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WORCESTER POLYTECHNIC INSTITUTE
INTERDISCIPLINARY AND GLOBAL STUDIES
DIVISION

Improving Voter Privacy for the Blind
Accessible Election and Voting Systems for Persons With a Visual
Impairment in Denmark

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Abstract

Visually impaired voters in Denmark are unable to vote privately in state elections. Our study examined voting systems that could improve voter privacy for the visually impaired in Denmark. We also investigated different methods of voting that would allow the visually impaired to participate in elections within organizations. Through interviews with blind and sighted voters and with members of the Danish government, we determined which voting systems would be most acceptable for use in Denmark. Based on our findings, we concluded that the Danish Association of the Blind should push for the implementation of electronic voting machines that print paper ballots. We have also created a list of best practices for making organizational elections accessible to the visually impaired.

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1 Introduction

The right to vote with a secret ballot is essential to upholding the legitimacy of a Democratic election. Without the privacy of a secret ballot, voters can feel intimidated or even embarrassed when voting. The knowledge that others will know one's vote in an election can lead to skewed election results and a general mistrust in the electoral system (Evans & Paul, 2004). In order to prevent fraudulent results from occurring, Article 21 of the United Nations Universal Declaration of Human Rights states that "the will of the people shall be the basis of the authority of government" and that this shall be determined "by secret ballot or by equivalent free voting procedures." Clearly, the United Nations views voter privacy as a central pillar of the political institution of Democracy.

Unfortunately, in many developed nations, the visually impaired are unable to vote by a secret ballot. One such nation is Denmark, which has faced significant challenges in implementing an accessible voting system for the visually impaired. Currently, the only method by which a visually impaired person may vote in Denmark is by having a government official read off, record, and cast the ballot for the visually impaired voter (MISA, 2009). Due to this requirement that a visually impaired person must tell their vote to a stranger, many visually impaired voters in Denmark feel that their privacy rights are being violated (Heilbrunn, 2011).

The implementation of a secure and private voting scheme for the visually impaired is a global problem and it is not surprising to find that there have been many, sometimes successful, attempts to implement voting systems that are usable by the visually impaired. For example, in 2002 the United States government enacted the Help America Voter Act (HAVA), mandating that all polling sites in the US provide at least one handicapped accessible voting station (VisionAware, 2010). This legislation has led to widespread adoption of electronic voting systems that provide the visually impaired with a private and independent method of voting (PR Newswire, 2004). Although the entirety of the US electoral system is not yet able to provide a secret ballot for every visually impaired voter, significant progress has been made since the passing of HAVA.

Another system of voting that has been relatively successful in providing privacy to the visually impaired has been telephonic voting. Telephone based systems have been used successfully throughout Australia, where they were first implemented in 2007. Indeed, the telephonic voting system generated extremely positive user feedback, with most visually

impaired voter finding it very appealing (Hutchinson, 2010). Furthermore, the costs of maintaining the call centers that record the telephone votes are relatively low compared to electronic voting systems (Hutchinson, 2010).

While there have been successes in some countries with voting systems that allow visually impaired voters to maintain their privacy, other countries have found some visually impaired accessible voting systems unacceptable. For example, Germany and France have attempted to integrate electronic voting machines into their electoral systems only to find that electronic machines were too expensive, sometimes inaccurate, and prone to tampering (Evans & Paul, 2004). Additionally, because the machines do not produce a paper trail, there have been voter trust issues (Evans & Paul, 2004). Moreover, even private, secure systems such as the telephonic system can be perceived as problematic by visually impaired voters because the system still does not allow them to vote in the same manner as sighted voters. This is a problem because, if visually impaired voters are unable to cast their ballot in a method similar to non-impaired voters, then they may feel like second class citizens (DAB, 2011).

Although there are many methods of voting that make private voting a reality for the visually impaired, Denmark has yet to implement one. The Danish Ministry of the Interior has stated that they are reluctant to look into any of these systems because they believe that there exists no accessible system that provides reliable election results and that will be accepted and trusted by the Danish voters (MISA, 2009).

Given that reliable and visually impaired accessible voting systems have been successfully implemented in other countries, it is necessary that such voting systems first be researched to determine how the challenges associated with each system were overcome and why each system may or may not be acceptable for use in Denmark. Additionally, it appears that no significant study on the possibility of implementing an accessible voting system in Denmark has actually been conducted. This seems to further support the necessity of a study examining different accessible voting systems and their likelihood of being successfully implemented in Denmark.

The primary focus of this project is to recommend a method of voting to the Danish Association of the Blind that allows the visually impaired to vote in private while still addressing the desires of the Danish government. We will do this through an extensive analysis on our stakeholders, such as the visually impaired and the Danish government, in order to determine what qualities they desire in a voting system. We will then present

our research of different voting schemes used throughout the world that allow the visually impaired to vote in private. By comparing the attributes of each voting system to the criteria set forth by our stakeholders, we will then critique each voting system. Finally, we will present the method of voting that we believe will be able to successfully implemented and allow the visually impaired to vote in private.

2 Background

In this section, we will start by presenting an overview of some of the political rights guaranteed to all individuals. Through two of the most well-known declarations on human rights, we will explain why it is necessary to protect the political rights of the visually impaired. We will then discuss the inadequacies of the current Danish election system regarding the visually impaired and their right to privacy while voting. Following the discussion on visually impaired voting in Denmark, we will describe the Danish electoral process as a whole in an attempt to explain why the system is the way it is. As there are many methods of voting around the world that allow the visually impaired to vote in private, we will briefly describe each voting system as a basis for a more detailed analysis in the Results section of this report. Finally, as it is necessary that we know who has a vested interest in our project, we will introduce the organizations and groups of people that we have deemed as important stakeholders in our project.

2.1 Political Rights

As this project is focused on the political rights of the visually impaired, it is necessary that we look at legislation that guarantees the visually impaired these rights. Though there are numerous international declarations and treaties detailing what liberties must be protected, we will only look at two of these in detail. The first is the Universal Declaration of Human Rights, commonly referred to as the UDHR. The UDHR outlines the basic human rights that are to be enjoyed by all individuals. The second document, the Convention on Rights of Persons with Disabilities (CRPD), is a more recent one. The CRPD states that the rights detailed in the UDHR must also be afforded to those with disabilities. In some instances, especially when discussing the political rights of the disabled, the CRPD is more specific than the UDHR, explaining how the rights are to be guaranteed. As both of these documents are of global significance, we will provide a detailed analysis into why they are important to our project.

2.1.1 Universal Declaration of Human Rights

Drafted by the United Nations in 1948, the Universal Declaration of Human Rights (UDHR) defines the basic “human rights and fundamental freedoms” that need to be protected by

members of the United Nations. Though it is a non-binding document, the UDHR has since become the most prominent document detailing the rights of the individual. Indeed, the UDHR has been used as the basis for many legally binding treaties and declarations, such as the International Covenant on Civil and Political Rights (ICCPR).

While the UDHR does not explicitly prescribe nor define democracy, the indication that members of the UN must accept democratic ideals is clearly present in Article 21. Article 21 of the UDHR details the basic political rights that must be recognized in order to maintain a legitimate government, stating that:

1. *Everyone has the right to take part in the government of his country, directly or through freely chosen representatives*
2. *Everyone has the right of equal access to public service in his country.*
3. *The will of the people shall be the basis of the authority of government; this will shall be expressed in periodic and genuine elections which shall be by universal and equal suffrage and shall be held by secret vote or by equivalent free voting procedures.*

Though it is split into three sections, there are two main ideas present in Article 21. The first is the right to participation, stating that everyone can participate in the political affairs of their government, either by voting for someone to represent them, or by directly participating as a representative. The second is the right to voter privacy during such elections. In the following sections, we will discuss the importance of both of these rights to ensuring the legitimacy of a democratic state.

Right to Participate

The right to partake in the political affairs of one's own country is one of the central principles of democracy. The right to participation embodies the idea that everyone is able to play a part in the decision making of one's government and that no citizen should be excluded from making their voice heard. It is meant to ensure that each citizen's views are fairly represented, and that everyone is able to be a member of the body politic.

While this involvement generally comes in the form of voting for representatives or referenda in state elections, this is not the only way one is able to influence the political activities

of their country. Indeed, Article 21(1) states that everyone should not only be able to vote for representatives, but may become a representative themselves. This means that anyone is able to appear on the ballot and be elected to public office.

The ability to run for public office is essential to the legitimacy of a government (House, 2011). By only allowing certain candidates or parties to run in an election, a government can control the outcome of an election by predetermining every candidate on the ballot. This type of electoral rigging can often be seen in countries where dictators “validate” the legitimacy of their power through “democratic” elections where they are the only candidate to appear on the ballot. The Soviet Union commonly employed this tactic in their elections by preselecting the candidates to appear on the ballot such that only members of the Communist party could be voted for. It comes as no surprise then, that when nearly 100% of the votes cast were for the Communist Party, the Soviet Union often triumphed this outcome as evidence that its citizens were content with their government.

Article 21(1) and (2) are meant to safeguard against elections like those in the Soviet Union. Indeed, they were written to ensure that elections would be conducted in a free and fair manner by guaranteeing that any candidate may appear on the ballot. The right to participate in an election, either through voting or by being represented on the ballot, is integral to the democratic tradition. Without it, governments are free to abuse their power to manipulate the results of an election.

Right to a Secret Ballot

The ability to participate in an election means little, however, if voters are still intimidated or otherwise forced into voting for a particular candidate or party. In order to prevent voter intimidation from occurring, Article 21(3) of the UDHR makes it clear that the legitimacy of a government shall be determined by the people through free and fair elections. In particular, Article 21(3) states that these elections “shall be held by secret vote or by equivalent free voting procedures.” Through Article 21(3), the United Nations clearly presents voter privacy as an essential political right.

While the concept of voting privacy has existed since Ancient Greece, legally mandated secret ballots are a much more recent phenomenon (Saalfeld, 1995). The first standardized secret ballot, or so called Australian ballot, was first implemented in Australia during the mid-1850’s. Since then, the secret ballot has spread throughout the world and is considered,

along with the right to participate in elections, an “indisputable legal principle” in modern democratic states (Buchstein, 2010). The presence of a secret ballot has undoubtedly become a fundamental measurement in the freedom and fairness of governments throughout the world (Dahl, 1998).

Without a secret ballot, voters are open to intimidation from outside forces. Such is the case in many autocratic countries where voter privacy is not respected, where voters fear repercussions for voting against the party in power. For instance, in Syria, where the right to a secret ballot is not respected, it is common for those who vote against the ruling party in election to be imprisoned (George, 2003). A similar situation occurred in the 2010 Burmese election, where voters were coerced into voting for the military junta to stay in power under threat of land confiscation (Davies, 2010). And while voting by secret ballot in was an option in East Germany from 1949-1989, it was not mandated by law. This led to the secret ballot becoming little more than a political gimmick, as voters were often intimidated into making their vote public (Buchstein, 2010). Faced with the threat of persecution, many dissenting voters often voted for the least dangerous choice, even though it may have been unfavorable to them. Indeed, the presence of a secret ballot as an option is not enough; secret ballots must be mandated in order to help ensure that elections are being conducted fairly.

Requiring that all ballots be secret is not only done to protect the voter. If one has the ability to prove how they voted, they are then able to sell their vote in exchange for personal gain. As economist and Nobel Laureate Thomas Schelling stated, “The mandatory secret ballot is a scheme to deny the voter any means of proving which way he voted. Being stripped of his power to prove how he voted, he is stripped of his power to be intimidated (Schelling, 1981).” While voters are free and able to make their vote known to as many people as they wish, the voters have no method of verifying their claim, and thus possibly compromising the fairness of an election (Buchstein, 2010).

Indeed, a mandatory secret ballot is often used one the standards by which international institutions evaluate the legitimacy of elections (House, 2011). The global recognition of a voter’s right to privacy is evidenced by the numerous declarations and legal documents put forth by the international community. Article 21(3) of the UDHR is supported by Article 25 of the International Covenant on Civil and Political Rights stating that votes “shall be held by secret ballot” in order to guarantee “the free expression of the will of the electors.” Within Europe, the Copenhagen Document, among other things, that it is the duty of the

government to “ensure that votes are cast by secret ballot.” The European Commission summarized the sentiment of all these acts in their Compendium of International Standards stating that, “The element of a secret vote is quite clear the voter should cast his vote in secret. Nobody else should be able to see how the voter votes (European Commission, 2009)” Clearly, the international community views the right to a secret ballot as a basic human right central to democratic institutions.

2.1.2 UN Convention on Rights of Persons with Disabilities

Supporting the belief that basic rights must be protected for all persons, many members of the United Nations, including Denmark, signed the United Nations Convention on the Rights of Persons with Disabilities (CRPD). Ratified in May of 2008, the CRPD states that all human rights are to be guaranteed to all individuals, regardless of their disability. The CRPD reiterates many of the rights mentioned in the UDHR, stating that provisions must be made to ensure that such rights can be enjoyed by those with any kind of disability, including visual impairment.

