

Subject: Centralized Subversion of Election Vote Totals and Paper Tapes

Analyst: Jeffrey Lenberg

Date: 6/9/2021

## **Executive Summary**

The Dominion Voting Systems Election Management System (EMS) and ImageCast Precinct (ICP) are susceptible to subversion by a modification of the election project files located in a repository at ElectionSource. ElectionSource technicians were responsible for provisioning the election project files for the November 3, 2020 general election in Antrim County along with at least twenty-two (22) other counties in Michigan according to the log files on the Antrim County Election Management System. The subversion can be accomplished through the modification of a single file for each tabulator contained in the ElectionSource repository of election project files. This subversion results in the manipulation of the votes recorded both in the county's results files on the compact flash (CF) cards and on the paper tapes printed by the ICP tabulators in each precinct. This subversion is undetectable using the routine canvassing process because the ICP paper tape matches the vote total reports from the EMS that are read from the CF cards.

The ElectionSource technicians responsible for provisioning and updating the election project files for Antrim County created the election project files on their corporate computing infrastructure (laptops, servers, cloud accounts, etc). The updated election project files deployed by the ElectionSource technicians were simply installed into Antrim County's election systems. It is likely that a complete repository exists at ElectionSource that contains all the election project files for the entire list of Michigan counties supported by ElectionSource.

The subversion of the EMS and ICP is accomplished by modifying a single file contained in the ElectionSource repository, and then having that specific file along with the rest of the election project files transferred onto the compact flash cards either at ElectionSource or the county running the election. Once the compact flash cards are provisioned containing the subversion, no additional modifications need to be made on the EMS or ICPs to modify the vote totals.

The ability to modify a single file in the ElectionSource repository used by their field technicians reveals a major attack vector for fraud to manipulate votes not just in Antrim County, but across all counties in Michigan where ElectionSource provides contractor support to the election process. To be clear, all of the counties in Michigan where ElectionSource provides pre-configured election project files are vulnerable to this attack and the resulting subversion of the vote totals at the EMS and paper tapes from the ICP tabulator would match precisely despite the vote totals being manipulated in a fraudulent fashion.

## Details

The Dominion Election Management System (EMS) and the ImageCast Precinct (ICP) are susceptible to subversion through the modification of a single file per tabulator. This single file is part of a package of files that are deployed on the compact flash cards that are used in each ICP tabulator in each individual precinct.

The name of the file is “VIF\_CHOICE\_INSTANCE.DVD” and it is contained in the directory for the specific precinct ICP it is meant to be deployed to. See an example in Figure 1 of the directory structure for the files stored on the compact flash cards. Note: the compact flash card contents are encrypted by default, however, Dominion or ElectionSource would have the tools and keys to decrypt, modify, and re-encrypt these election project files.

▶ AntrimNovember2020ElectionFiles > ElectionFiles > Helena Township, Precinct 1 ICP

Name	Date modified	Type	Size
📁 dcf	4/29/2021 12:43 AM	File folder	
📁 election	4/29/2021 12:43 AM	File folder	
📁 resources	4/29/2021 12:44 AM	File folder	
📄 TabulatorData.xml	10/23/2020 4:39 PM	XML Document	1 KB
📄 TabulatorManifest.xml	10/23/2020 4:39 PM	XML Document	1 KB

*Figure 1 - Election Project File Directory Structure for Compact Flash Cards*

▶ AntrimNovember2020ElectionFiles > ElectionFiles > Helena Township, Precinct 1 ICP > election

Name	Date modified	Type	Size
📄 VIF.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_AUDIO.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_BALLOT_GROUP.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_BALLOT_INSTANCE.DVD	10/23/2020 4:39 PM	DVD File	3 KB
📄 VIF_BALLOT_LAYOUT.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_CHOICE.DVD	10/23/2020 4:39 PM	DVD File	5 KB
📄 VIF_CHOICE_INSTANCE - Copy.DVD	10/23/2020 4:39 PM	DVD File	6 KB
📄 VIF_CHOICE_INSTANCE.DVD	10/23/2020 4:39 PM	DVD File	6 KB
📄 VIF_CONTEST.DVD	10/23/2020 4:39 PM	DVD File	5 KB
📄 VIF_CONTEST_INSTANCE.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_ELECTION.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_ELECTORAL_GROUP.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_GLOBAL_LAYOUT.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_LANGUAGE.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_PARTY.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_POLL.DVD	10/23/2020 4:39 PM	DVD File	1 KB
📄 VIF_PRECINCT.DVD	10/23/2020 4:39 PM	DVD File	1 KB

*Figure 2 - Election Project DVD Files (Encrypted)*

In addition, the encryption algorithm used to protect the data on the compact flash cards is AES-128 which is known to be easily broken via ciphertext only attack. Moreover, the AES-128 keys for the election project files are stored on the EMS itself within the database (see Logan expert report 4/9/2021).

The VIF\_CHOICE\_INSTANCE.DVD file is a binary file that contains the instructions on how the tabulator will process ballots, how vote totals are assigned to each candidate, and ultimately how the paper tapes and results files are generated. Simply editing the VIF\_CHOICE\_INSTANCE.DVD file and modifying the mapping of the bullets on the ballots (vote selections) to the candidates allows for manipulation of the vote results.

Figure 3 and Figure 4 are the output of a purpose-built forensics analysis program that decrypts and decodes the data in the compact flash results file and associates it with the controlling record in the VIF\_CHOICE\_INSTANCE.DVD configuration file. The highlighted area in Figure 4 shows the manipulation of the raw binary data that creates the modification of both the paper tapes and the results file.

