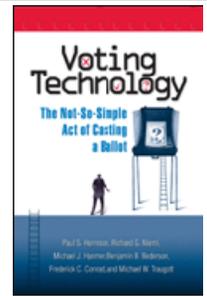


Voting Technology: The Not-So-Simple Act of Casting a Ballot



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Voting Systems: A Balancing Act

How to make
engineering
decisions?

Balance
requirements

- Accessibility
- Accuracy
- Complexity
- Cost
- Reliability
- Security
- Security Perception
- Size
- Speed
- Usability

Our focus □ Usability



Known Usability Problems: Hanging Chad

- Hanging chad



[Florida 2000]



Known Usability Problems: Butterfly Ballot

- Confusing alignment

Although the Democrats are listed second in the column on the left, they are the third hole on the ballot.

Confusion over Palm Beach County ballot

Punching the second hole casts a vote for the Reform Party.

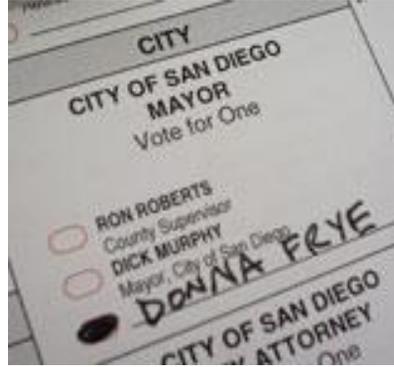
(REPUBLICAN)	3 →	(REFORM)	4 ←
GEORGE W. BUSH - PRESIDENT		PAT BUCHANAN - PRESIDENT	
DICK CHENEY - VICE PRESIDENT		EZOLA FOSTER - VICE PRESIDENT	
(DEMOCRATIC)	5 →	(SOCIALIST)	6 ←
AL GORE - PRESIDENT		DAVID MAREYNOLDS - PRESIDENT	
JOE LIEBERMAN - VICE PRESIDENT		MARY CAL HOLLIS - VICE PRESIDENT	
(LIBERTARIAN)	7 →	(CONSTITUTION)	8 ←
HARRY BROWNE - PRESIDENT		HOWARD PHILLIPS - PRESIDENT	
ART OLIVIER - VICE PRESIDENT		J. CURTIS FRAZIER - VICE PRESIDENT	
(GREEN)	9 →	(WORKERS WORLD)	10 ←
RALPH NADEAU - PRESIDENT		MONICA MOOREHEAD - PRESIDENT	
WINONA LEGOSKE - VICE PRESIDENT		GLORIA LI RIVA - VICE PRESIDENT	
(SOCIALIST WORKERS)	11 →	WRITE IN CANDIDATE	
JAMES HARRIS - PRESIDENT		To vote for a write-in candidate, follow the directions on the long stub of your ballot card.	
MARGARET TROWE - VICE PRESIDENT			
(NATURAL LAW)	13 →		
JOHN HAGELIN - PRESIDENT			
NAT GOLDHABER - VICE PRESIDENT			

[Florida 2000]



Known Usability Problems: Optical Scan Write-in

- ❑ Write-in requires bubble
- ❑ Frye claims to have lost 4-5,000 votes
- ❑ Murphy won mayoral race by 2,205 votes
- ❑ Murphy resigned 5 months later



[San Diego 2004]



Known Usability Problems: Missed Race

- ❑ Banner blindness
- ❑ Consistency
- ❑ 18,000 votes "lost"

U.S. REPRESENTATIVE IN CONGRESS 15TH CONGRESSIONAL DISTRICT (Vote for One)		
Vern Buchanan	REP	<input type="checkbox"/>
Christine Jennings	DEM	<input type="checkbox"/>
STATE		
GOVERNOR AND LIEUTENANT GOVERNOR (Vote for One)		
Charlie Crist	REP	<input type="checkbox"/>
Jeff Rothkamp		<input type="checkbox"/>
Jim Davis	DEM	<input type="checkbox"/>
Beryl L. Jones		<input type="checkbox"/>
Max Linn	REP	<input type="checkbox"/>
Tom Macklin		<input type="checkbox"/>
Richard Paul Bombinsky	NPA	<input type="checkbox"/>
Dr. Joe Smith		<input type="checkbox"/>
John Wayne Smith	NPA	<input type="checkbox"/>
James J. Kearney		<input type="checkbox"/>
Karl C. C. Belm	NPA	<input type="checkbox"/>
Carel Castagnero		<input type="checkbox"/>
Write-In		<input type="checkbox"/>