Indeed, the Article 29 of the CRPD echoes many of the political rights mentioned in Article 21 of the UDHR. Article 29 of the CRPD discusses the rights of disabled people to participate in political and public life, stating that, “States Parties shall guarantee to persons with disabilities political rights and the opportunity to enjoy them on an equal basis with others” Article 29(a) in particular, outlines what each signatory must do in order to protect the political rights of disabled individuals, and has been quoted in its entirety below:

Ensure that persons with disabilities can effectively and fully participate in political and public life on an equal basis with others, directly or through freely chosen representatives, including the right and opportunity for persons with disabilities to vote and be elected, inter alia, by:

- 1. Ensuring that voting procedures, facilities and materials are appropriate, accessible and easy to understand and use;*
- 2. Protecting the right of persons with disabilities to vote by secret ballot in elections and public referendums without intimidation, and to stand for elections, to effectively hold office and perform all public functions at all levels*

of government, facilitating the use of assistive and new technologies where appropriate;

- 3. Guaranteeing the free expression of the will of persons with disabilities as electors and to this end, where necessary, at their request, allowing assistance in voting by a person of their own choice;*

Both the right to participate in the political affairs, as well as the right to a secret ballot, are explicitly mentioned in Article 29(a). Furthermore, it states that actions must be taken to ensure that all parts of the voting process, including the procedure and the materials used, are accessible to persons with disabilities. Article 29 notes that new technologies may be required to allow disabled voters to cast their vote in private, however, and that it is the responsibility of the government to provide the disabled voters with such technologies. While this does not mean that a government must overhaul its entire electoral process, the government must provide disabled voters with a method of voting that allows them to vote in private.

Article 29 goes on to state that, if the disabled voter wishes, they may be assisted by a third party. It is important to note, however, that Article 29 makes it clear that this third party is to be selected by the voter themselves. This implies that nobody but the voter, not even the government, can decide who is to assist the voter in filling out their ballot. This stipulation is important, because it guarantees that untrusted individuals or strangers to the voter are not influencing their vote. Without the requirement that they choose who is to assist them, a disabled voter, may not place their trust in the electoral process.

2.2 Visually Impaired Voting in Denmark

From the multiple declarations and conventions discussed in the previous section, it is clear that voter privacy is of the utmost importance, even for the disabled. However, visually impaired voters in Denmark are currently unable to vote by a secret ballot in governmental elections. The only method of voting currently used in Denmark is the paper ballot. In order to fill out and cast their vote under the current system, a visually impaired voter in Denmark requires the assistance of a third party. This system of voting inherently violates the blind voter's right to privacy. Below, we will describe the numerous challenges that a Danish visually impaired voter must face when voting with the current voting process.

Furthermore, we will discuss how the current voting process for visually impaired voters came about, and what its implications are with regards to voter privacy.

2.2.1 The Danish Ballot

The Danish ballot, an example of which is shown in Figure 1, is a traditional paper ballot that has remained relatively unchanged for over 100 years. In order to vote, the voter simply

Sønderjyllands Amts
3. opstillingskreds

Folketingsvalget 2001

Sæt x til højre for en listebetegnelse (et partinavn)
eller et kandidatnavn.
Sæt kun ét kryds på stemmesedlen.

A. Socialdemokratiet

Frode Sørensen
Inger Bierbaum
Dorte Dinesen
P. Qvist Jørgensen
Eva Roth
Lise von Seelen
Søren Ebbesen Skov

B. Det Radikale Venstre

Nicolas Lund-Larsen
Per Kleis Bønnelycke
Bente Dahl
Inger Harms
Bjarke Larsen
Henrik Larsen

C. Det Konservative Folkeparti

Kaj Ikast
Martin Andresen
Bent P. Have
Jens M. Henriksen
Bente Lassen
Lars Munk
Klaus Rehkopff

D. Centrum-Demokraterne


Henning Nielsen
Henning Borchert-Jørgensen
Helmuth Carstens
Flemming Hübschmann
Holger Madsen
Peter Berthel Nissen
Kai Paulsen

F. Socialistisk Folkeparti

Bjarne Eliassen
Bent Iversen
Jesper Petersen
Kirstine Rask Lauridsen
Jørn Ulrik Larsen
Jørgen Jørgensen
Mathias Gotthardsen

O. Dansk Folkeparti

Søren Krarup
Kell Kristiansen



O. Dansk Folkeparti

Søren Krarup
Kell Kristiansen
Jørn Larsen
Jytte Lauridsen
Theis Mathiasen
Niels Oluf Michaelsen Petersen
Lars Rydhard

Q. Kristeligt Folkeparti

Michael Lund Markussen
Vibeke Christensen
Bjarke Friis
Knud Erik Hansen
Henning Holm

V. Venstre, Danmarks Liberale Parti

Bjørn Scherbarth
Sven Buhrkall
Peter Christensen
Allan Emiliussen
Gunnar Hattesen
Helga Moos
Hans Chr. Schmidt

Z. Fremskridtspartiet

Ole Jensen
Heine Andresen
Henning Brandt
Carl Hahn
Margit Petersen
Preben Ravn
Jens Willatzen

Ø. Enhedslisten - De Rød-Grønne

Baltser Andersen
Svend Brandt
Signe Færch
Jette Hedegaard
Egon Laugesen
Niels-Erik Aaes




Figure 1: Sample Danish Ballot (Trinity College Dublin)

places an “X” next to the candidate or party of their choice. While this may seem like a straightforward and trivial task for sighted voters, this system has several aspects that can make voting on Election Day a tedious task.

First, ballot is only available in printed paper form. While a partially sighted voter may be able to use a magnifying glass to read the ballot, it is nearly impossible for a blind voter to vote without the assistance of another individual. This lack of an accessible ballot or technologies to assist the voter results in the voter’s right to privacy being compromised, as a third party is able to see who the blind voter votes for.

Second, the Danish ballot can be rather long. Instead of having a single nominee represent each political party, there can be numerous candidates running under a single party. Furthermore, Denmark’s body politic is composed of multiple political parties. As voters have the option of voting for either a person or a ballot will often consist of approximately 70 different possible choices (Gallagher, 2009). This length and complexity makes it difficult for visually impaired Danes to browse through the ballot and make a selection without having to constantly ask for their aide to re-read the names, which can lead to confusion and frustration. Furthermore, the complexity of the ballots makes some assistive technologies, such as printing the ballot in Braille, unfeasible, as the resulting ballot would be exceedingly long.

2.2.2 A Lack of Privacy

The Parliamentary Election Act of Denmark stipulates how elections are to be conducted in Denmark. The original Elections Act, passed in 1987, included voting procedures for those citizens who were unable to vote without the assistance of a third party due to a disability, including visual impairment. This act stated that, in the case of such a disability, two election officials would assist the voter when marking and casting their ballot (MISA, 2009). The Election Act did, offer provisions for visually impaired voters, stating that they could select a trusted friend, family member, or significant other to enter the polling booth with them rather than the two election officials. Although the requirement that someone assist the blind voter in casting their ballot violates the voter’s right to privacy, many visually impaired voters were content with this requirement. Indeed, while being able to vote privately and independently would be more ideal, many blind voters felt that the ability to choose who was to assist them in voting provided an adequate amount of privacy within the constraints

of the Danish voting system.

In 2009, the Danish Parliament passed a new Election Act that, among other changes, redefined the process by which voting was to be carried out for disabled persons (MISA, 2009). The 2009 Election Act no longer makes any distinction between visually impaired and other disabled voters. Subsequently, visually impaired voters must now comply with the requirement that election officials be present at the marking of the ballot. While a visually impaired voter is able to replace one of the election officials with a trusted individual of their choice, there will still be an election official watching them mark their ballot. Preliminary background research has not suggested any reason for this change in voting procedure other than that it places all disabled persons on an equal footing. While the concept of treating all disabled people as equals may seem just, this is not the case when doing so limits the rights of one of the involved parties.

Indeed, the requirement that two strangers be told who the voter is selecting has caused many visually impaired voters, as well as the Danish Association of the Blind, to feel that their right to voter privacy is being infringed upon (Heilbrunn, 2011). This argument is validated by the fact that the requirement that a visually impaired voter must tell their vote to an untrusted stranger is in direct violation of the UDHR and CRPD.

Other than being required to tell their vote to two government officials, there have been many other complaints brought up against the current voting procedure. For example, some visually impaired voters have complained that forcing three people into the tiny voting booth creates an uncomfortable environment to vote in. Also, many visually impaired voters have expressed concerns over the lack of sound insulation in the voting booths. As the visually impaired voter is required to speak the answer to the two election officials, the vote can easily be overheard by someone outside the voting booth. Finally, the election officials at the polling station are often members of their local communities. Therefore, it is possible that the official assisting the visually impaired voter with their vote may know the voter. This could cause the voter to feel pressured to vote in one way or another.

2.3 The Danish Electoral System

In order to understand the roots of the problem of visually impaired voting in Denmark, it is necessary that the Danish electoral system be understood. Denmark is a constitutional monarchy that follows a parliamentary system of rule. As is common with many parlia-

mentary systems, there are a multiple major parties that appear on the Danish ballot each election. While having more parties to choose from does increase the likelihood that a voter will find a candidate or party that adequately represents the voter's views, it also result in a more complicated electoral system than simply determining which party has the most votes.

The Danish electoral system is notable for its high level of transparency throughout the electoral process. This transparency has led many Danish voters, as well as the government, to place a great deal of trust in the current electoral process. This socially ingrained trust has made it difficult to implement a newer, more visually impaired accessible system.

In this section, we provide a brief explanation of the Danish parliamentary system, including how each parliamentary seat is allocated to a particular party or candidate. We also present an overview of the electoral process in Denmark, from the point when the Prime Minister first calls for an election, to when the last vote is counted and the results are announced.

2.3.1 The Parliamentary System

Like many European nations, Denmark's political system is a parliamentary one, that is, the executive branch is chosen by a democratically elected legislative branch. An interesting aspect of the parliamentary system is that there are generally multiple political parties involved. Due to the larger number of political parties, it is rare that any one party will succeed in gaining a majority of the votes. It is therefore necessary that parties with similar values form coalitions in order to form a government. Furthermore, a party only needs to receive 2% of the nationwide vote to be guaranteed representation in parliament. This allows a larger number of small parties to be represented than one would see in a two-party system, such as in the United States.

Denmark's parliament, known as the Folketing, is made up of 179 ministers, 175 of which come directly from Denmark, with the other 4 split between Greenland and the Faroe Islands. The 175 Danish seats available to parliament are allocated through a two-tiered system based upon the election results in Denmark's electoral districts. These districts are composed of three electoral provinces that are further divided into a total of ten multimember constituencies.

The ministers are elected to parliament in order to represent the views of these constituencies, similar to how congressmen are elected in the United States to serve the needs

of their voting districts. Thus, the people appearing on the ballot vary from constituency to constituency. This helps to ensure that each region of Denmark is being accurately and proportionally represented in parliament.

Of the 175 seats, 135 are “constituency seats” divided among the ten constituencies, while the remaining 40 are “compensatory seats” allocated by the overall voting totals. Specifically, the 135 “constituency seats” are apportioned according to the d’Hondt formula. An example of how this process works can be seen in Table 1. In the simplified example in Table 1, let us assume that there are eight seats available to the constituency and four parties to choose from. The number of votes each party received can be seen in the “Votes Received” column. According to the d’Hondt formula, these total vote numbers are then divided by 2, 3, 4, etc. and placed in their respective party’s rows below each divisor. Seats are then distributed according to the highest eight values among the resulting quotients. In the case of Table 1, the highest eight numbers are boldfaced for clarity. This means that Party A would receive three constituency seats, Parties B and C would each receive two seats, and Party D would be left with the remaining seat.

Table 1: Sample Distribution of Seats Through d’Hondt Formula

Parties:	Votes Received	Divisors			Seats Obtained
		2	3	4	
Party A	120000	60000	40000	30000	3
Party B	90000	45000	30000	22500	2
Party C	100000	50000	33333	25000	2
Party D	60000	30000	20000	12500	1

Once the constituency seats are decided, the “compensatory seats” are then allocated in order to ensure proportional representation of the parties. A sample calculation of this allocation can be seen in Table 2, taken from the Danish Ministry of the Interior. In this example, the overall number for each party is divided by the total nationwide number of votes. This number is then multiplied by 175 in order to determine how the 175 (third column) seats would be allocated according to a proportional distribution. The total number of constituency seats awarded to each party is then subtracted from this number to generate

Table 2: Allocation of Compensatory Seats to Eligible Parties (MISA)

Party	Nationwide Votes	Allocation of seats, per nationwide vote	Constituency seats awarded	Difference = compensatory seats
Total	3428858	$175.000 = 175$	135	40
Social Democratic Party	881037	$44.966 = 45$	41	4
Social Liberal Party	177161	$9.042 = 9$	3	6
Conservative Party	359904	$18.343 = 18$	11	7
Socialist People's Party	450975	$23.017 = 23$	19	4
Danish People's Party	479532	$24.474 = 25$	20	5
Liberals	908472	$46.366 = 46$	40	6
New Alliance	97295	$4.966 = 5$	0	5
Unity List	74982	$3.827 = 4$	1	3

the number of compensatory seats to be awarded (fifth column).

2.3.2 The Electoral Process

The Danish electoral process begins when the prime minister dissolves parliament and calls for an election, an action that must occur within four years following the previous election. After the election is called for, an election date will be set and preparations will begin (Folketing, 2011). When it comes to the actual polling, the responsibility of carrying out the voting rests primarily with municipalities.