Contest 689: 7 choices			
	Over Votes: 0	Under Votes: 0	Cross Votes: 0   Double Votes: 0
Choice	Marks	Config Index	Data
Biden 3016	2	225	b'00000bc8000000000006001300004f1a0000a54800000000000010000008'
Trump 3017	4	256	b'00000bc9000000000006001500004f1a0000b35800000000000020000021'
Jorgensen 3018	1	287	b'00000bca000000000006001700004f1a0000c16800000000000030000079'
Blankenship 3019	0	318	b'00000bcb000000000006001900004f1a0000cf780000000000004000003c'
Hawkins 3020	0	349	b'00000bcc000000000006001b00004f1a0000dd8800000000000050000095'
De La Fuente 3021	0	380	b'00000bcd000000000006001d00004f1a0000eb98000000000000600000ab'

Figure 3 - Run of 7 Ballots with No Manipulation

Contest 689: 7 choices			
	Over Votes: 0	Under Votes: 0	Cross Votes: 0   Double Votes: 0
Choice	Marks	Config Index	Data
Biden 3016	4	256	b'00000bc8000000000006001500004f1a0000b3580000000000020000021'
Trump 3017	2	225	b'00000bc9000000000006001300004f1a0000a5480000000000010000008'
Jorgensen 3018	1	287	b'00000bca000000000006001700004f1a0000c16800000000000030000079'
Blankenship 3019	0	318	b'00000bcb000000000006001900004f1a0000cf780000000000004000003c'
Hawkins 3020	0	349	b'00000bcc000000000006001b00004f1a0000dd8800000000000050000095'
De La Fuente 3021	0	380	b'00000bcd000000000006001d00004f1a0000eb98000000000000600000ab'

Figure 4 - Run of 7 Ballots with Manipulation

The output from this subversion results in the ICP tabulator creating fraudulent paper tapes that do not match the votes processed on the paper ballots along with results files written to the compact flash card that reflect the same manipulated vote totals. The results files on the compact flash cards are also fraudulent and will be processed normally by the EMS showing the same fraudulent vote totals matching the paper tape. This subversion is undetectable in the current canvassing

process, as the paper tapes and vote totals reported on the EMS will precisely match despite the fact they have been fraudulently manipulated.

### **Simulated Election Validating Central Subversion**

In order to validate the central subversion, a simulated election was run with the ballots listed in Appendix A. The breakdown of the Presidential contest votes on the ballots are:

2 for Biden  
4 for Trump  
1 for Jorgenson

Note that the same ballots were run twice in the same sequence, thus a total of 14 ballots were run in all.

Using the subversion in Figure 4 the following election results were generated.

President and Vice President of the United States (1)	
Joseph R. Biden / Kamala D. Harris (Democrat):	8
Donald J. Trump / Michael R. Pence (Republican):	4
Jo Jorgenson / Jeremy Cohen (Libertarian):	2
Don Blankenship / William Mohr (U.S. Taxpayers):	0
Howie Hawkins / Angela Walker (Green):	0
Rocky De La Fuente / Darcy Richardson (Natural Law):	0
Write-in:	0
Total Votes:	14

United States Senator for State (1)	

*Figure 5 - The Tabulator Paper Tape Showing Modified Totals*

Contest:	<b>President and Vice President of the United States</b>		
Number Of Postions :	<b>1</b>		
Precinct Portion:			
Ballot Manifestation :	<b>0</b>		
 <a href="#">Ballot Statistics</a>			
 <a href="#">Contest Results</a>			
Overvotes:	0		
Undervotes:	0		
Blank:	0		
Double Votes:	0		
Invalid Votes:	0		
Writein Overrides:	0		
 <a href="#">Candidate Results</a>			
	Name	Party	Votes
	Joseph R. Biden / Kamala D. Harris	DEM	8
	Donald J. Trump / Michael R. Pence	REP	4
	Jo Jorgensen / Jeremy Cohen	LIB	2
	Don Blankenship / William Mohr	UST	0
	Howie Hawkins / Angela Walker	GRN	0
	Rocky De La Fuente / Darcy Richardson	NLP	0
	Write-in		0

*Figure 6 - EMS Vote Total Modified*

It is crucial to realize that no access to the EMS is required for an attacker to modify the election outcomes in any precinct for any tabulator. There is no need to modify the EMS database locally in any manner for this subversion to effectively modify both the paper tape and EMS results. This subversion does defeat the canvassing process that relies on discrepancies in the paper tape and EMS electronic totals to be found by human inspection. Only the original ballots would show the true votes during a one-hundred percent paper ballot audit process.

In addition, the access needed for an attacker to utilize this subversion would be confined to Election Source and their central repository of election files used for provisioning elections across the State of Michigan. The subversion could be used by

a malicious insider or a remote cyber attacker to modify election results across the State of Michigan with impunity.

### **Other Subversion Outcomes**

There are other variants of this same subversion that include the modification of the “VIF\_BALLOT\_INSTANCE.DVD” file, the table below describes the possible outcomes when modifying the VIF\_CHOICE\_INSTANCE.DVD file and/or the VIF\_BALLOT\_INSTANCE.DVD file.

Note: Ballots are ground truth.		05/22/21	PAPER	RESULTS
VIF_CHOICE_INSTANCE	VIF_BALLOT_INSTANCE	TAPE	FILE	
Modified	Unmodified	Modified	Modified	
Unmodified	Modified	Modified	Unmodified	
Modified	Modified	Unmodified	Modified	

*Figure 7 - Variants of Subversions*

The combination of modifications to VIF\_CHOICE\_INSTANCE and VIF\_BALLOT\_INSTANCE allow for an attacker to choose a variation where either paper tape or the results file are modified alone, see Figure 7. While this report focuses on modifying both the paper tape and results file to match the manipulated vote totals, it is conceivable that an attacker may wish to employ a variant to provide plausible deniability that the subversion was a “technical glitch” versus a fraudulent activity.