[Sarasota 2006]



So we did a study

- Expert review (10 experts)
- Field study (1,500 participants in 3 states)
- Lab study (42 participants)

Looked at:

- Accuracy
- Preference

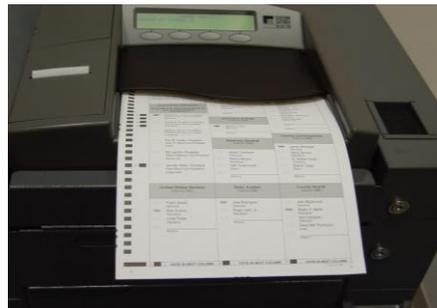
On:

- 6 voting machines
- 4 verification systems



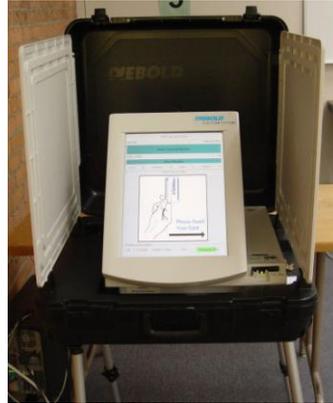
ES&S Model 100

- Paper ballot/optical scan
- Intake similar to a fax machine
- Warnings for overvotes
- No warning for undervotes
- Can cast a flawed ballot



Diebold AccuVote-TS

- ❑ Touch screen
- ❑ Smart card activation
- ❑ Manual navigation
- ❑ Ballot review
- ❑ Impossible to overvote
- ❑ Highlights undervotes



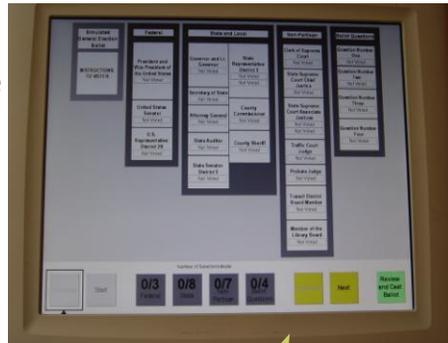
Avante Vote Tracker

- ❑ Touch screen
- ❑ Automatic advance navigation
- ❑ Paper printout for verification
- ❑ Impossible to overvote
- ❑ Highlights undervotes



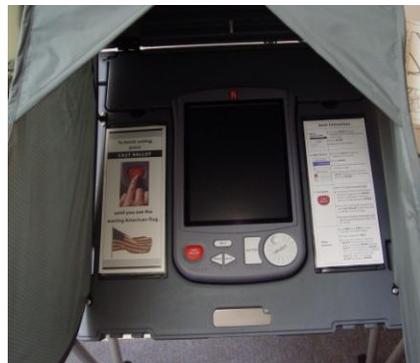
Zoomable Prototype

- Zooming navigation
- Overview of full ballot
- Voting decisions replace names of offices
- Impossible to overvote
- Highlights undervotes
- Developed at the University of Maryland



Hart InterCivic eSlate

- Mechanical buttons and dial for navigation and candidate selection
- Impossible to overvote
- Highlights undervotes



Nedap LibertyVote

- ❑ Full-face voting system
- ❑ Membrane buttons to select candidates
- ❑ Blue lights indicate selections
- ❑ Impossible to overvote
- ❑ Warning for undervotes



Experimental Setup

Tasks:

- ❑ 18 offices & 4 ballot questions
- ❑ Office block & Straight party
- ❑ Multi-candidate election
- ❑ Change a vote
- ❑ Cast a write-in vote

Process:

- ❑ Pre-mark booklet
- ❑ Write-in matched voter with booklet



Accuracy – Vote for President

Percent of votes	ES&S Model 100	Diebold AccuVote TS	Avante Vote-Trakker	Zoomable Prototype	Hart InterCivic eSlate	Nedap Liberty Vote
Voted as intended	95.8	96.7	96.7	97.5	96.3	96.3
Proximity error	3.0	2.4	2.2	1.4	2.4	2.4
Voted for another candidate	1.0	0.4	1.0	0.5	0.4	0.5
No vote cast	0.2	0.5	0.1	0.6	0.9	0.8