The municipalities are responsible for setting up polling booths and providing voters with necessary voting materials, such as pencils and ballots. Municipalities are also responsible for ensuring that polling stations are staffed with well-prepared election officials. These election officials are tasked with ensuring that the election is carried out fairly and efficiently, as well as assisting those voters with any questions or challenges they have while voting.

Upon arriving at a polling station a voter will verify their identity, either through the

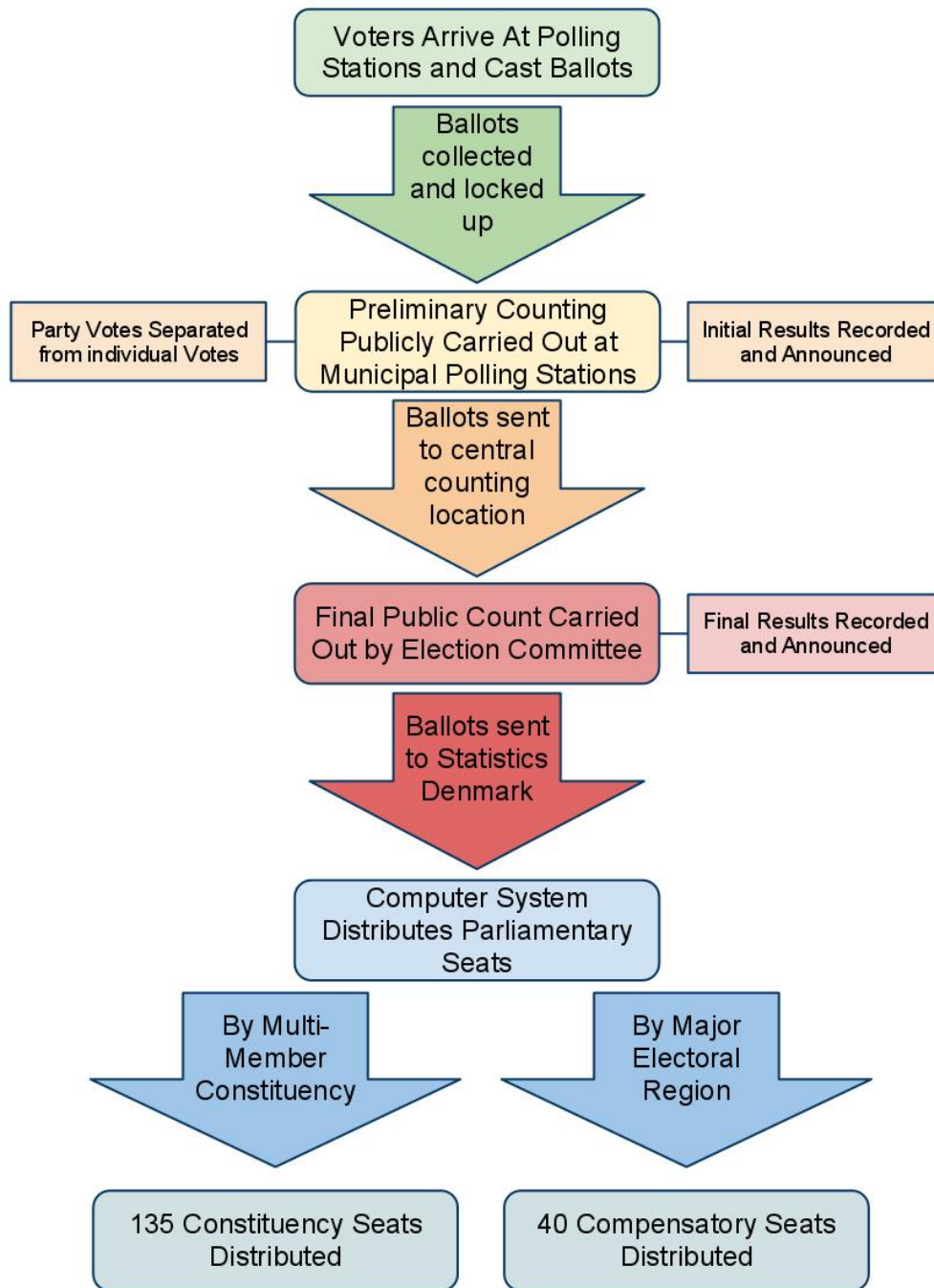


Figure 2: Flowchart of Danish Electoral Process

presentation of a poll card, or by giving the election official their name, address, and date of birth so that it may be checked against public records. Once the voter's identity is confirmed, they receive a ballot for the election. The voter takes the ballot to a voting booth, shuts the curtains, and fills out their vote in private. Once they have finished filling out their ballot, the voter exits the booth and places their ballot into a sealed ballot box, and then exits the

polling station (Gallagher, 2009).

Denmark has a very in-depth system for counting votes cast during elections, the process of which is outlined in Figure 2. The preliminary counting process occurs as soon as the polls close. This preliminary count entails election officials counting the total number of votes each party received, regardless of whether or not it was a party vote or a preferential vote for a candidate within a party.

Once the preliminary count is complete and the initial results are announced, the ballots are locked up and sent to the “district municipality” in charge of the polling station. It is in these district municipalities that the final and official counts of the votes are conducted. The district election committee publicly counts each vote in order to ensure the transparency of the election. First, the election committee counts each vote in the same manner as was done in the preliminary count where only the total number of votes for the party is being found. Once the votes for each party are counted, the election committee then separates the party votes from the preferential votes and recounts them, in order to determine how many votes each candidate received.

After the counting is finished, the results are recorded and sent to both the Ministry of the Interior a Copenhagen-based governmental organization known as Statistics Denmark. Statistics Denmark is responsible for creating and recording statistics regarding Danish society, including demographics and election results. It is at Statistics Denmark that the seats are allocated to each party and their respective candidates according to the method discussed in Section 2.3.2. If the results are not contested, a digital record of the election is created, and the original ballots are destroyed. Following the destruction of the ballots, the election process is complete.

2.4 Methods of Voting

Due to the transparency throughout the Danish electoral process, voters and government officials are reluctant to move towards different methods of voting (Evans & Paul, 2004). There are, however, many different voting systems used throughout the world that allow the visually impaired to vote in private that may be suitable for use in Denmark. Paper ballots are among the most common form of voting worldwide, and can easily be modified to be more accessible to the visually impaired. Mechanical systems are another common voting scheme that may offer increased privacy to the visually impaired. Electronic voting machines

are widely used in around the world as a blind-accessible alternative to traditional voting methods, such as paper ballots. Finally, there are various forms of remote voting that allow a visually impaired voter to cast their ballot from the privacy of their own home. While we will examine these voting methods in detail the Results section of this report. However, below, we provide a brief description of each voting system.

2.4.1 Paper Ballots

Paper ballots are among the oldest and simplest methods of voting. The most popular paper ballot system in use throughout the world is the Australian Ballot, involving an official, government distributed ballot that has a list of the candidates or parties involved in the election. The voter need only mark the ballot with a pen or pencil, and place the ballot in a secure box for future tabulation by election officials.

Braille Ballots

Braille ballots are a modification of paper voting systems that are accessible to the visually impaired. In some cases, the modification is achieved by printing a braille version of the normal paper ballot. However, a more common modification is to create a braille “template” that can be placed over a standard ballot. This template has holes in it corresponding to the locations where the voter is to mark the ballot. The voter lines up the template with the ballot by using position markers on both the ballot and the template, and is able to read the vote.

2.4.2 Mechanical Systems

Although mechanical voting systems are widely regarded as an antiquated method of voting, they are still in use in many areas of the world. A mechanical voting system consists of a console displaying many levers, a mechanism by which the votes may be tallied, and a private booth so that the voter may cast their vote in private. In order to use this system, a voter must enter the booth and turn the levers that correspond with their vote and then pull a master lever to cast it. The votes are then tallied by a built-in mechanical counting mechanism.

2.4.3 Electronic Systems

While mechanical voting systems have seen a sharp decline in usage in recent years, electronic voting machines have experienced significant growth (USFEC, 2000). Electronic voting machines have become especially prominent throughout the United States, with nearly 32.6% of American voters using an electronic voting machine in 2008 (Moran, 2008). This represents an increase of more than 400% over the data from 14 years ago (USFEC, 2000). Furthermore, electronic voting machines are widely considered to be highly accessible to the visually impaired. With the passage of the Help America Vote Act, many districts within the United States have adopted electronic voting machines in order to meet the requirement that each voting precinct have at least one handicap accessible voting machine available. Of the many different brands of electronic voting machines, there are two distinct types, Direct Recording Electronic (DRE), and ballot marking systems.

Direct Recording Electronic Systems

DRE systems are the most common type of electronic voting system available. The voter operates the machine by navigating the ballot through a computer screen, often with touch screen capabilities. For the visually impaired, DRE systems will often include a hardware keypad to navigate the ballot and an audio system that reads the ballot through a headset. The important feature of DRE machines is that the entire process is digital, there is no paper ballot involved. Votes are stored directly onto a hard drive or other storage medium and electronically counted following the conclusion of Election Day. Thus, DREs allow election results to be calculated with speed and accuracy far superior to any previous method of counting.

Ballot Markers

Ballot markers are almost identical to DRE systems in terms of operation and accessibility features. The main difference is only apparent when the voter actually casts their ballot. The main difference is only apparent when the voter actually casts their ballot. Instead of storing the vote electronically, ballot marking systems produce a completed paper ballot. In some cases the system prints out a completed ballot after the vote has been cast. Alternatively the voter could place an uncompleted ballot into the ballot marker device and select his or her vote, at which point a mechanism within the ballot marker will place a mark in the desired

field. The main benefit of ballot marking systems is that they offer the usability of a DRE system, while still producing an auditable paper trail in case a recount must be conducted.

2.4.4 Remote Voting

Remote voting is the process of voting or casting one's ballot from a location other than the polling station. There are numerous methods of remote voting, the most common being a postal ballot. Telephonic voting has also been used in recent years to allow the visually impaired to vote in private. Finally, with recent advances in technology, some countries have found it more feasible to use the internet as an online polling station.

Postal Voting

The oldest and most common method of remote voting comes in the form of mail-in ballots (Karp & Banducci, 2000). If a person so chooses, they may receive a ballot through the mail that they can then fill out in their own home. While postal ballots were traditionally used only for those who had a legitimate reason for not being present at the voting booth, postal ballots have since been made available to the general populace ((Qvortrup, 2005). Proponents of mail-in voting state that postal voting is able to increase voter turnout while significantly reducing costs. Implementing a postal ballot for the visually impaired, however, would still require that an individual, likely a trusted friend or family member, be present to assist the blind voter in completing the ballot.

Telephone Voting

Voting via telephone is a relatively new method of voting being implemented in some countries to help improve voter privacy for the visually impaired. There are multiple methods by which a visually impaired voter may vote by telephone, each of which will be presented and critiqued in detail in the Results section of this report. While telephone based voting involves telling one's vote to an election official, steps are taken to ensure that the identity of the voter is unknown to the election official recording the votes. It is interesting to note that a telephone based system would, in effect, be identical to the current method of voting for visually impaired, wherein they tell their vote to one or more election officials. The critical difference would be that the voter's identity would remain anonymous.

Internet Voting

Internet voting is one of the most recent developments in the field of voting technologies and is not yet widely used throughout the world. A typical Internet voting system consists of a personal computer, some type of identification key, and the software and hardware required to securely and accurately record the votes. In order to cast a ballot the voter must log onto a voting website using their identification key and complete an online ballot. After the ballot is submitted a system of computers securely decrypts and tallies the votes.

2.5 Stakeholders

In order to truly analyze any of the voting systems discussed above, it is imperative that all of the parties involved in the issue are identified and evaluated. These parties, also known as stakeholders, have a vested interest in the outcome of our project. We must therefore tailor our project to suit their needs and desires. The sponsoring party and a key stakeholder of this project is the Danish Association of the Blind, a non-profit organization dedicated to improving the quality of life for the visually impaired in Denmark. Visually impaired voters are another group of stakeholders, for the obvious reason that the focus of this project is to provide them with a means of accessible voting. Along with the visually impaired voters, we must also take into account the desires of non-visually impaired voters. Because sighted voters make up nearly all of the population, no voting system can be implemented without their support. As it is the duty of the Danish government to oversee how elections are conducted, they must consider any voting system we recommend to be acceptable if it is to be implemented in Denmark. A brief description of each stakeholder can be found below, while a more detailed analysis can be found in the Results section of this report.

The Danish Association of the Blind

Comprising of approximately 11000 members, the Danish Association of the Blind (DAB) is the leading proponent for the rights of the visually impaired in Denmark (DAB, 2011), and the sponsor behind this project. The primary concern of the Danish Association of the Blind is improving the quality of life of visually impaired persons in Denmark. Some of the key objectives of the organization are the creation of a fully accessible community, the support of the visually impaired in living productive healthy lives, and the integration of the

visually impaired into all facets of society. The Danish Association of the Blind holds stake in this project because installing a system of voting that is accessible for the visually impaired would satisfy all their objectives by providing the visually impaired with Independence and privacy.

Visually Impaired Voters

Visually impaired persons (those with less than 33% normal vision) make up an estimated 1% (50,000 people) of the overall Danish population (Heilbrunn, 2011). According to John Heilbrunn, Vice President of the Danish Association of the Blind, the visually impaired are unhappy with the current system of voting in Denmark. As explained earlier in this report, the issue of visually impaired voter privacy has not been viewed as a severe problem until recently, when Denmark enacted new laws that require voting officials to enter voting booths with visually impaired voters in order to aid them in casting their votes (MISA, 2009). This project is very important for the visually impaired because, if successful, it could play a role in providing them with a means of accessible voting.