## Provisioning the Compact Flash Cards in Antrim County

The UserLog table indicates there were very few compact flash cards provisioned using the EMS for Antrim County. In fact, the only compact flash card provisioning activities noted in the log files were for Central Lake Township, Precinct 1, by Election Source on September 25<sup>th</sup>, and Mancelona Township Precinct 1 and 2 by Antrim County on October 23<sup>rd</sup>. In addition, Antrim County provisioned Central Lake Township Precinct on November 5<sup>th</sup>, see Figure 8.

executedCommand	operationTimestamp
CF card for tabulator Central Lake Township, Precinct 1 ICP has been programmed.	2020-09-25 10:20:39.517
Backup CF card for tabulator Central Lake Township, Precinct 1 ICP has been initialized.	2020-09-25 10:21:07.440
CF card for tabulator Central Lake Township, Precinct 1 ICP has been programmed.	2020-09-25 10:24:36.527
Backup CF card for tabulator Central Lake Township, Precinct 1 ICP has been initialized.	2020-09-25 10:24:59.477
CF card for tabulator Mancelona Township, Precinct 1 ICP has been programmed.	2020-10-23 16:46:25.477
Backup CF card for tabulator Mancelona Township, Precinct 1 ICP has been initialized.	2020-10-23 16:46:42.297
CF card for tabulator Mancelona Township, Precinct 2 ICP has been programmed.	2020-10-23 16:47:21.703
Backup CF card for tabulator Mancelona Township, Precinct 2 ICP has been initialized.	2020-10-23 16:47:36.250
CF card for tabulator Central Lake Township, Precinct 1 ICP has been programmed.	2020-11-05 10:22:29.563
Backup CF card for tabulator Central Lake Township, Precinct 1 ICP has been initialized.	2020-11-05 10:22:46.097

*Figure 8 - UserLog Table Showing Compact Flash Card Provisioning*

Only a small number of ImageCast-X (ICX) Ballot Marking Device Smart Cards were found to have been provisioned in the UserLog table on the Antrim County EMS including Custer Township Tabulator 20, Banks Township Tabulator 17, Chestonia Township Tabulator 19 by ElectionSource, see Figure 9. Mancelona Township Tabulator 27 was provisioned by Antrim County. All other smart cards have no log evidence of how or who provisioned them.

executedCommand	operationTimestamp
Smart Card for user Admin has been programmed for tabulator 20.Custer Township, Precinct 1 ICX.	2020-09-22 16:03:32.160
Smart Card for user Admin has been programmed for tabulator 17.Banks Township, Prec nct 1 ICX.	2020-09-23 13:58:38.893
Smart Card for user Admin has been programmed for tabulator 17.Banks Township, Prec nct 1 ICX.	2020-09-23 14:00:19.220
Smart Card for user Admin has been programmed for tabulator 19.Chestonia Township, Prec nct 1 ICX.	2020-09-23 14:47:09.553
Smart Card for user Admin has been programmed for tabulator 27.Mancelona Township, Prec ncts 1, 2 ICX.	2020-10-23 17:00:46.280

*Figure 9 - UserLog Table Excerpt Showing ICX Smart Cards Provisioning*

The conclusion regarding the provisioning of the compact flash/smart cards for Antrim County is that only a limited number are recorded in the user log. The remaining compact flash/smart cards could have been provisioned via ElectionSource using their own computing infrastructure as there is no evidence that function was performed using the Antrim County EMS.

Under the penalties of perjury, I declare that I have read the foregoing report and that facts stated in it are true.

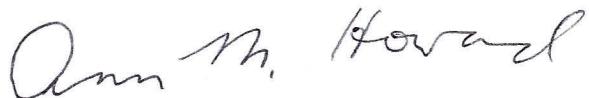
  
\_\_\_\_\_  
Jeffrey Lenberg

## MICHIGAN NOTARY ACKNOWLEDGEMENT

State of Michigan  
County of Oakland

The foregoing instrument was acknowledged before me on this 9th day of June, 2021 by Jeffrey Lenberg.