Accuracy – Impact of Task

Task	ES&S Model 100	Diebold AccuVote TS	Avante Vote-Trakker	Zoomable Prototype	Hart InterCivic eSlate	Nedap Liberty Vote
No special tasks	97.4	97.7	97.5	97.6	97.1	97.5
Vote for two	96.5	95.7	93.5	96.6	86.6	94.6
Change vote	89.6	93.9	85.6	92.8	92.0	90.7

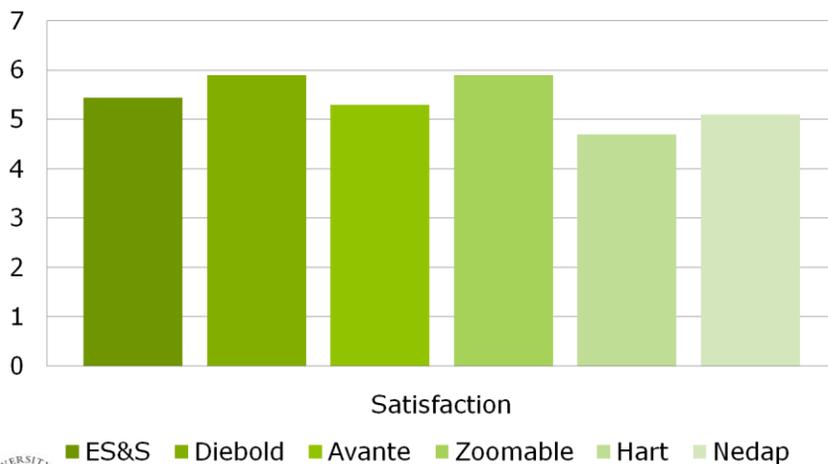


Accuracy – Write-In Errors

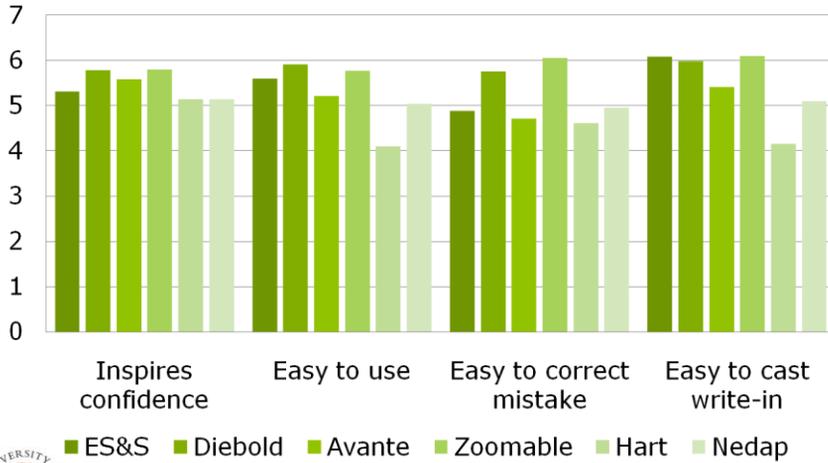
Percent of ballots	ES&S Model 100	Diebold AccuVote TS	Avante Vote-Trakker	Zoomable Prototype	Hart InterCivic eSlate	Nedap Liberty Vote
Perfect	70.2	90.7	92.2	89.3	86.2	88.2
Error writing name	1.7	6.3	4.3	8.1	10.6	8.1
Unlikely to be counted	28.1	3.0	3.5	2.6	3.2	3.7
No vote cast	1.0	0.9	0.8	0.9	1.3	2.6
Other cand.	2.0	1.7	2.4	1.4	1.7	0.4
No Bubble	25.0	n/a	n/a	n/a	n/a	n/a