Non-blind Danish Voters

While the visually impaired are a key stakeholder, it is important to note that they make up less than 1% of the entire voting population. The other 99% of voters are sighted voters, most of whom feel very comfortable using the current voting system. Therefore, in order for a new system of voting to be accepted by the unimpaired voters of Denmark, it must gain their trust by meeting high standards. An estimated 85% of eligible population of Denmark will turnout for any given parliamentary election (IIDEA, 2001). Thus, Danish voters are very serious about their electoral system and it is very important that they feel comfortable when using the system and feel confident that their votes are correctly recorded. Any voting system that cannot win over the sighted voter population is doomed to fail. Non-blind Danish voters want to see a fair system of voting made available to all, but not at the cost of jeopardizing the security of the electoral system.

The Danish Government

The government's primary concern when it comes to voting is to ensure that the electoral process is carried out in a manner that is seen as legitimate and fair by all parties involved,

including an assurance that the process of voting follows a non-biased, private, and secure system that is capable of providing trusted results. As noted by the Ministry of the Interior, the government has been very hesitant to employ any modern voting technologies due to common stigmas and a general mistrust in electronic voting systems ((MISA, 2009). Additionally, the government has mandated that an election official be present in the voting booth when a visually impaired person wishes to vote. The Danish government is a stakeholder in this project because the recommended voting system could allow them to provide an accessible system of voting to a neglected minority, and still be able to provide a secure system of voting for the entire population.

2.6 Voting in Organizations

Although elections by secret ballot are on occasion necessary, they are not as common in organizations and corporations. One can, however, envision situations in which a member's vote must be private. For example, when electing a new President or corporate CEO, private elections are almost always a necessity. Such elections are problematic when visually impaired members of the organization participate in voting if proper measures are not taken to ensure they can vote in private.

Fortunately, there are multiple voting systems that allow the visually impaired to privately vote in an organizational or corporate setting. For simple yes-no votes, marking or leaving blank an index card to vote is a trivial task for both sighted and visually impaired voters. For more complicated elections, a special booklet, known as a braille book, is used. Finally, for elections when there are many voters present, electronic devices known as audience responses systems can make the process of voting simple, straightforward, and accessible for everyone involved. We will discuss these methods of voting in greater detail in the Results and Analysis section of this report, and explain when it is appropriate to use each voting system in our Recommendations section.

2.7 Summary of Background Research

In summation, the issues that this project seeks to rectify were made apparent by a recent act of the Danish parliament, which mandates that visually impaired voters can only cast their vote by telling an election official their vote. This act denies the visually impaired their

right to a secret ballot and violates several human rights resolutions made by the European and international communities. However, visually impaired voting in Denmark has never been totally private because a visually impaired voter cannot fill out the paper ballot that has been used as Denmark's sole form of voting since it became a democracy. Fortunately, there have been alternative voting systems developed over the years that have allowed the visually impaired voters in other countries to vote independently. In order for one of these systems of voting to be implemented it must measure up to the standards of its stakeholders: the Danish Association of the Blind, visually impaired voters, sighted voters, and the Danish government.

3 Methodology

The purpose of this project was to recommend to the Danish Association of the Blind a method of voting that allows visually impaired persons in Denmark to vote in state and organizational elections with the same privacy afforded to all citizens. For state elections, we also were seeking to recommend a course of action for the Danish Association of the Blind to follow to help implement the recommended voting system throughout Denmark. Finally, to help improve the privacy of visually impaired voters within Danish organizations and corporations, we developed a list of best practices for conducting visually impaired accessible elections.

As can be seen in Figure 3, there were three main phases in this project. The first phase involved preliminary analysis regarding visually impaired voting. Much of this re-

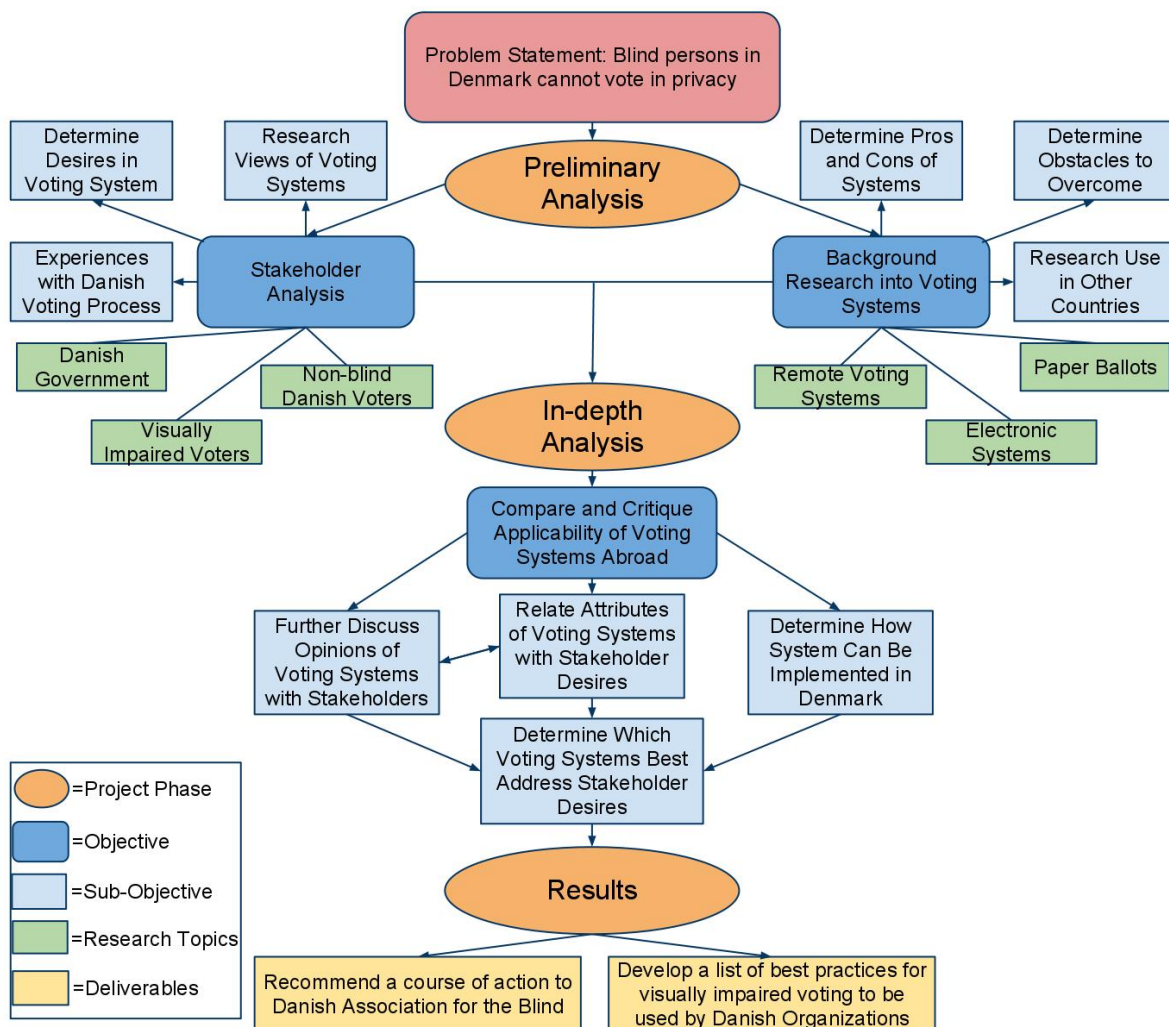


Figure 3: Methodology Flowchart

search and analysis was conducted during the preparation for the project, and can be seen in the “Stakeholders” and “Comparisons between Voting Systems” sections of our report. The second phase of work consisted of a more detailed analysis of the information we had acquired. The second phase was conducted once we arrived in Denmark and were able to hold discussions with our stakeholders. In the final phase of the project, we compiled and presented our findings to the Danish Association of the Blind in the form of this report.

In order to assist us in completing the project, we created the chart seen in Figure 3, detailing our approach to solving the problem presented by the Danish Association of the Blind.

Furthermore, we created a series of project objectives that helped us to accomplish our stated project goal. These objectives, which can also be seen in their respective phases in Figure 3, are as follows:

- Research existing voting systems used by other countries to help visually impaired voters vote in private.
- Conduct a stakeholder analysis.
- Compare and critique the existing voting systems with respect to the desires of our stakeholders.

As we only had a limited amount of time to complete the project, we created a timeline to assist us in time management, seen in Figure 4.

Objectives	Methods	Week							
		Prep	1	2	3	4	5	6	7
Conduct Stakeholder Analysis	Research interests of stakeholders	■	■	■					
	Conduct interviews with stakeholders		■	■	■				
Research Existing Voting Systems	Conduct thorough background research on voting systems in other countries	■	■						
Compare and Critique Existing Voting Systems	Discuss opinions of voting systems with stakeholders				■	■	■		
	Assess which system best addresses stakeholder desires				■	■	■	■	
	Determine how voting system could be implemented in Denmark	■				■	■	■	■
Results	Recommend a course of action to the Danish Association of the Blind							■	■
	Develop a list of best practices for visually impaired voting							■	■

Figure 4: Timeline of Expected Completion of Objectives

3.1 Research existing voting systems

The first goal of this project involved researching existing voting systems that allow the visually impaired to vote in private. Information on the visually impaired accessible voting systems was gathered through extensive background research. This background research served two main purposes.

First, the information provided us with a better understanding of how each system operates. In order to make an accurate assessment of the benefits and drawbacks to using each system, especially with regards to visually impaired voters, it was important that we learn how each voting system functions. We also investigated the merits of each voting system that make it an attractive method of voting in Denmark. Likewise, this research allowed us to recognize and understand the different qualities of each voting system that visually impaired voters or the Danish government may find unappealing. The background research on the qualities of the different voting systems proved to be vital when determining which system to recommend to the Danish Association of the Blind.

Second, a history of how each of the voting systems have been used in other countries, including their implementations, successes, and failures, was constructed to serve as a guideline for choosing a system to recommend, as well as suggesting an action plan for its implementation. We looked not only at the outcome of the utilization of each method of voting, but also at why that outcome occurred. We determined if there were any major issues associated with using each voting system and examined how these problems were addressed by other countries. By understanding if and why the different voting schemes did or did not work, we were able to properly compare the different methods of voting.

3.2 Conduct a stakeholder analysis

The second goal of this project was to determine what qualities our stakeholders wished to see in a voting system. In order to accomplish this goal we conducted a thorough stakeholder analysis in order to determine what qualities of voting systems were important to each stakeholder and to gather information about any experiences and opinions the stakeholder had regarding each voting system. In some cases, such as with the Danish Government, significant background research was able to show what properties of a voting system a given stakeholder was most interested in. Other stakeholders, such as visually impaired voters,

required more direct contact in the form of interviews. We will present the methods we used to gather information on each of our stakeholders in the following subsections.

3.2.1 Visually Impaired Danish Voters

As the primary stakeholders in this project are visually impaired voters in Denmark, it was necessary to analyze their opinions regarding voting prior to any significant analysis of voting systems. In particular, we covered three important topics that allowed us to identify which voting solution would best accommodate the desires of visually impaired voters. These topics were:

1. Satisfaction with the current and previous methods of voting in Denmark.
2. Opinions regarding alternative voting systems.
3. Voting and elections within organizations.

In order to cover these topics, we conducted a series of one-on-one interviews with visually impaired voters. Through the interviews, we were able to discuss the desires, experiences, and views that blind voters in Denmark have regarding voting. By interviewing each subject individually, rather than as a whole group or through a mass survey, we were able to better understand into any concerns or opinions that the subject had with the different voting methods or the Danish electoral process.

As the Danish Association of the Blind has a large membership composed of visually impaired individuals, we requested their assistance in finding subjects for the interviews. We created an interview request, seen in Appendix A, that was sent to all members of the Danish Association of the Blind. Although the initial response was lower than expected, a second series of emails prompted a much larger response rate. In total, we were able to conduct seven interviews with members of the Danish Association of the Blind. These subjects were selected to represent visually impaired voters of different ages, professions, and levels of visual impairment, in order to best represent the visually impaired community in Denmark. Of these interviews three were conducted in person, and four were conducted by phone.

In order to prepare for each interview, we created an interview plan that we used to guide us through the interview process. While a general interview plan for a visually impaired voter

can be seen in Appendix B, each plan was tailored to the individual we were interviewing. Furthermore, we conducted what background research we could on the subjects in order to make the interview specific to the subject being interviewed. This included information on the subject's relationship with the Danish Association of the Blind, their current profession, and level of visual impairment.

During each interview, one person was designated as the interviewer, and another as the note taker. The interviewer read the verbal consent form, seen in Appendix C, to each of the subjects before the interview began. While the note taker did write down the subjects responses to the questions asked, no interviews were ever recorded. Each interview lasted approximately 30-60 minutes. After each interview, summaries of the responses were compiled from the interview notes. Following the completion of the Phase 1 interviews, the general responses were summarized and analyzed. The resulting information gathered during these interviews was used in the creation of the Results and Analysis section of this report.