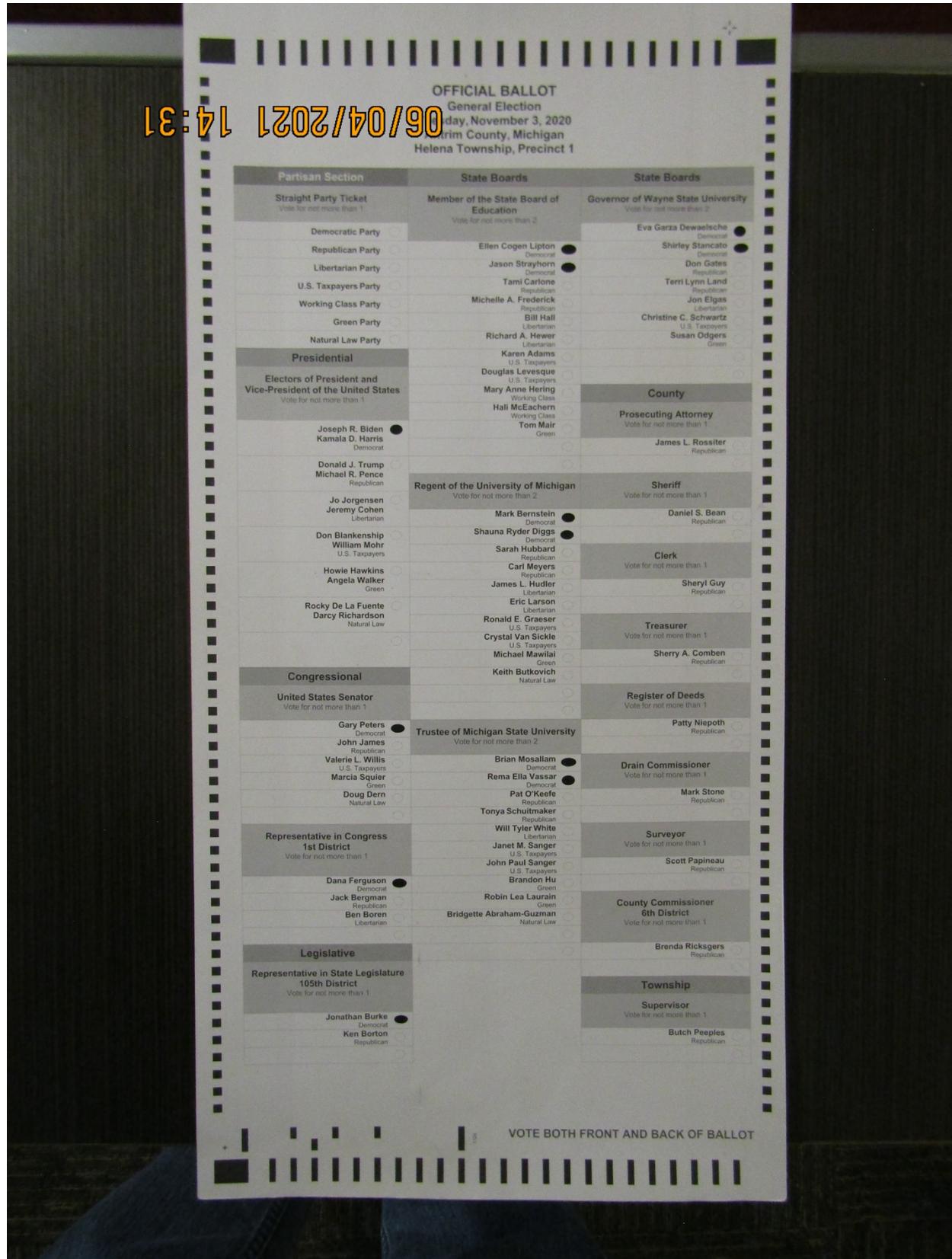
Notary Public Signature:

A handwritten signature in black ink that reads "Ann M. Howard". The signature is fluid and cursive, with "Ann" on the first line and "M. Howard" on the second line.

Notary Printed Name: Ann M. Howard  
Acting in the County of: Oakland  
My Commission Expires: 2/24/2023

