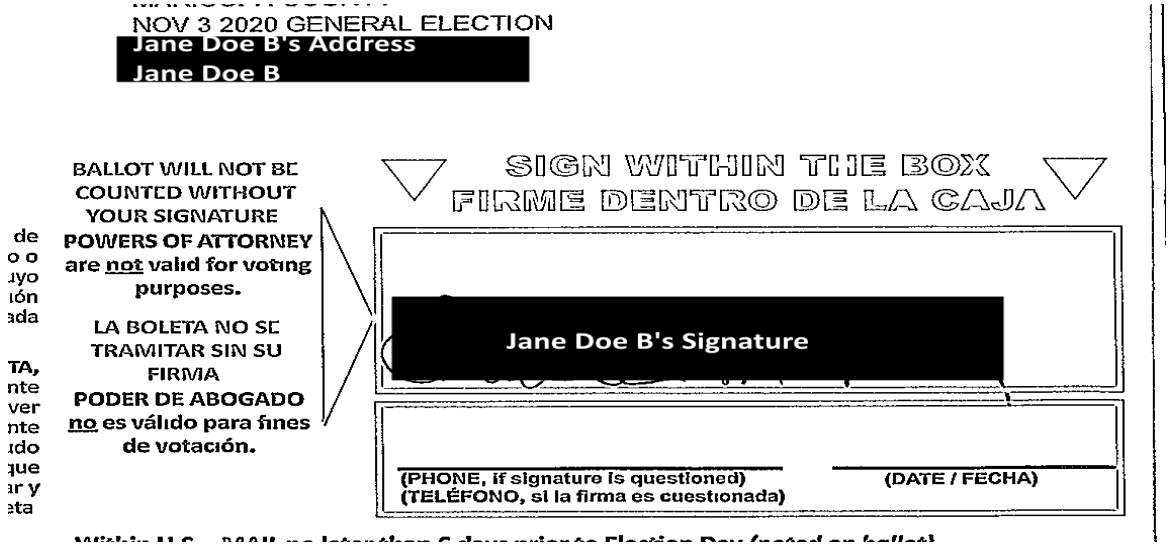


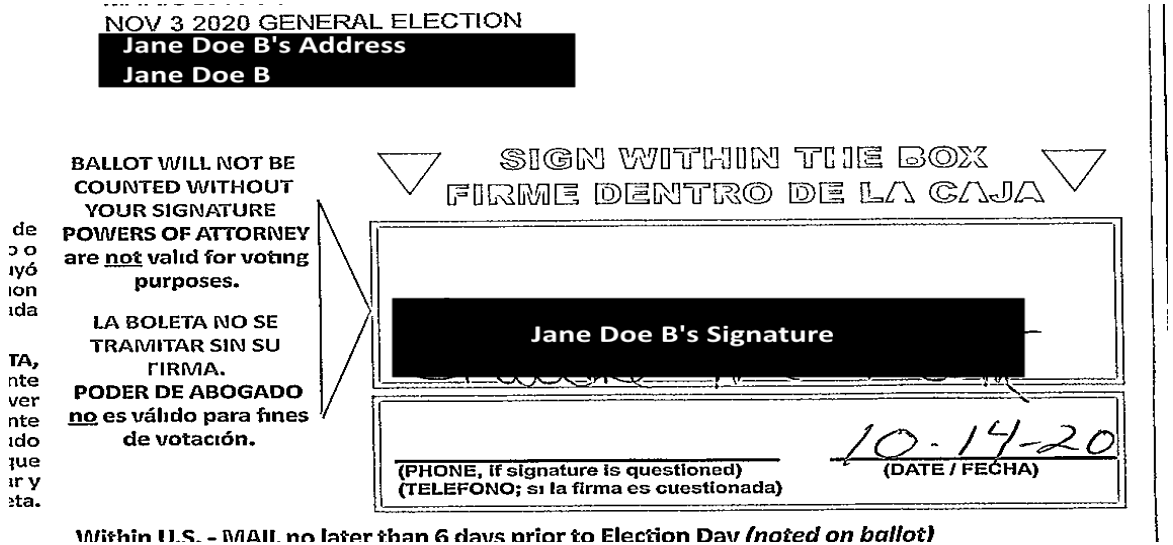
Same Name/Address/Signature/Phone, Two Different Voter IDs