3.2.2 Non-blind Danish Voters

It is possible that the voting system that we recommend to the Danish Association of the Blind will be used by everyone, not only the visually impaired. Therefore, we had to determine which voting systems are acceptable to both visually impaired and sighted voters. In order to investigate what qualities a voting system would need in order to be accepted by non-blind Danish voters, we conducted significant research into the opinions of sighted Danish Voters through surveys.

We conducted a large survey of sighted voters on their opinion of electronic voting systems. We felt it important to exclusively discuss electronic voting systems in these surveys for two reasons. First, as these surveys were meant to take no longer than five minutes, we were limited in the number of questions that we could ask. Secondly, though electronic voting systems are among the most accessible in the world, there is a great deal of controversy surrounding their use. We conducted these surveys in order to better gauge the public's reaction towards a switch to an electronic voting system. We conducted these surveys by travelling to the center of Copenhagen and asking people on the street if they would like to participate in an anonymous survey. If they accepted, we then asked them two questions:

1. Would you trust an electronic system to be used in governmental elections? Why or why not?

2. Would you trust an electronic system to be used in governmental elections if it printed out a completed paper ballot, rather than storing the votes electronically? Why or why not?

Though the identities of the responders remained anonymous, we have compiled the demographics and results of the surveys, and placed them in the Analysis section of the report.

3.2.3 The Danish Government

If any method of voting is to be adopted in Denmark, it must first be approved by the Danish government. Therefore, it was important that we recommend to the Danish Association of the Blind a method of voting that not only provides the visually impaired with the ability to vote in private, but one that would also be deemed acceptable for use by the Danish government. We went about determining what criteria a voting system must fulfill to be approved by the Danish government through two methods.

First, we conducted significant background research into the views of the Danish government towards the different accessible voting systems used in foreign elections. A great deal of this background research originated from official statements released by the Ministry of the Interior and the Ministry of Social Affairs regarding the electoral process in Denmark. In these statements, both Ministries note their stances on the usage of certain voting schemes, such as electronic voting, and explain why they hold that stance. These statements were used as the basis for our stakeholder analysis, as they detail specifically what their issues are with such voting systems. By analyzing the concerns outlined in these statements, we were able determine how the different voting schemes needed to be modified if they were to be considered acceptable for use by the Danish government.

The second method we used to conduct a stakeholder analysis on the Danish government was through discussions with the members of the Danish government. While the official documents proved useful in our analysis, they left out many important options for accessible voting systems. Thus, we decided that by contacting members of the Danish government, we could better determine which voting systems could be implemented in Denmark. The members of the government that we contacted included the members of the Danish parliament, the Ministry of the Interior, and municipal elections boards. We hoped that we could present our findings thus far, and determine if any of the researched systems adequately met

the criteria put forth by the Danish government. If none of the systems were acceptable, we would be able to directly ask what would need to be done to make them acceptable, and use that feedback to better find or craft a voting scheme that would meet the desires of both the Danish government, and visually impaired voters.

Once the background research and interviews were completed the information that was gathered was used to compile an analysis of the opinions of the Danish Government in regards to accessible voting for the visually impaired. This analysis was then used to help us make our final recommendation. The analysis can be found in the Results and Analysis section of this report.

3.3 Compare and critique existing solutions with respect to the desires of our stakeholders

After background research and a preliminary stakeholder analysis had been conducted, we moved on to the second phase of our project involving a more in depth analysis of the different methods of voting. Because each voting system had at least some qualities that made it preferable to other methods of voting, we could not analyze each voting system in a vacuum. Therefore, the primary component of this in depth analysis was conducted by comparing and critiquing the attributes of the voting systems against each other. We assessed the different methods of voting in two main ways.

First, we qualitatively compared the attributes of each voting system with the desires of our stakeholders. For instance, though electronic systems are expensive, they do offer significant usability advantages when compared to other methods of voting. Therefore, we determined exactly what criteria we felt was most important, and from that, determined which methods of voting would appeal to the broadest number of stakeholders.

Second, just as important as knowing why a voting system worked, is understanding the political and social process that led to its adoption. We found that no system is perfect, and that all systems had hurdles that needed to be overcome before they were adopted. We determined how these challenges were met so we could propose not only a system, but also a method of implementation that fits Denmark's needs. Therefore, we had to know how other countries were able to overcome the challenges inherent to each system. We also researched the causes behind the implementation of accessible voting systems around the world. An understanding of the political climate of a country that adopted a voting system that is

usable by the visually impaired was necessary to understand why one system was adopted over another.

3.4 Summary of Methods

The goal of this project was to recommend to the Danish Association of the Blind a method of voting that would allow the visually impaired to privately vote in state and organizational elections. We accomplished this goal by setting forth three objectives. First, by conducting a thorough stakeholder analysis, we were able to determine what criteria a voting system must meet in order for it to be successfully implemented in Denmark. Second, we researched different methods of voting used around the world. Through this research, we were able to see the different benefits and challenges associated with each voting system. Finally, we compared and critiqued the different voting schemes with respect to the desires of our stakeholders. Through these three objectives, we were able to successfully determine which method of voting should be implemented in Denmark, as well as recommend a course of action for the Danish Association of the Blind to follow.

4 Results and Analysis

In this section, we discuss our results from addressing the three objectives of this project. As discussed in the Methodology section of this report, our objectives consisted of background research into existing voting systems, conducting an extensive stakeholder analysis, and, finally, comparing and critiquing the voting systems with respect to our stakeholders' desires.

4.1 Research of Existing Voting Systems

Through our research, we studied and analyzed the many different methods of voting used around the world, ranging from simple paper ballots to high-tech electronic machines. Though we found that some voting systems, such as mechanical ballots and traditional paper ballots, are completely inaccessible to the visually impaired, many of the voting systems researched have measures in place that allow blind voters to vote in private. In this section, we will discuss and analyze our findings on the different voting systems.

4.1.1 Paper Ballots

The most time tested and consistently utilized method of voting is the paper ballot. One of the main reasons that the paper ballot has been so successful is that people trust it more than any other method of voting (Randell, 2006). There are several reasons for this strong sense of trust in paper systems. One reason is the fact that the paper ballot has been around since the time of the Roman Empire and people have an instinctive trust in systems that have been in place for such a long time (Randell, 2006).

Another factor that contributes to paper ballot being the most trusted system is the fact that a paper ballot is a physical record of a vote that can be counted by hand. Therefore in order to cast a vote one must physically insert a ballot into a ballot box. These ballot boxes are very easy to keep watch over, which means election officials can prevent election fraud with relative ease. Also since the ballots are locked in the ballot box it is very easy to inspect and review the votes in case there have been any concerns about the legitimacy of the vote (Randell, 2006).

Yet another reason for the high levels of trust that voters have for the paper ballot system is the simplicity of the system. There are no moving parts and therefore there is no room for mechanical error, only human error, and people are more likely to trust a person than a

machine (Randell, 2006). In addition there seems to be very little instance of user related errors from any age group. These factors contribute to a very low overall error rate of just 1.5% (Byrne, 2007). This low error rate shows that paper ballots are a very reliable and trusted way of voting.

Although most people have no trouble when completing a simple paper ballot, there are many people with disabilities that make it impossible or very difficult to vote on a plain paper ballot. People who are visually impaired or even illiterate for that matter have no means by which to vote independently and secretly in an election that is solely paper based (Byrne, 2007). Therefore, in order to vote on paper ballots, a visually impaired voter must have another person fill out their vote for them.

Braille Ballots

The Braille ballot is currently a common alternative for making paper ballots accessible to the visually impaired. Braille ballots are a very easily implementable method of accessible voting because they simply modify a system already in place. But, while it may seem like an obvious solution to the challenge of allowing the visually impaired to vote in private, there are many problems associated with Braille ballots.

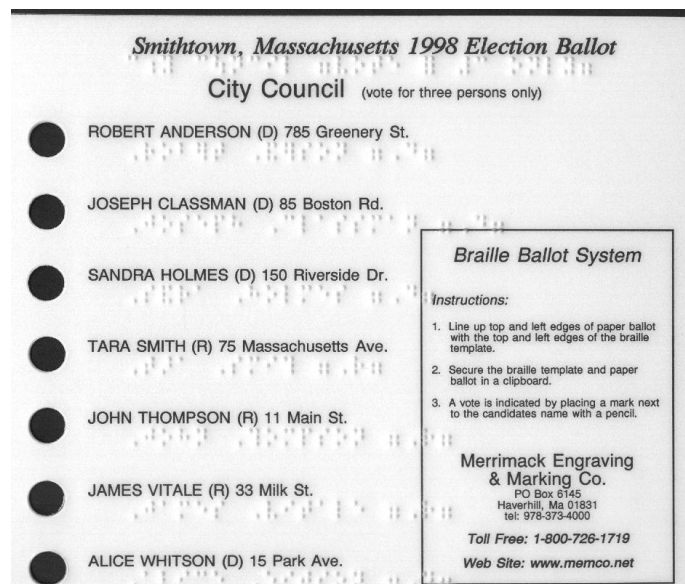


Figure 5: Sample Braille Ballot Template (Source: <http://www.memco.net/ballot.htm>)

Printed Braille ballots are much more expensive than their traditional paper counterparts, costing about ten times more than regular ballots (Jacobsen, 2008). For this reason Braille

templates are more commonly used than printed Braille ballots, because only one Braille template needs to be printed off per polling station. A Braille template, seen in Figure 5, is essentially a copy of the regular ballot with holes cut in it that match up with the fields on a regular ballot where a voter is supposed to mark their vote. In order to vote the voter places the template over the regular ballot and indicates their vote by marking the regular ballot through the chosen hole in the template. While it may not be obvious from the picture, the black circles located next to the candidate's names in Figure 5 are the holes where the mark is to be placed.

A major challenge associated with using Braille ballots is the fact that so few visually impaired people are Braille literate. A study carried out by National Federation for the Blind reports that, "Fewer than 10 percent of the 1.3 million legally blind people in the United States read Braille" (Associated Press, 2009). Braille illiteracy is also becoming very prevalent in other countries especially in Europe (Christensen, 2000). There are several reasons for this decrease in literacy. One large factor is that more and more visually impaired people are opting to use speech synthesis software in place of Braille. Less and less people are bothering with Braille, because it is difficult to learn, and Braille devices are usually more expensive than the speech synthesis alternative (Christensen, 2000). Furthermore, reading via Braille is very time consuming. Many Braille readers can only get through 50 words or less in a minute's time (Associated Press, 2009). Another contributing factor to the loss of Braille literacy is the reluctance of the late or elderly blind to put in the effort required to learn Braille (Christensen, 2000).

Yet another problem braille ballots is that Braille print takes up much more space on a piece of paper than print does. For example, "a one-page ballot paper translates into 11 pages of braille" (Jacobsen, 2008). This proves to be an issue when applied to the already complex and cumbersome Danish paper ballot.

4.1.2 Mechanical Systems

One type of voting system that has been widely used in the past are Mechanical Lever Voting Machines. The lever machine was invented in 1892, and by the 1960s it was the most used voting system in the US, but by 2000 only about 18 percent of voters used the machines (Evans & Paul, 2004). In order to use the lever machines a voter enters a private booth and turns a series of levers that signify their choices for the election. If a voter wishes to change

their vote for any reason all they have to do is turn the lever back on the unwanted choice and pull the lever on the new choice. After the voter is satisfied with their choices, they pull a large master lever, and the vote is mechanically tallied. When the voter exits the booth the action of the door or curtain opening resets all the levers (Novick, 2009).

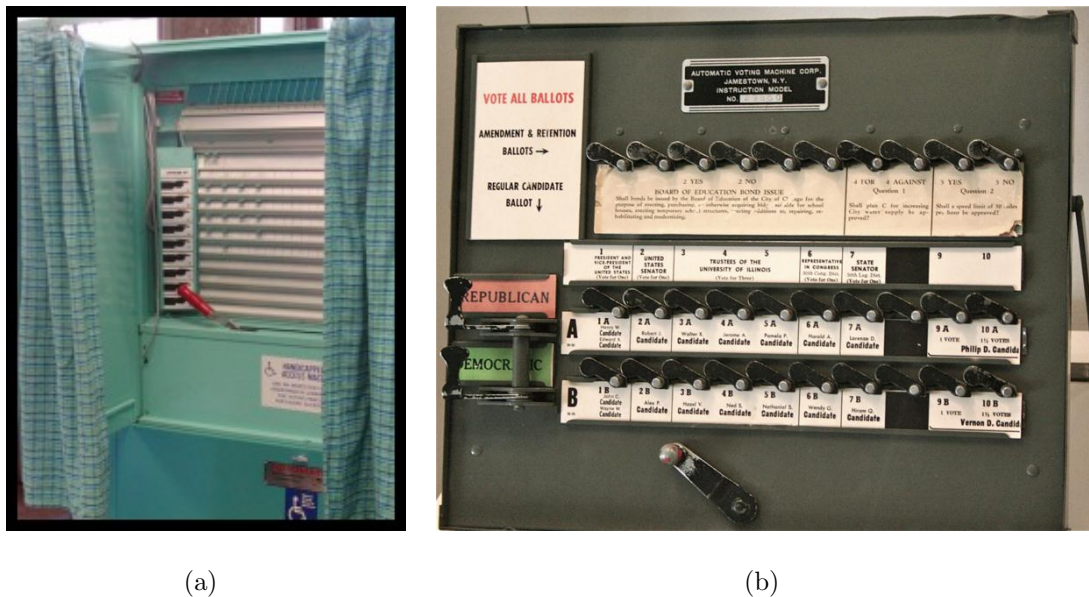


Figure 6: Examples of Lever Machines (<http://www.braddblog.com/?p=6956> and http://en.wikipedia.org/wiki/File:Voting_machine.png)

Although today the lever machines, seen in Figure 6, are viewed as obsolete and outdated in many areas of the US, there are still some places, such as the state of New York that prefer these machines due to the unique advantages they possess over other systems (Novick, 2009). One distinct advantage of mechanical voting machines is that it is difficult for anyone to rig or tamper with the machines. Since there are only mechanical components these machines cannot be hacked like their electronic counterparts (Novick, 2009). In addition these machines emit a loud “thunk” sound when the master lever is pulled which contributes to voter satisfaction that their vote has been cast (Evans & Paul, 2004). This voting system is also able to completely eliminate the issue of over-voting by mechanically disabling the voter from casting an over-vote (Schwartz, 2002).