Satisfaction - Overall



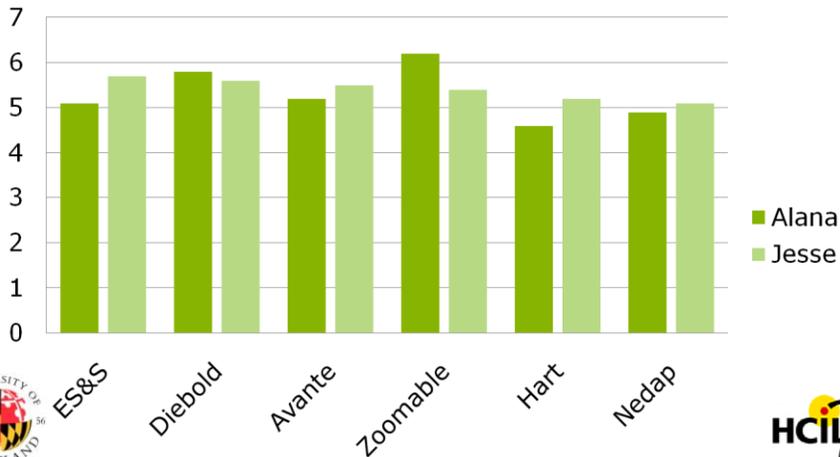
Satisfaction - By Kind



Satisfaction - By Voter Type

Alana – Young white female (master's)

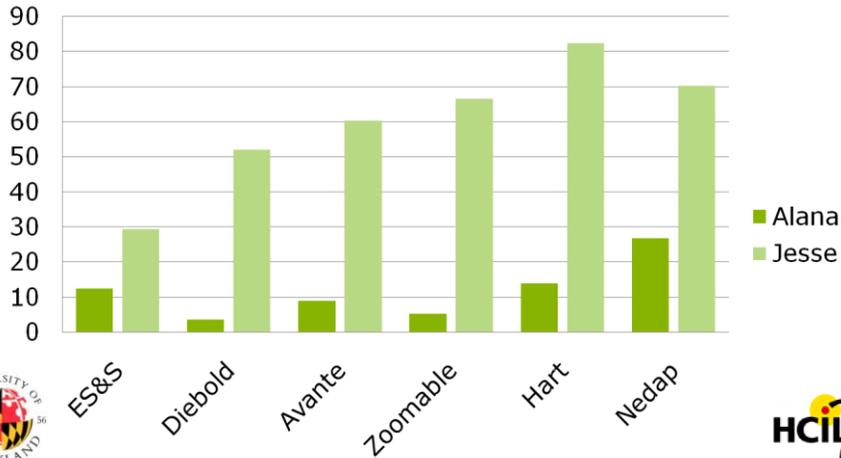
Jesse – Older African American male (high school)



Percent Requesting Help

Alana – Young white female (master's)

Jesse – Older African American male (high school)



Specific Problems

- Hard to correct mistakes
- Paper did not give enough feedback
- Automatic advance problematic
- Non-touch screen display confusing
- Full screen problematic
- Review screen problematic
- Paper trail ignored or frustrated



Verification Study

- ❑ Test the usability of four vote verification systems
- ❑ Requested by Maryland SBE
- ❑ Review by HCI experts
- ❑ Field experiments with approximately 800 participants



Diebold AccuVote-TSx with AccuView Printer Module

- ❑ Paper printout
- ❑ After-the-fact verification
- ❑ No independent verification unit
- ❑ Magnifying glass
- ❑ Privacy cover
- ❑ Two chances to review prior to casting ballot
- ❑ Ballots not randomly stored (privacy issues)
- ❑ Bar code can be scanned for recount



VoteHere Sentinel

- ❑ Cryptography
 - Very complicated
- ❑ After-the-fact verification
- ❑ Independent verification unit
- ❑ Paper printout
- ❑ Simple verification-all
 - Was ballot counted?
- ❑ Advanced verification-500
 - Were individual votes accurately cast?
- ❑ Ballots randomly stored
- ❑ Compare computerized vote totals to voting system



Scytl Pnyx

- ❑ Small computer monitor
- ❑ After-the-fact verification
- ❑ Independent verification unit
- ❑ Voters review elections race by race
- ❑ Can change ballot on system and cast vote
- ❑ Ballots randomly stored
- ❑ Compare computerized vote totals to totals on voting system



MIT Prototype

- ❑ Audio
- ❑ Recorder/headphones
- ❑ Analog tape
- ❑ Simultaneous verification
- ❑ Independent verification unit
- ❑ Ballots not randomly stored (privacy issue)
- ❑ Tape can be played for recount



Diebold AccuVote-TS

- ❑ No verification unit
- ❑ Used in Maryland & other states & localities
- ❑ Control system in field experiment