Same Name/Address/Signature/Phone, Two Different Voter IDs

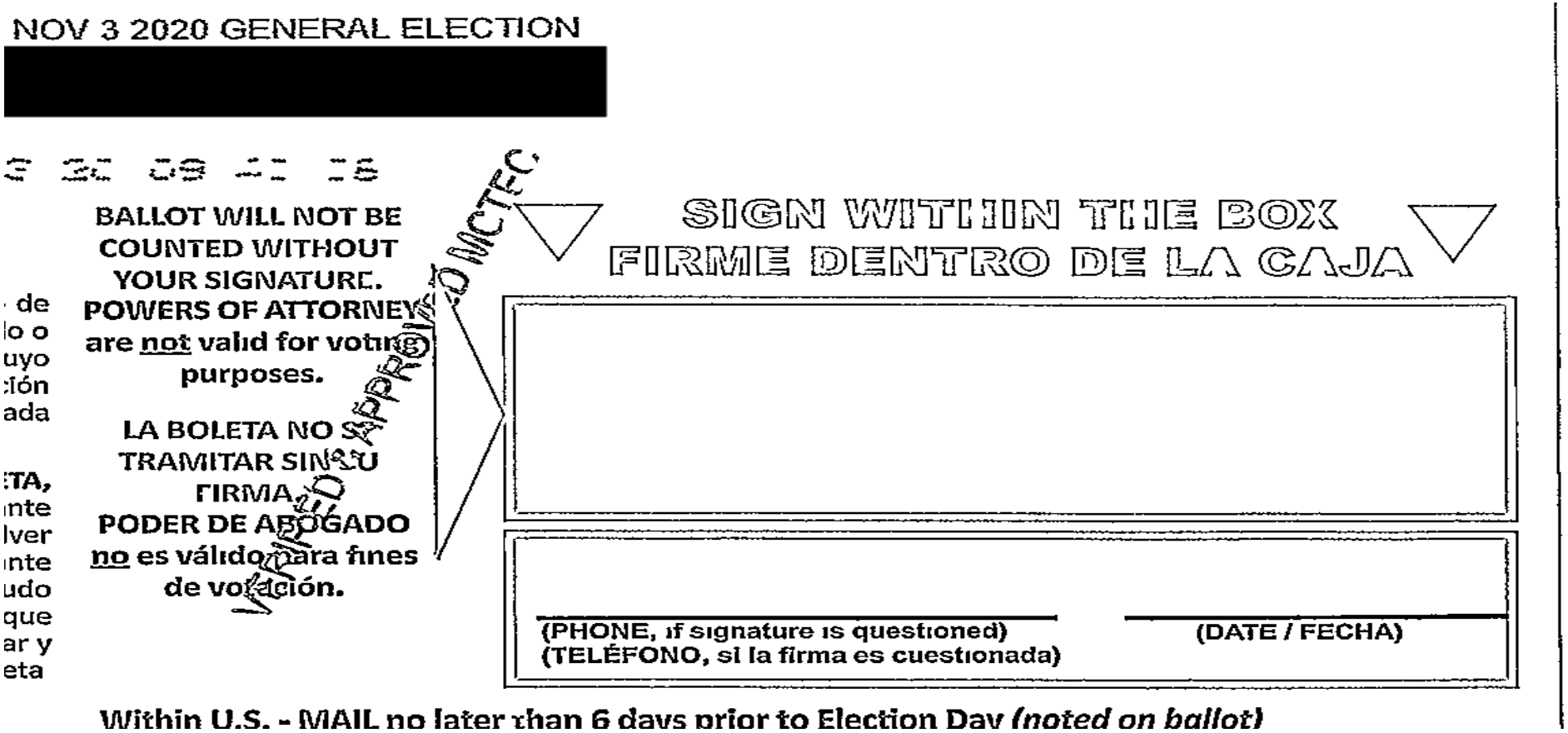


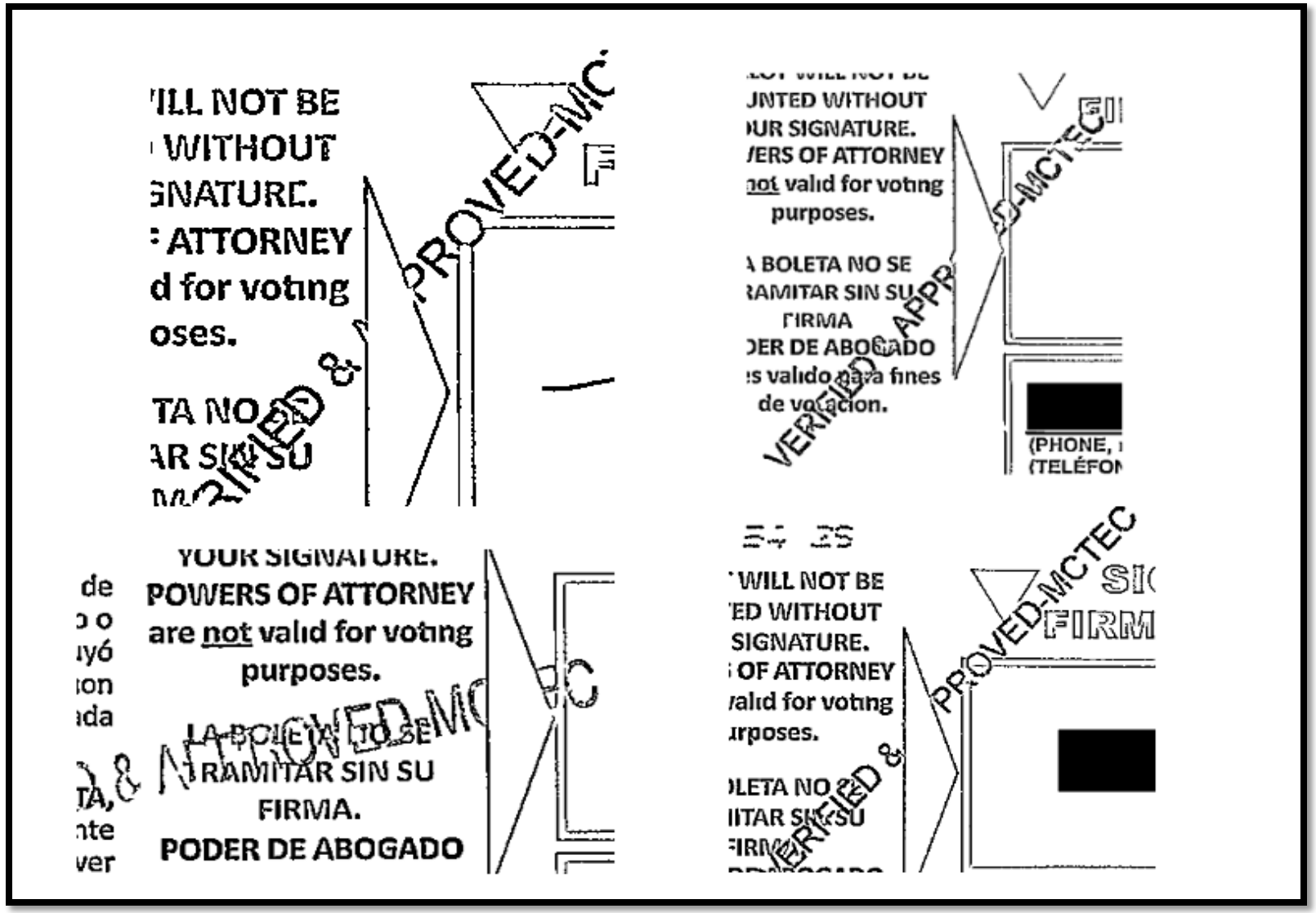


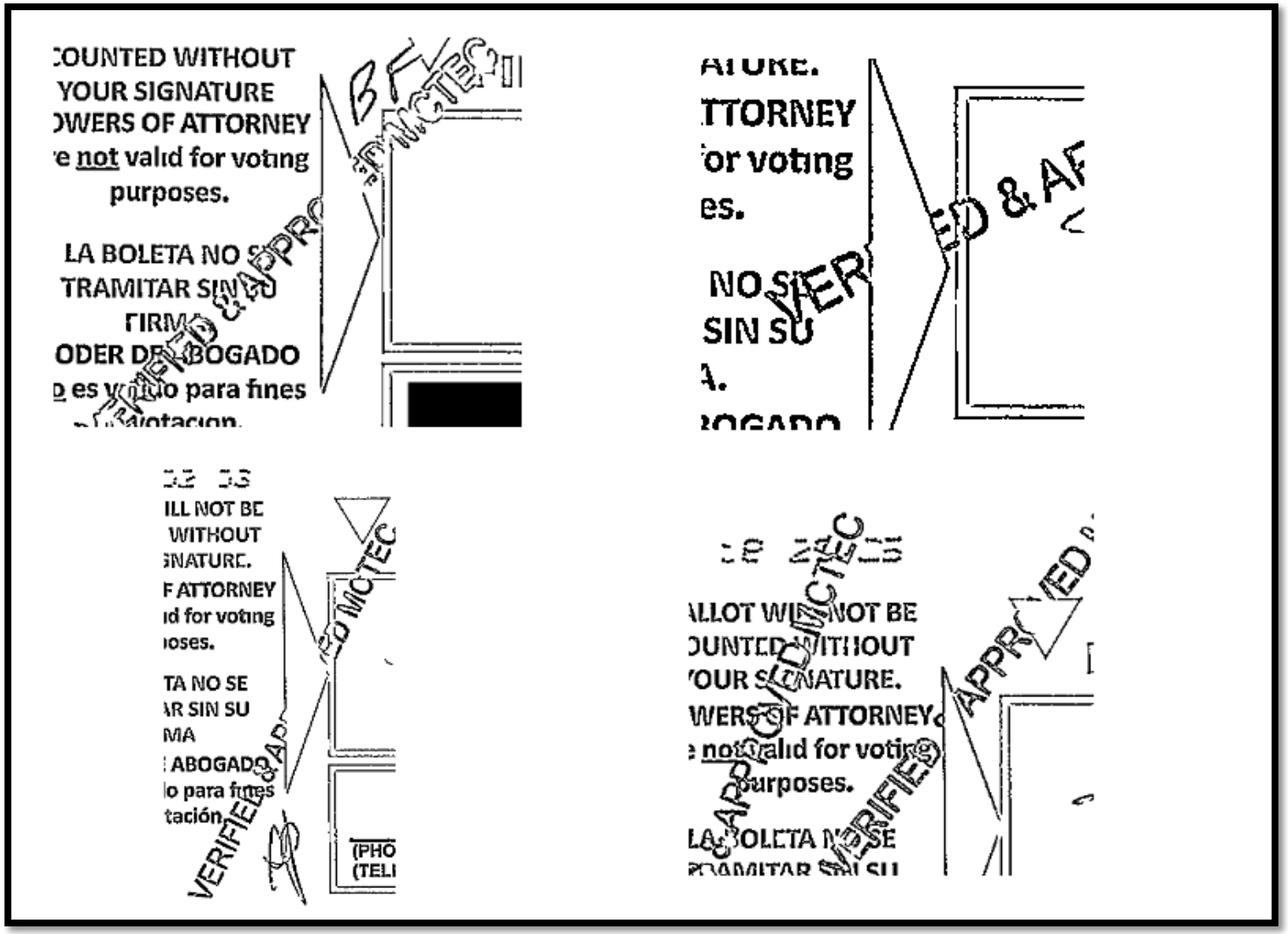
Anomaly #11

ECHOMAIL

"VERIFIED & APPROVED STAMP" Behind Envelope Triangle







Questions to Maricopa Election Officials

Questions for Maricopa

- Did Maricopa County receive any duplicate EVBs
  - EchoMail identified 34,448 EVB return envelope images being 2-copy, 3-copy and 4-copy Duplicates originating from 17,126 unique voters, while no Duplicates were reported in Maricopa's *CANVASS* report

- Is the reason that EchoMail has ***more*** "No Signatures" than reported by Maricopa because EchoMail analyzed solely the Signature Region? If not, why?
  - EchoMail identified 1,919 Blanks in Signature Region of EVB return envelopes
  - Maricopa reported 1,455 "No Signatures" in EVB return envelopes

Questions for Maricopa

- Why did EchoMail detect more Scribbles than Maricopa's reporting of "Bad Signatures"?
  - EchoMail identified 2,580 Scribbles in Signature Region of EVB return envelopes
  - Maricopa reported 587 "Bad Signatures" from its Signature Verification
  - Had EchoMail been commissioned to identify "Bad Signatures," at least 2,580 Scribbles would have been classified as "Bad Signatures;" 1,993 more "Bad Signatures" than the 587 identified by Maricopa

- Are the date stamps on the directories for SIFs, in the data set provided to EchoMail, the date in which the Maricopa election officials received the EVB return envelopes?