However there are several striking disadvantages with the use of mechanical voting systems. First, the lever machines do not create any physical record of each voter’s ballot. When the master lever is pulled the votes are simply tallied on a gauge (Schwartz, 2002). This eliminates the possibility of a recount if fraud is suspected and prevents a voter from being

sure if the vote they cast was recorded correctly (Evans & Paul, 2004). Second, mechanical voting machines have also been known to be inaccurate and unreliable due to mechanical error. For instance, when the mechanical counting device turns over from 999 to 1000 much more force is needed to turn the multiple wheels. In some instances, this results in the wheels failing to turn completely, and thus failing to record a vote (Evans & Paul, 2004). Third, there is also wide spread voter dissatisfaction with the mechanical voting system. A study performed by Rice University indicates that in comparison with electronic and paper voting systems, the fewest participants preferred the mechanical lever system (Kristen K. Greene & Everett, 2006).

Unfortunately the mechanical lever voting system does not seem to be a viable option for solving the issue of providing a secret ballot for the visually impaired. The visually impaired would, for example, have no way of knowing which levers should be pulled for which candidates and would need to be accompanied into the voting booth by an aide who casts their vote for them (Evans & Paul, 2004). Although the location of certain levers and their function may be described to visually impaired voters audibly or by Braille writing on the machines, this can be extremely frustrating and confusing when the number of choices on the machine is very large (Gallagher, 2009).

4.1.3 Electronic Systems

Though not as common as paper ballots, electronic voting machines have become one of the most widely used alternative methods of voting around the world. Electronic voting machines have become especially prevalent in the United States, where they are being used to replace aging mechanical systems. A map of states that use electronic voting systems can be seen in Figure 7. While it may seem as though electronic voting systems make up a small portion of the total votes cast, the number of voters using electronic machines is growing. Five times as many voters used electronic voting machines in the 2008 elections than in the 2000 elections.

While there are many different electronic voting machines, they all fall into one of two categories. The first and most common type of electronic voting machine are Direct Recording Electronic, or DRE, machines. DRE voting systems stores votes directly to a hard drive or other storage medium. The second type of electronic voting machine is known as a ballot marker. Ballot markers are almost exactly the same as DRE machines, except they produce

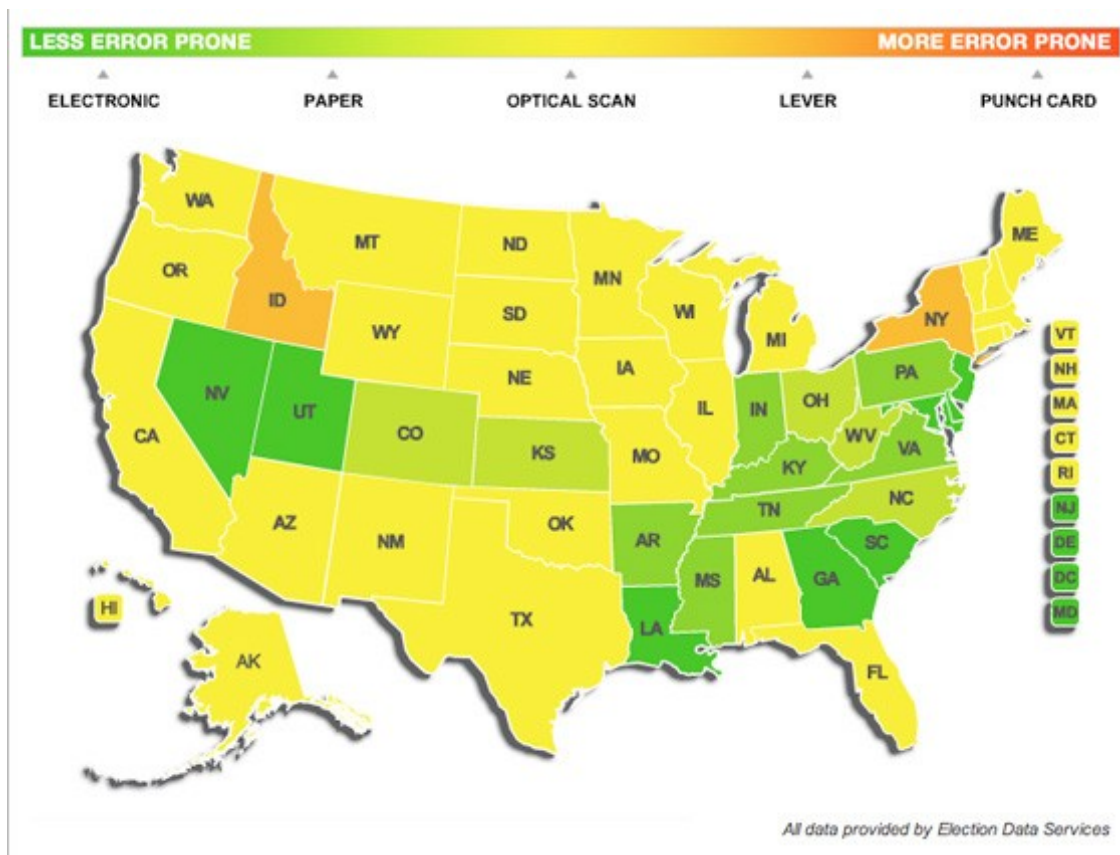


Figure 7: Map of Voting Systems Used by States (<http://dvice.com/voting/map2.php>)

a paper ballot, rather than storing the vote electronically.

DRE Machines

DRE machines are by far the most common form of electronic voting used worldwide. Rather than create a physical ballot, DRE machines are entirely digital; no paper ballot is produced. As a result, election results can be tabulated immediately following the closing of the polling station. Furthermore, because there is no paper ballot, DRE machines, if implemented correctly, can greatly reduce the chance of voter error. Spoiled ballots caused by voting for too many or too few candidates, or incorrectly marking a paper ballot, can result in many votes being declared invalid. In the 2000 US election alone, approximately two million ballots were spoiled due to voter error, accounting for 1.8% of the national vote (The Center for Election Science, 2011). Two million votes can easily be the difference between one candidate and another. DRE machines can eliminate accidental under votes or over votes by notifying the voter when there is an error with their ballot.

This ability to detect errors in the ballot is one of the reasons why electronic systems are often considered by voters to be much easier to use. Cathy Cox, former Georgia Secretary of State describes the opinions of voters using electronic systems stating that “97% of respondents reported that they had no difficulties” when using the electronic systems (Cox, 2003). Indeed, a study conducted at Rice University found that voters were “significantly more satisfied with their experience on voting” on electronic machines when compared to other voting methods (Everett, 2007). This increase in usability comes from the greater versatility of electronic systems. Rather than have to fit every party and candidate on a single page, electronic voting machines allow for more intuitive methods of navigating the ballot.

The increase in usability is not limited to sighted voters. Electronic voting machines are among the most accessible method of voting to the visually impaired. For example, electronic voting systems often have ballot magnification features that allow those with partial sight to better read the ballot (VisionAware, 2010). For completely blind voters, most electronic



Figure 8: Diebold Accuvote System

(<http://pcworld.about.com/magazine/2206p121id115608.htm>)

voting machines use audio cues to help the voter navigate ballots (Sanchez-Palacios, 2000). By speaking the names on the ballots through a pair of headphones, DRE systems such as the iVotronic Audio Ballot allow blind persons to vote independently in complete privacy (Waterstone, 2003). A numerical keypad is often used for these systems so that the voter can scroll through the list of names without difficulty (VisionAware, 2010). Such is the case with the Diebold Accuvote system seen in Figure 8.

Auditory voting systems have been used successfully in Washington DC, allowing individuals with visual impairments to vote privately since 2004 (PR Newswire, 2004). According to Jim Dickson, the vice president of the American Association of People with Disabilities, the organization that lobbied for the electronic voting machines in Washington DC, the response among blind voters has been overwhelmingly positive, stating that the inclusion of these systems is a “huge step for democracy.”

DRE voting systems, however, are not without their faults. Many critics of DRE systems cite security and privacy concerns associated with DRE machines as unacceptable and “damaging to the credibility of the electoral process (Blanc, 2007).” As with all machines, DREs are vulnerable to tampering, both in hardware and software, in many cases without the end user knowing what is occurring (Hursti, 2006). Even after all votes are cast, it is possible for an attacker to modify the voting records to be in favor of one candidate over another (Ariel J. Feldman, 2006). Additionally, as many DREs use smart cards that store voter registration lists, a hacker could access this list to identify what candidates voters chose, negating any privacy offered by the machine (Arthur M. Keller, 2004).

The concerns over the security of DRE machines are only heightened by the lack of a paper trail, making it difficult, if not impossible, to conduct a recount if election fraud is committed (Moynihan, 2004a). This absence of a physical ballot to ensure that one’s vote has been counted correctly has led to a distrust of electronic systems in many societies, including Denmark (Heilbrunn, 2011). Germany, for instance, declared DRE systems unconstitutional in 2009 because the absence of a paper ballot in such systems makes tampering difficult to detect (Federal Constitutional Court Press office, 2009). Similarly, the Netherlands returned to using paper ballots after using electronic voting machines for over a decade, citing the lack of any paper receipt as the systems “biggest shortcoming (Libbenga, 2007).”

While migrating to DREs can save money in the long term due to decreased administrative costs, the short term costs associated with DRE systems may be prohibitive. According

to the Verified Voting Foundation, the average cost of a DRE system can range between \$3500 and \$4500. Bearing in mind that multiple machines would need to be purchased in order to reduce backlog, the cost to change to DREs is not insignificant, especially when one considers the fact that these machines may only be used once every 2-4 years. A report published in December of 2005 noted the increased costs of DREs, stating that the electronic systems can increase a voting districts annual election-related expenditures by up to 57.3% when compared to paper ballots (Myerson, 2005).

Even though learning how to use a DRE machine is considered easy, learning a new interface can still lead to confusion among voters. This confusion could lead to increased wait times, as voters unfamiliar with using electronic voting machines spend more time navigating and filling out their electronic ballot. While it is possible to prepare voters for the new system by allowing them to try out the voting machine beforehand or through information sessions, studies have shown that voters rarely take part in such sessions. When New York City began adopting electronic machines in 2010, only 9000 of the 4 million registered voters attended the information sessions and machine demonstrations that the city provided (Kaminer, 2010).

Although the above concerns are reasonable, most can be easily addressed through policy or technology solutions. For example, the security issues with electronic systems can be addressed by isolating the electronic voting machines from the internet and limiting access to input ports on the machines (Shamos, 2004). While the public is still likely to be wary of privacy and security concerns inherent in electronic voting systems, these fears can be addressed. In his master's thesis, "Trust in E-Voting Systems", Mikkel Sorenson describes the four most important factors for gaining trust in electronic voting systems in Denmark. The first of these comes from positive attention from the media. Danish individuals place a great deal of trust in their local media, and the endorsement of local news organizations will almost certainly result in an increased level of voter confidence in electronic systems. Second, Sorenson states that giving the voter the ability to verify that their vote was correctly counted by displaying a receipt of the vote will also result in an increased acceptance of electronic systems. What is interesting is that these receipts need not be paper in nature, electronic receipts appear to be a sufficient enough proof for a voter to place their trust in an electronic machine (Sørensen, 2008).

One interesting measure that can be used to increase both security and voter trust in

DREs is making the voting machine hardware and software open source. Rather than keeping the hardware and software of the voting machine secret, as many DRE manufacturers currently do, some companies have begun to release every detail of their voting machine, including the source code, to the public. According to Matt Quinn, lead engineer on an open source DRE known as eVACS stated that making the source code public guarantees that developers do not have any “election subverting code” present within the system (Zetter, 2003). Quinn goes on to note that releasing the source code of eVACS has “deflected” much of the criticism aimed at DRE machines and led to a very positive reaction among users. Open source voting machines, such as eVACS, have been successful in Australia, where they have been used since the early 2000s.

While detailing how the voting system operates may seem like it would decrease the security of such a system, in reality, the opposite occurs. Opening the software up to public inspection can result in flaws being discovered that would have otherwise remained in the code. Open source operating systems have been using this methodology of bug checking for years, leading to quick fixes when any security flaws are found. Indeed, Bruce Schneier, one of the world’s foremost experts and cryptography and computer security, has stated that computer security experts unanimously agree that “software used on DRE machines must be open to public scrutiny (Schneier, 2004).” According to Schneier, open sourcing the voting machine is one of the best methods of mitigating security concerns associated with DREs.