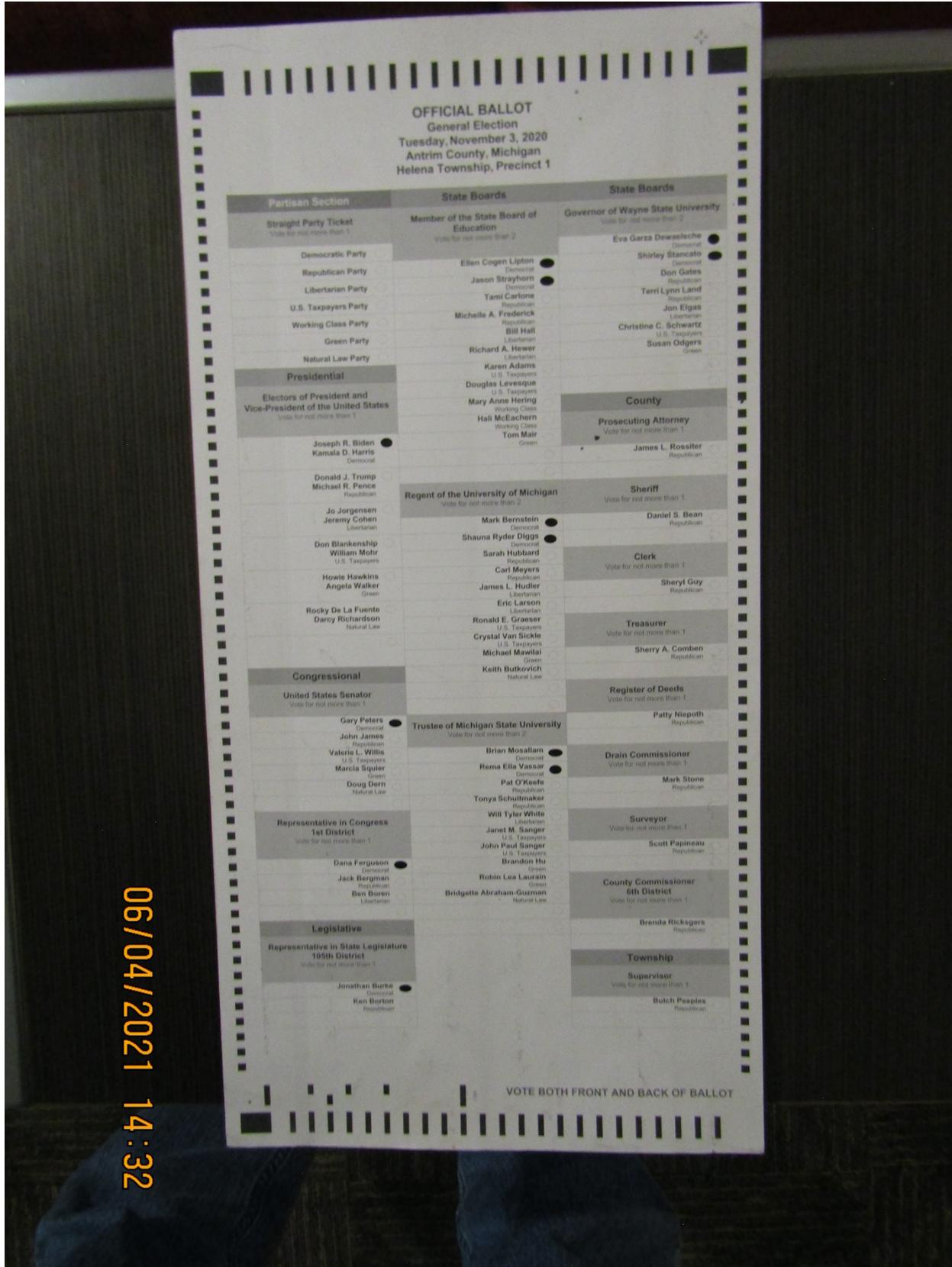
## Appendix A

Ballots used for this test.



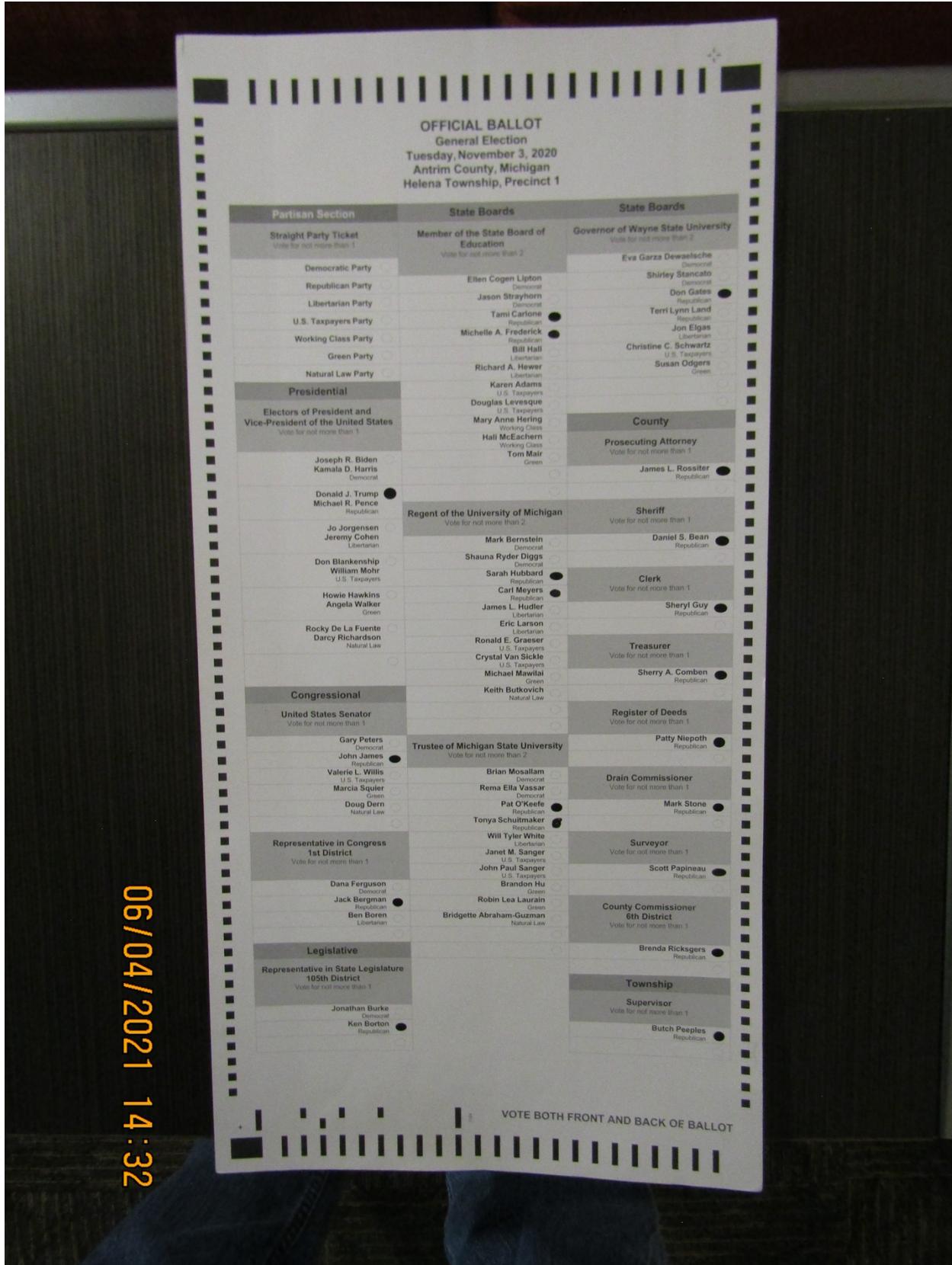
## Appendix A

Ballots used for this test.