Questions for Maricopa

- Why does the approval stamp, ***"VERIFIED & APPROVED MCTEC"*** appear to exist only on a relatively small subset of EVB return envelopes?
- Did Maricopa stamp some EVB return envelopes as ***"VERIFIED & APPROVED MCTEC"*** **even though Signature Region is blank**, since they found a signature elsewhere i.e. outside of the Signature Region, during Signature Verification?
- What is the Standard Operating Procedure ("SOP") for the EVB processing?
- What is the SOP for Signature Verification and curing of questionable signatures?
- What is the Chain of Custody for EVB return envelopes?

Questions for Maricopa

- Why is the surge in Duplicates (and Blanks and Scribbles) during 11/04/2020 to 11/09/2020 incongruent with the trend of EVBRE daily counts during the same period?
- Why is the ***"VERIFIED & APPROVED MCTEC"*** stamp appearing "behind" the printed envelope triangle?
- Can Two Voter-IDs be associated with the same person at the same address with matching signatures?
- Why are Blanks being stamped as ***"VERIFIED & APPROVED MCTEC?"***
- Why is the stamp ***"VERIFIED & APPROVED MCTEC"*** appearing in a blank Signature Region?

Conclusion & Summary

Conclusion & Summary

- The EVB Return Envelope IS the CONTAINER of the Ballot
- Significant opportunities to enhance:
  - Precision
  - Verifiability
  - Reliability
  - Auditability
  - Reproducibility

Future Research

- Full Signature Verification Audit is Necessary
- Systems analysis needed to quantify efficacy of the current Signature Verification process
  - Acquire Maricopa County's SOP for signature verification
  - Acquire Maricopa County's 27-point analysis algorithm for signature comparison
  - Replicate signature verification process to scientifically calculate false positives, false negatives, error rate to determine a true confidence value of the signature verification of EVBs
- Need to review Chain of Custody
  - How were the signatures verified in communications
  - Phone/Email

Author's Bio

Dr. Shiva Ayyadurai, MIT PHD, SMME, SMVS, SBEE, the inventor of email and polymath, holds four degrees from MIT, is a world-renowned engineer, systems scientist, inventor and entrepreneur. He is a Fulbright Scholar, Lemelson-MIT Awards Finalist, India's First Outstanding Scientist and Technologist of Indian Origin, Westinghouse Science Talent Honors Award recipient, and a nominee for the U.S. National Medal of Technology and Innovation. He holds multiple patents, is the author of twenty books, and has published original research, in leading peer-reviewed high-impact scientific journals including *IEEE, IJPRAI, Nature Neuroscience, CELL Biophysical Journal,* that have received thousands of citations. He has started seven successful high-tech companies, received numerous industry awards, consults for Global 2000 organizations and government, and has been invited to present Keynote and Distinguished lectures at leading institutions such as NSF, NIH, FDA, Harvard, and at MIT, where he delivered the Presidential Fellows Lecture.[1]

In 1978, as a 14-year-old, he was recruited as a Research Fellow by the University of Medicine and Dentistry of New Jersey (UMDNJ), in Newark, NJ after graduating with Honors from a special program in Computer Science at the Courant Institute of Mathematical Science at NYU. At UMDNJ, he invented email – ***the system*** as we know it today – when he was the first to convert the old-fashioned *interoffice paper-based mail system* consisting of the Inbox, Outbox, Memo (To:, From:, Date:, Subject:, Cc:, Bcc:), Attachments, Folders, etc. into its electronic equivalent by writing 50,000 lines of code to create a software system, which he named "Email," – a term never used before in the English language – and went on to be awarded the first U.S. Copyright *TXu 111-775* for "EMAIL, COMPUTER PROGRAM FOR ELECTRONIC MAIL SYSTEM" recognizing him as the inventor of email at a time when Copyright was the only legal mechanism to protect software inventions. Only in 1994 did the Federal Circuit recognize software as a "digital machine" allowing for software patents. Email is not the simple exchange of text messages. Dr. Shiva has never claimed to be the inventor of electronic messaging, which predates email - the system that he created in 1978.[2,3]