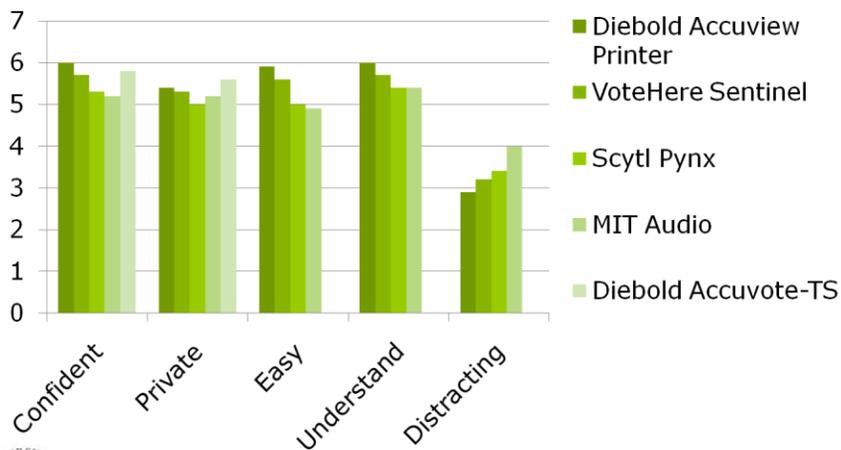


Voting Tasks

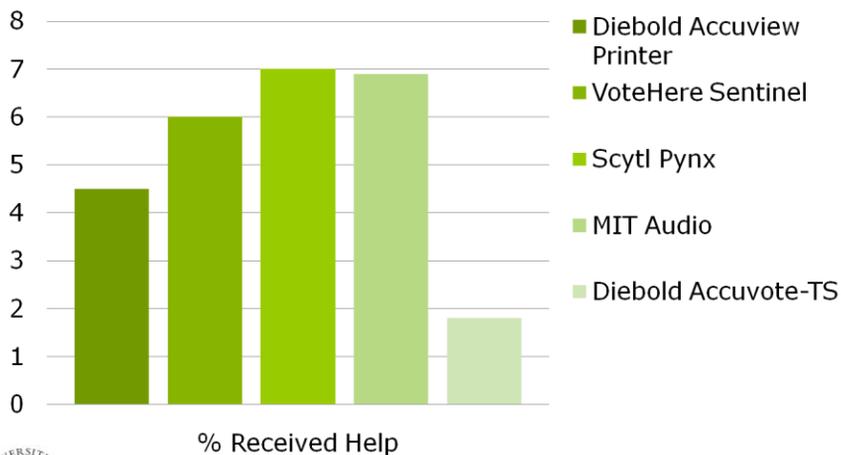
- Vote for 5 offices
- Change a vote
- Vote for two candidates
- Cast a write-in vote



Voter Satisfaction



Need For Help



Verification Systems Summary

- All fairly positive
- Tradeoffs between usability & verification
- Tradeoffs between actual and perceived security (cryptographic vs. paper trail)
- After-the-fact preferable to simultaneous



Conclusions

- ❑ Vote verification systems decrease usability of voting systems
 - Does not increase satisfaction
 - Increases need for help
- ❑ No significant differences in voters' evaluations of paper receipt, system with no verification unit, and cryptographic system



Recommendations

- ❑ Usability must be considered in acquisition
- ❑ Simple and fewest actions good
- ❑ Avoid straight-party device
- ❑ Avoid overwhelming voter with too much info
- ❑ Review should show undervote
- ❑ Verification systems should be considered cautiously



Usability vs. Security?



Usability **AND** Security – My Opinion

Alternative Solutions:

- Open source & secured touch screen system
- Run by public not-for-profit corporation

Or:

- Touch screen EBM (also counts)
- Optical scan printout for the record
- Centralized optical scan reader
- Discrepancy with TS causes recount

Or:

- Same as above but with reader per precinct
 - Enhances speed at which discrepancies are caught
 - Improves clarity of process



Usability **AND** Security – My Opinion

But:

- Paper not a panacea
(Lyndon Johnson's first election to Senate made possible by missing ballot box...)
- Security perception not a broad problem
- Paper fraud has lower technical barrier



Summary

- That press release ...
- I think voter trust *is* important
- I think voting usability should be equal to security in USACM's communications
- Consider building our own ...



For More Information

www.cs.umd.edu/~bederson/voting

www.capc.umd.edu

**NSF #0306698
Carnegie Corporation #D05008
Maryland SBE**

Thank you!