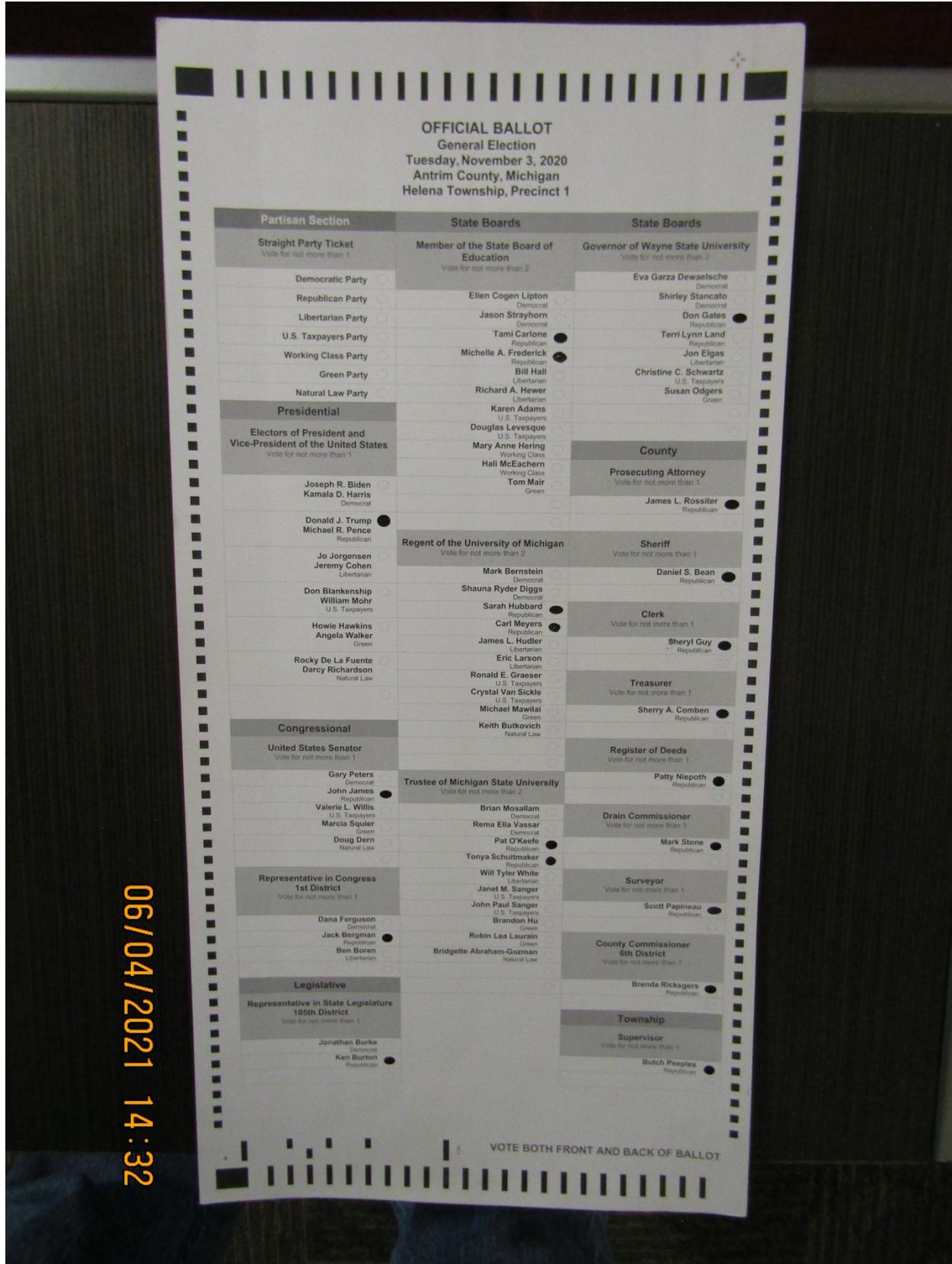
## Appendix A

Ballots used for this test.