Ballot Markers

Though not as commonly used as DRE voting systems, ballot markers retain many of the positive features associated with electronic voting machines, such as their accessibility and ability to detect and correct voter errors, while eliminating many of the common criticisms. The process of voting with a ballot marker is illustrated in Figure 9 on the next page. Though the navigation of the ballot and the selections of candidates is the same as on DREs, ballot markers are very different when it comes to casting the vote. Instead of storing the vote digitally, as DREs do, ballot markers either print out a completed paper ballot, or fill in a paper ballot that is inserted by the voter. By looking at the printed ballot, the voter is able to confirm that their vote was correctly recorded.

The ability to verify that one’s vote was accurately cast has led many to trust ballot markers over other electronic machines. Indeed, a report on the United States Voter Confi-

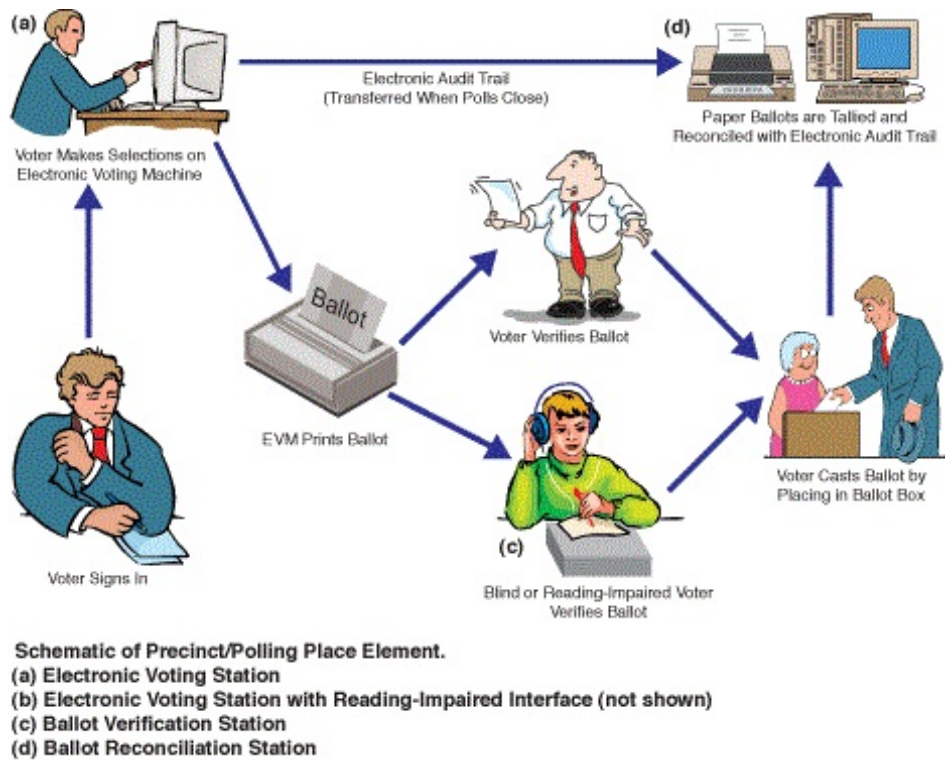


Figure 9: Diagram of Paper-Verified Electronic Voting System

dence and Accessibility Act of 2007 stated that having an electronic machine print a paper ballot “restores public confidence” in the voting machine (Brady, 2007). Voters feel more certain that their vote will be properly recorded if they have a tangible ballot. The presence of a paper ballot not only increases the perceptions of election security, but it actually results in a more secure election.

The risk of election fraud is greatly reduced if printed ballot is used to cast ones vote, rather than an electronically recorded tally. As Dan Wallach, an associate professor at Rice University, notes, with ballot markers, the security and “correctness” of the voting system software no longer an issue (Wallach, 2005). Wallach goes on to state that, if the voter is able to read the printed ballot, then “either [the voting machine] consistently produces paper ballots that match voters’ intent, or it is taken out of service.” Even if such a system were to be hacked or tampered with, there is no way the hacker could modify the system to influence the results of the election. A voter would be able to notice any differences in the ballot and their intended vote before they cast the ballot.

Interestingly, the increased security from printing out a paper ballot means that fewer precautions need to be taken to ensure the security of the voting machine. If a voting machine

prints a ballot and erases the voter's selections from memory, there is no need to develop and implement a complex security algorithm that protects the voter's choices from tampering. Similarly, proprietary hardware designed to be tamper-proof is unnecessary. Instead, any computer outfitted with a printer could sufficiently carry out all of the necessary functions of a ballot marker. An example of this can be seen in Figure 10, showing an eVACS system designed to be accessible by the visually impaired. The entire system is composed only of a computer, a printer, a monitor, and a keypad. As a result, ballot markers can be significantly less expensive than other electronic voting machines.



(a)

(b)

Figure 10: eVACS Voting System (<http://www.softimp.com.au>)

Like all voting methods, however, ballot markers are not perfect. As with DRE machines, voters must learn the ballot marker's interface in order to use the voting machine. If the ballot marker requires the voter to insert a ballot beforehand, the extra step may result in even more confusion. According to the Association of Computing Machinery, any electronic voting system will need to be "as simple as possible" if it is to be considered usable by the public Harry Hocheiser (2005). With every step added to the voting procedure comes an increased chance that the voter may become confused.

This complexity becomes an even greater problem if the voter is visually impaired. If the ballot marker simply marks an existing paper ballot, rather than printing a brand new one, the visually impaired voter must be able to insert the ballot into the ballot marker in the correct orientation. Furthermore, as the ballot produced by ballot markers is still a paper ballot, it is not verifiable by visually impaired voters. If a blind voter is to be sure that their

ballot was correctly printed, a second system would need to be implemented that could read the printed ballot to the voter. This is added component only increases the overall cost of the voting system, while adding to the complexity of voting.

The increased complexity associated with ballot markers not only presents challenges to the voter, but also adds to the complexity of the voting system, and the potential problems posed by such complexities. The addition of a printer to the voting system greatly increases the likelihood that such a system could breakdown. As former president of the League of Women Voters of the United States Kay Maxwell stated before the US Election Commission, “Printers are among the least reliable of computer system components. They jam, they need paper, they are slow. . . (Maxwel, 2004)” Considering that that voting machines are expected to be used all day, any malfunction can result in significant wait times. In one instance, printer failures in Brazil resulted in voters waiting as long as 12 hours to be able to vote (Shamos, 2004).

Many of these challenges, however, are of concern only if ballot markers are the only available system to vote with. Fortunately, this is rarely the case. Indeed, implementing ballot markers does not necessitate that everyone cast votes via a ballot marker. Rather, if the ballot marker is made to produce a paper ballot that is identical to the standard ballot, their use by voters can be optional. Those comfortable with manually filling out a paper ballot can do so, while those who wish to use an electronic voting machine can use the ballot marker.

Making the usage of ballot markers optional rather than mandatory also results in a decreased cost of implementation, as fewer ballot marking machines need to be purchased. Instead of completely refitting each polling center with electronic machines, only one or two ballot markers would need to be purchased for each polling station. Furthermore, having a few ballot markers at each polling station would still enable the visually impaired to vote in private, while reducing the possibility of increased wait times caused by voters attempting to learn a new interface. If the voter backlog becomes too great, voters may opt to manually fill out their ballot. Similarly, if the voting machine breaks down, voters will not have to wait until the machine is fixed. While having ballot markers complement the existing system does not fix the problems associated with ballot markers, it does address those challenges in a manner that limits their potential to disrupt the voting process.

It is important to note, though, that ballot marking devices should still be able to be used

by anyone who wishes to vote through them, not just the visually impaired. If all voters are able, but not required, to vote through ballot markers, sighted voters can indirectly verify the machines accuracy for the visually impaired. While the visually impaired may not be able to read their ballot, sighted voters who use the machine will be able to confirm whether or not their vote was accurately printed. If a sighted voter notices that the ballot marker is incorrectly marking their ballot, they will be able to alert election officials of the malfunctioning machine. Similarly, as the voting machine has no way of determining whether or not the voter is blind or sighted, if sighted voters consistently see that their ballot is correctly printed, it is safe to assume that the machine is functioning properly for visually impaired voters (Wallach, 2005).

4.1.4 Remote Voting

While electronic machines are useful in addressing many of the privacy issues disabled voters face in the voting booth, some visually impaired voters may find it easier to vote in the privacy of their own homes. Remote voting has been used for many decades in countries around the world, though not always for the blind or visually impaired. Many countries use postal ballots in order to allow voters, to vote in government elections if they cannot make it to the polling station, due either to disability or geographic complexities. Advances in technology have opened up new ways of voting from afar, be it by telephone or the internet. These systems have allowed voters, especially those with visual impairments, to conveniently vote in privacy.

Postal Voting

The oldest and most common method of remote voting comes in the form of mail-in ballots (Karp & Banducci, 2000). If a person so chooses, they may receive a ballot through the mail that they can then fill out in their own home. While they were traditionally used only for those who had a legitimate reason for not being present at the voting booth, postal ballots have since been opened for use to the general populace (Qvortrup, 2005). Proponents of mail-in voting state that postal voting is able to increase voter turnout while significantly reducing costs. According to Qvortrup, the state of Oregon was able to reduce the cost of voting from US\$4.33 per vote to US\$1.33 per vote by switching to a postal voting system. These reductions in costs are not isolated; New Zealand was able to save 3.6 million USD

by using a mail-in ballot in one of their referendums (Karp & Banducci, 2000).

One country where postal ballots are used extensively is the United States, where they are more commonly known as absentee ballots. While the original intent of absentee ballots was to allow voters who could not make it to their designated polling station to vote, many states now allow that anyone be granted a postal ballot. The use of mail-in ballots is so widespread that nearly 26% of registered voters, approximately 32 million people, voted using postal ballots in the 2008 presidential election (USFEC, 2000). In some states, such as Washington, 88% of the votes cast are done so via mail. When studying the public opinions of voting by mail, the Washington state election board noted the some important benefits to remote voting in such a manner. First, many voters do not have the time to travel to their polling station to vote. Mail-in ballots allow electors to vote on their own time. Second, voters may not always know about every candidate on the ballot before voting. A postal ballot allows voters to research each individual on the ballot before making their decision. These factors, according to Washington's States 2007 report, have led to Washington having one of the highest voter turnout rates in the country (Office of the Secretary of State of Washington, 2007).

For these reasons, voting by mail seems to be a viable solution if one wishes to allow the blind to vote in the privacy of their own home. While a blind individual may need a trusted person to fill out the ballot for them, many blind persons in Denmark found this to be acceptable when voting in a polling booth (Heilbrunn, 2011). If the voter wishes to have even more privacy, a braille ballot may be used. Furthermore, because the blind person would be able to fill out the ballot whenever they wish, the increased size, and therefore time devoted to the ballot, becomes less of an issue.

Even with these benefits, however, many countries in Europe are wary of allowing postal voting in a non-supervised setting. Finland requires that votes be filled out at specified polling stations, effectively negating many of the benefits gained from mailing in one's vote. The causes for this mistrust vary from the fear that one's vote may not actually be counted, to a detachment from the democratic process (Qvortrup, 2005). Additionally, while many locales have had success in increasing voter turnout through postal votes, this certainly is not always the case. Qvortrup notes that Britain's attempts at using a mail-in ballot to increase turnout was a failure. Furthermore, because Danish law requires that an election official be present if a Danish citizen, even a perfectly sighted one, wishes to fill out a postal

ballot from their own home (Grabenwarter, 2004), adoption of a mail-in ballot seems would face significant challenges.

Telephone Voting

Voting via telephone is a relatively new method of voting being implemented around the world to help improve voter privacy for the visually impaired. In a telephone-based voting system implemented by the UK, each voter registered to televote receives a unique personal identification (PIN) number via mail or a specified election office (Katsakis, 2005). The voter can then call a specified call center at any time in the two weeks leading up to the election, identify themselves with their PIN, and have their vote recorded by the call center. According to the UK Electoral Commission, user feedback of the televote system has been exceptional, with 93% of the voters rating the system as good or very good, 99% saying that the system was convenient, and over 90% reporting that the privacy provided by the system was adequate (Katsakis, 2005).

Similar to postal voting, one of the major benefits to using a telephone based voting system is greater convenience for the voters. According to the UK Electoral Commissions, 99% of voters who used a televoting system stated that it was convenient for them (Katsakis, 2005). Because voters can vote whenever they please, and are not required to travel to a polling stations, voter turnout has improved in many of the districts where voting by telephone has been implemented. In the town of Stewiacke in Canada, voter turnout jumped from 35% to 71% after televoting technology became available in municipal elections (Comeau, 2010). Dean Smith, the president and founder of Intelivote, a company that manufactures electronic and telephonic voting systems, states that the impetus behind this rise in voter participation stems from the convenience of being able to vote whenever one wishes. While we could find no study on Danish opinions of telephone based voting, positive feedback from users of televoting systems across the world indicate that it might be readily accepted by the Danish populace.