Recognizing his talents in software programming, UMDNJ gave him the opportunity to conduct medical research focused on developing pattern recognition classification methods for categorization of sleep signature patterns from babies with Sudden Infant Death Syndrome (SIDS). His research was published in IEEE and presented at the IEEE-EMBS conference in Espoo, Finland. Since that time and for more than forty years, his research and development efforts in academia and industry have been focused in the field of pattern recognition classification systems, systems science, and development of large-scale computational systems for analysis of diverse signals and signatures across a range of industries: biology and medicine, engineering (e.g. aeronautical, civil, mechanical, electrical), banking, finance, and, government, as well as across a diversity of applications including handwriting recognition of courtesy amounts on bank checks, automatic analysis and classification of electronic documents e.g. email, ultrasonic and radar wave signature classification for

[1]Dr. Shiva Ayyadurai, Biography and Curriculum Vitae, https://vashiva.com/about-va-shiva-ayyadurai/
[2]Facts on the invention of email, https://www.inventorofemail.com/thefacts/
[3]The Man Who Invented Email, TIME, https://techland.time.com/2011/11/15/the-man-who-invented-email/

Author's Bio

non-destructive evaluation (NDE), signals analysis of Tadoma feature identification, biomarker analysis for determining signatures of efficacy for multi-combination therapies, image analysis for cardiology, and signal detection of fluid flow anomalies in fluidized bed reactors.

He earned a Bachelors in Electrical Engineering and Computer Science, a Masters in Mechanical Engineering, and another Masters in Visual Studies from the MIT Media Laboratory. In the midst of his PhD research in 1993, where he aimed to create a generalized platform – Information Cybernetics – for pattern recognition, he won an industry-wide competition sponsored by the White House, Executive Office of the President, to automatically analyze and classify President Clinton's email, resulting in his developing EchoMail® - a platform for automatic classification of electronic documents –, and subsequently launching EchoMail, Inc., a company that grew to nearly $200 million in market valuation. EchoMail today applies its technologies across a diversity of applications.

In 2003, he returned to MIT complete his doctoral work in systems biology in the department of Biological Engineering where he developed CytoSolve®, a scalable computational systems biology platform for mathematically modeling the whole cell. Following his PhD, Dr. Shiva was selected for a Fulbright Fellowship returning him to India where he discovered the systems theoretic basis of eastern systems of medicine resulting in Systems Health®, a new educational program that provides a scientific foundation for integrative medicine. In 2012, Dr. Shiva launched CytoSolve, Inc. with the aim of modeling complex diseases and biomolecular processes to discover multi-combination medicines. His efforts led to CytoSolve earning an FDA allowance for a multi-combination therapy for pancreatic cancer in a record eleven months, developing innovative nutraceutical products, and garnering numerous industry and academic partnerships.

As an educator dedicated to the field of systems science and systems thinking, Dr. Shiva pioneered Systems Visualization, a course he taught at MIT to graduate and undergraduate students, which integrated systems theory, narrative story telling, metaphors, and data science to provide a pedagogy for visualization of complex systems. He founded the International Center for Integrative Systems, a research and educational institution and home to Innovation Corps and R.A.W./C.L.E.A.N. Food Certified, for broader applications of systems science.

Dr. Shiva has appeared in The MIT Technology Review, TIME, The Wall Street Journal, New York Times, NBC News, USA Today and other major media. Dr. Shiva was named Top 40 Under 40 in the Improper Bostonian. He continues his passion for entrepreneurialism as Managing Director of General Interactive to incubate, mentor and fund new startups in various areas including healthcare, media, biotechnology, information technology, to name a few.

Dr. Shiva is a member of Sigma-Xi, Eta Kappa Nu, and Tau Beta Pi.

Pattern Recognition Classification of Early Voting Ballot (EVB) Return Envelope Images for Signature Presence Detection

An Engineering Systems Approach to Identify Anomalies to Advance Integrity of U.S. Election Processes

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