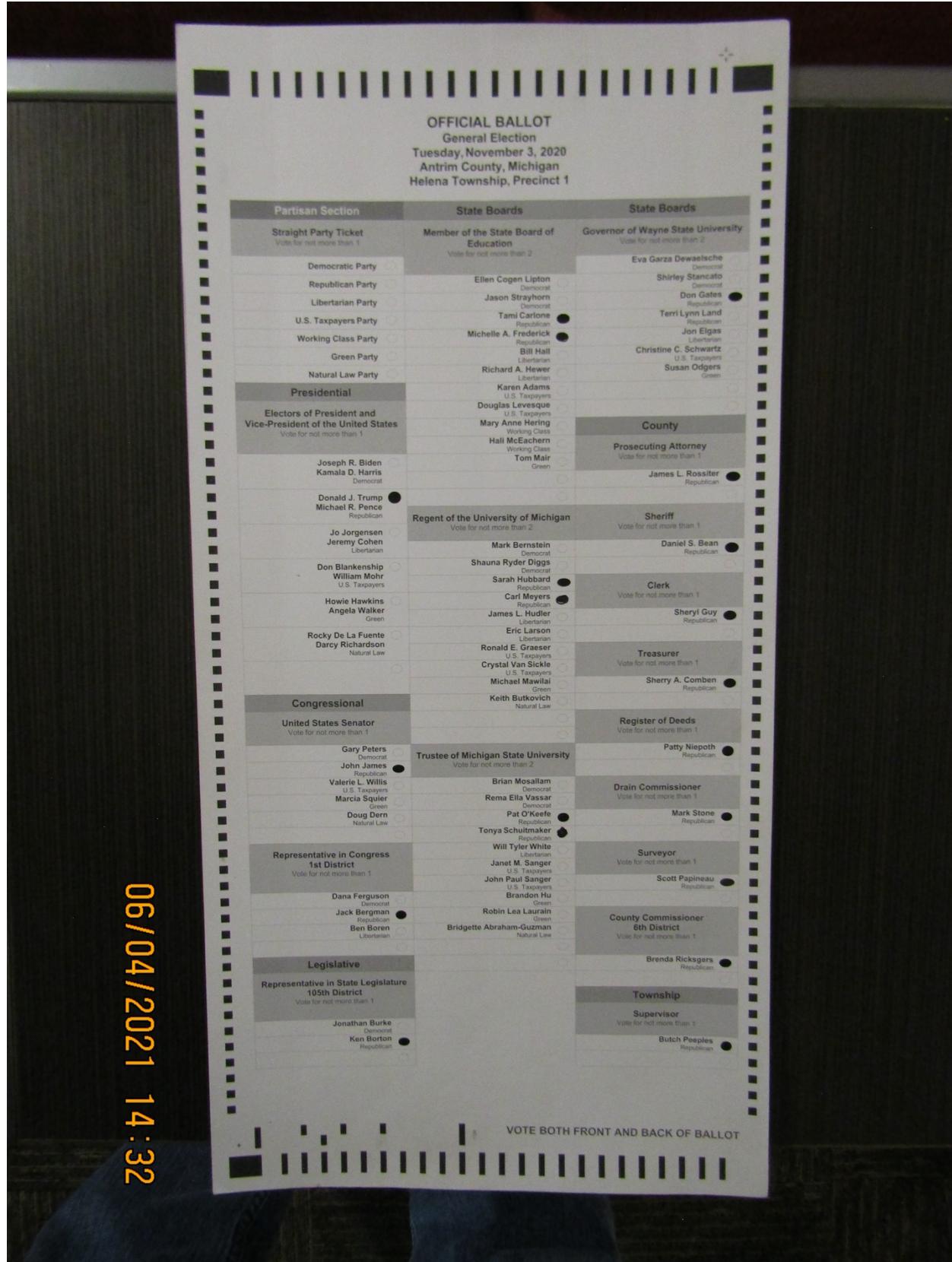
## Appendix A

Ballots used for this test.



## Appendix A

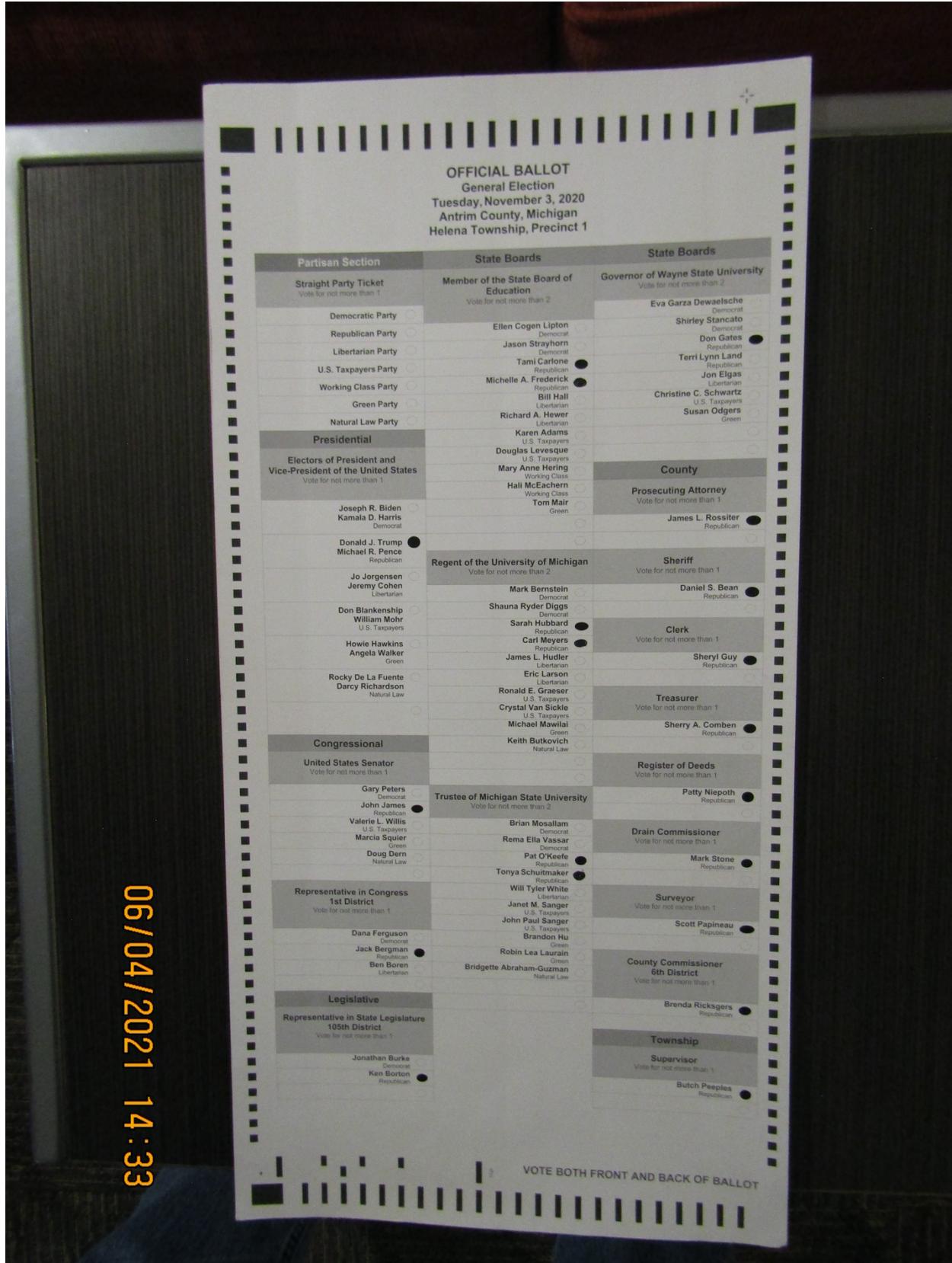
Ballots used for this test.



06/04/2021 14:32

## Appendix A

Ballots used for this test.



06/04/2021 14:33

## Appendix A

Ballots used for this test.

**OFFICIAL BALLOT**  
 General Election  
 Tuesday, November 3, 2020  
 Antrim County, Michigan  
 Helena Township, Precinct 1

Partisan Section	State Boards	State Boards
<b>Straight Party Ticket</b> <small>Vote for not more than 1</small>	<b>Member of the State Board of Education</b> <small>Vote for not more than 2</small>	<b>Governor of Wayne State University</b> <small>Vote for not more than 2</small>
Democratic Party <input type="radio"/>	Ellen Cogen Lipton <small>Democrat</small>	Eva Garza Dewaeleche <input type="radio"/>
Republican Party <input type="radio"/>	Jason Strayhorn <small>Democrat</small>	Shirley Stancato <small>Democrat</small>
Libertarian Party <input type="radio"/>	Tami Carbone <small>Republican</small>	Don Gates <small>Republican</small>
U.S. Taxpayers Party <input type="radio"/>	Michelle A. Frederick <small>Republican</small>	Terri Lynn Land <small>Republican</small>
Working Class Party <input type="radio"/>	Richard A. Howor <small>Libertarian</small>	Jon Elgas <small>Libertarian</small>
Green Party <input type="radio"/>	Karen Adams <small>U.S. Taxpayers</small>	Christine C. Diaz <small>U.S. Taxpayers</small>
Natural Law Party <input type="radio"/>	Douglas Levesque <small>U.S. Taxpayers</small>	Susan Odgers <small>Green</small>
<b>Presidential</b>	<b>Electors of President and Vice-President of the United States</b> <small>Vote for not more than 1</small>	<b>County</b>
Joseph R. Biden Kamala D. Harris <small>Democrat</small>	Halli McEachern <small>Working Class</small>	<b>Prosecuting Attorney</b> <small>Vote for not more than 1</small>
Donald J. Trump Michael R. Pence <small>Republican</small>	Tom Mair <small>Green</small>	James L. Rossiter <small>Republican</small>
Jo Jorgenson Jeremy Cohen <small>Libertarian</small>	<b>Regent of the University of Michigan</b> <small>Vote for not more than 2</small>	<b>Sheriff</b> <small>Vote for not more than 1</small>
Don Blankenship William Mohr <small>U.S. Taxpayers</small>	Mark Bernstein <small>Democrat</small>	Daniel S. Bean <small>Republican</small>
Howie Hawkins Angela Walker <small>Green</small>	Shauna Ryder Diggs <small>Democrat</small>	
Rocky De La Fuente Darcy Richardson <small>Natural Law</small>	Sarah Hubbard <small>Democrat</small>	
<b>Congressional</b>	Carl Morris <small>Republican</small>	<b>Clerk</b> <small>Vote for not more than 1</small>
<b>United States Senator</b> <small>Vote for not more than 1</small>	James L. Hudler <small>Libertarian</small>	Sheryl Guy <small>Republican</small>
Gary Peters <small>Democrat</small>	Eric Larson <small>Green</small>	
John F. Kennedy <small>Republican</small>	Ronald E. Graeser <small>U.S. Taxpayers</small>	<b>Treasurer</b> <small>Vote for not more than 1</small>
Valerie L. Willis <small>U.S. Taxpayers</small>	Crystal Van Sickle <small>U.S. Taxpayers</small>	Sherry A. Comben <small>Republican</small>
Marcia Squier <small>Green</small>	Michael Matul <small>Green</small>	
Doug Dorn <small>Natural Law</small>	Keith Butkovich <small>Natural Law</small>	
<b>Representative in Congress 1st District</b> <small>Vote for not more than 1</small>	<b>Trustee of Michigan State University</b> <small>Vote for not more than 2</small>	<b>Register of Deeds</b> <small>Vote for not more than 1</small>
Dana Ferguson <small>Democrat</small>	Brian Mosalam <small>Democrat</small>	Patty Niepoth <small>Republican</small>
Jack Bergman <small>Republican</small>	Reema Ella Vassar <small>Democrat</small>	
Ben Boren <small>Libertarian</small>	Pat O'Keefe <small>Republican</small>	<b>Drain Commissioner</b> <small>Vote for not more than 1</small>
<b>Legislative</b>	Tonya Schmidtaker <small>Democrat</small>	Mark Stone <small>Republican</small>
<b>Representative in State Legislature 105th District</b> <small>Vote for not more than 1</small>	Will Tyler White <small>Libertarian</small>	
Jonathan Burke <small>Green</small>	Janet M. Sanger <small>U.S. Taxpayers</small>	<b>Surveyor</b> <small>Vote for not more than 1</small>
Ken Burton <small>Republican</small>	John Paul Sanger <small>U.S. Taxpayers</small>	Scott Papineau <small>Republican</small>
	Brandon Hu <small>Democrat</small>	
	Robin Lea Lauren <small>Green</small>	
	Brigitte Abraham-Guzman <small>Natural Law</small>	
<b>Township</b>		<b>County Commissioner 6th District</b> <small>Vote for not more than 1</small>
		Brenda Ricksger <small>Republican</small>
		<b>Supervisor</b> <small>Vote for not more than 1</small>
		Butch Peeples <small>Republican</small>

VOTE BOTH FRONT AND BACK OF BALLOT