Furthermore, telephone-based voting systems are relatively low-cost when compared to electronic voting machines. While a trial in outfitting 29 districts in Australia with electronic voting machines cost US\$2.2 million, a telephonic voting system cost Australia only US\$375,000 (Hutchinson, 2010). This low cost can be seen elsewhere around the world; the Intelivote system used in Canada cost only US\$2 per vote (Comeau, 2010). While this is

still greater than the cost of postal voting, it is much less than the traditional ballot, and far cheaper than using a braille ballot.

Telephone voting systems are also considered to be both private and secure (Headd, 2005). While it may seem counterproductive to have a voting system in which you must tell your vote to another, telephonic voting systems often do not require that the person recording the vote know the name of the elector, they only need a Pin or other form of verification to ensure that the person voting is registered (AEC, 2010). Therefore, while the election official on the other end of the line knows the voters choices, there is no way for them to connect that information to a specific person, the voter is kept anonymous. In countries such as Australia, this level of privacy has been deemed sufficient by blind persons (Hutchinson, 2010). Furthermore, speech recognition technologies have advanced to the point where it is possible that a fully automated system can handle the entire process, from reading the ballot to the voter, to understanding and recording who the voter wishes to elect (Headd, 2005). For the purposes of auditing the election, the system could collect the audio recordings of the person's votes. This could alleviate fears that one's vote may be tampered with, as election officials would be able to review the audio recordings to make sure they were properly cast.

One of the major challenges that would need to be overcome if voting by telephone were to become available in Denmark is the Danish stance on remote voting. As stated by the Danish Ministry of the Interior, the Danish government believes that remote voting, and especially remote electronic voting, is antithetical to one of the primary principles of Danish electoral law, that an official is present to ensure not only that the person voting is who they say they are, but that their vote is conducted in private. While voting by telephone provides a somewhat greater assurance that one's votes are not tampered with, compared with electronic systems, due to the ability to audit one's votes and the presence of an election official on the other end of the phone, it could be difficult to verify that the person voting is who they say they are. If someone was to acquire a voter's PIN, and that was the only form of identification necessary, they would be able to cast a vote as someone else. The Ministry of the Interior has also stated that a paper ballot is necessary for any voting system to appropriately integrate into the Danish electoral process. In the case of a telephone based voting method, the introduction of a paper ballot may be complicated.

There are also questions raised on the stability of telephone based systems. Electronic and Telephone based systems suffered blackouts in the 2010 municipal elections for many towns

across Ontario (Schnurr, 2010). According to Joanne Schnurr, reporting for the Canadian news network CTV, “hundreds of voters” were unable to vote due to the system crashing. While it is important to note this was both a web and telephone based system, and that the crashing was due to the unexpected volume of votes cast, the issue of system instability needs to be addressed.

These challenges can be resolved by implementing a phone based system similar to the one currently being used in Australia. During the 2010 federal election, Australia used an in-polling station method of telephone based voting that allowed visually impaired persons to vote in private. Just like non-blind voters, visually impaired voters would still be required to vote inside a voting center to verify their identity. However, rather than casting their vote in a voting booth, a voting assistant would escort them to a private area with a telephone. Another election official would be on the other end of the phone that would read the ballot to the blind person, and record their responses. To ensure that the voter’s choices were correctly recorded, a second election official listened to the phone call and watched as the votes were marked (AEC, 2010). Using this method would not only address the Danish government’s concerns regarding voter privacy, but would also meet the criteria that an election official is present to ensure that the voter’s choice was correctly registered. Furthermore, because the system crashed in Canada were due to overwhelming traffic, it is unlikely that a telephone system such as the one implemented in Australia would suffer similar problems if its use is limited to visually impaired persons.

A telephone-based voting system can be further modified to output a paper ballot, in accordance with the desires of the Danish government. Rather than have the election official on the other end record the vote electronically, they could fill out a paper ballot. Doing so would address the Danish government’s main argument against electronic systems. If a printer was in the same room as the voter, it would also be possible to modify the system such that it prints the ballot for the voter to turn in at the polling place. This would allow a visually impaired person to cast their ballot in the same manner as a non-blind individual. Furthermore, there is no disruption to the infrastructure already in place for counting votes, which will likely increase the chance that the Danish government approves a telephone based system, should it be recommended to the Danish Association of the Blind.

Internet Voting

A reliable internet-based voting system can greatly improve the electoral process. One of the most commonly cited benefits of internet voting systems is the tendency to increase voter participation. In a manner similar to postal voting, internet voting allows voters to vote whenever they please. By eliminating hindering factors, such as finding the time or transportation to travel to the polling station, or the inconvenience of waiting in crowded polling centers, internet voting has been shown to increase voter turnout significantly. In the 2000 Democratic Primary, Arizona experienced a 200% growth in voter turnout following the implementation of an internet based voting system (Blanger & Carter, 2010). While increase in voter participation in general is a good indicator of a voting systems success, an increase in participation within groups that are typically in frequent voters is a much more important indicator of success.

Turnout among young voters is consistently the lowest among all age groups. Election statistics around the world show that voter turnout between the ages of 18-25 is often less than half of that of older age groups (UK Electoral Commission, 2002; Nasrallah, 2011; US Census Bureau, 2011). Even in Denmark, with its comparatively high turnout rates, voter participation among youths is lower than every age group besides voters over the age of 80 (Jørgen Elklit & Togeby, 2005). According to many proponents of internet voting, the option to vote online could lead to significantly higher voter turnout among young voters. Belanger believes that internet voting “has the potential to increase turnout among individuals between the ages of 18-25.” Belanger goes on to explain that, given the youth’s proficiency with using the internet and the idea of being able to use the latest technology, would make online voting popular among them (Blanger & Carter, 2010).

Furthermore, the ability to vote online provides a means for those with visual impairments to vote. Any visually impaired voter with access to a computer with a screen reader should be able to cast their vote online (Hall, 2001). Furthermore, being able to vote online would eliminate many user interface issues that blind voters may have with other electronic voting machines. So long as the layout of the webpage is usable by the visually impaired, they should have no problem navigating an online ballot.

Although there are many benefits to implementing an internet based voting system, it has long been surrounded by controversy. The primary concern with internet voting is security, and rightly so. The internet is filled with vulnerabilities that could allow hackers

to tamper with an election. For example, in 2010, when Washington D.C. tested an internet voting system, students from the University of Michigan hacked the system and skewed the votes such that a “Star Wars” character became one of the options on the ballot (Barnes, 2010). When developing an internet based voting system for American soldiers abroad, the Department of Defense concluded that internet voting was too unreliable for significant use (Gideon, 2009). Indeed, internet voting is susceptible to many different forms of hacking such as viruses, worms, and denial of service attacks that can in effect prevent people from voting or even skew the results of an election (Jefferson et al., 2004).

While external threats can disrupt the voting process, insider attack perpetrated by the manufacturers on the voting software can cause even more damage to an internet based voting system. Without a paper trail that can be audited, internet based voting systems suffer from many of the same problems as DRE machines, in that the voter must place absolute trust in the system they are using (Schryen & Volkamer, 2010).

Furthermore, while voting online allows voters to cast their vote in private, there exists the possibility that the voter may choose to voluntarily eschew their right to privacy. If they simply print the webpage showing how they voted, they can use that as evidence that they voted for a particular candidate. This opens up the possibility that voters can either be intimidated or bribed into voting for one candidate or another. As stated before the use of a secret ballot while voting must be mandated in order for an election to be fair. If an internet voting system does not meet this requirement than the validity of the election results must be called into question.

Despite these criticisms, some countries have managed to carry out successful elections using the internet. The most prominent of these countries is Estonia, the first, and so far only, country to carry out a binding national election online. Since 2005, all registered voters in Estonia have been able to vote in national elections through the internet. International investigations into these elections have shown that they were conducted without any hacking or other malicious action affecting the integrity of the system (ENEC, 2009). Furthermore, there were virtually no complaints of the election process filed by the voters.

There are many factors that contributed to the success of the Estonian voting system. Arguably the most innovative factor is the actual process of voting. Almost all Estonian citizens possess a government issued ID card that is used for multiple purposes, such as for health insurance, or as a credit card, driver’s license, et cetera (ENEC, 2009). By inserting

the ID card into a special card reader attached to a computer, an Estonian voter is also able to access the voting webpage. While the card reader must be purchased individually, they are relatively cheap, costing only 15 USD. Furthermore, many Estonians already have a card reader, as it has many other uses besides voting in elections. Once the voting website has been accessed, the voter is presented with the Internet ballot which looks similar to a regular paper ballot. After the voter has selected their vote they are presented with a confirmation screen. Once the voter confirms their vote it is sent to a voting server.

What makes the Estonian system inventive, though, is that the voter is allowed to vote as many times as they please. In order to prevent citizens from voting multiple times the system only counts the most recent vote cast. The ability to vote multiple times provides many benefits. For one, if a voter feels uncomfortable with how they voted, for one reason or another, they can change their vote at any time. If they feel they may have voted incorrectly, they need only navigate back to the web page and recast the ballot. Secondly, being able to vote multiple times eliminates the possibility of voter intimidation or vote selling. Even though a voter will still be able to print out a page detailing how they voted, they can change that vote at any time which means that it is impossible for the voter to proof of vote to another person (Schryen & Volkamer, 2010). Furthermore, if the voter is at any time uncomfortable with voting online, they may cast their vote at a polling station on election day by traditional paper ballot, even if they already voted online. If they voted online previously, that vote is voided, and only their paper ballot vote is counted.

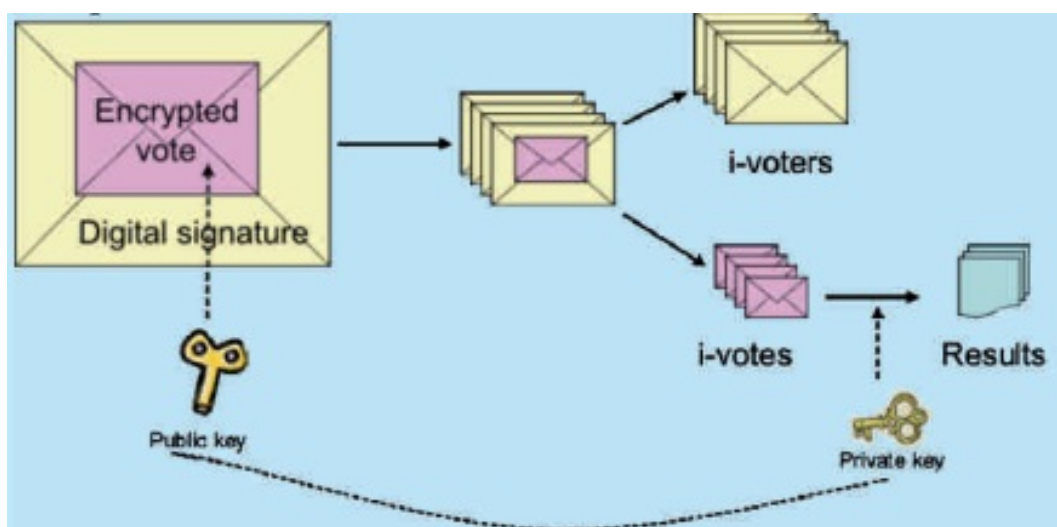


Figure 11: Security System Used by Estonia in Internet Voting
(http://www.vvk.ee/public/dok/Internet_Voting_in_Estonia.pdf)

The Estonian system also has measures in place to help reduce the possibility of hacking, as well as safeguard the privacy of the voter. As seen in Figure 11, Estonia has a multi-layered security system in place to ensure that election results cannot be altered. When the vote is cast, the information on the ballot is stored in an encrypted digital “envelope.” This “envelope” is then placed in a second encrypted “envelope” that contains a verification code to prove that the vote is coming from the correct registered voter. Once the “envelope” reaches the main server, and the polls close, it is decrypted and the verifying information is checked against other ballots to make sure that only the last vote cast is counted. The verifying information is then discarded to ensure voter privacy. The first “envelope” containing the voter’s choices is placed on a CD-ROM containing other votes in a randomized order. After being transported to a secondary computer that is not connected to the internet, the “envelopes” are decrypted, and the results tallied. This multi-layered security system has helped to prevent tampering with the three Estonian elections that have been held by an online vote (ENEC, 2009). The Estonian voting system has proven that conducting secure elections online is possible if proper precautions are taken.

4.1.5 Summary of Voting Systems

In conclusion, there are many different methods of voting used around the world that allow the visually impaired to vote in private. The most accessible among these voting systems are those that are electronic in nature, but these types of voting systems often have trust and security issues that need to be addressed. Voting schemes that involve paper ballots are widely considered more secure than purely electronic systems, but require secondary systems, such as ballot markers, in order to make them usable by visually impaired voters.

4.2 Research on Voting Systems in Organizations

The bulk of our research on accessible voting methods in Danish organizations was derived from interviews with visually impaired voters. While the focus of the interviews with the visually impaired voters was to determine which methods of voting in state elections would be most acceptable, the interviews provided us with an opportunity to discuss how the interviewees participated in elections in their respective organizations, and whether or not such practices could be improved.

Interestingly, while the majority of the subjects participated in elections or votes where

their vote was secret, the overall opinion among the subjects was that private voting within organizations and corporations was not a major concern. The cause behind this indifference stemmed from the fact that private votes were rarely conducted within the subjects organizations. When secret voting was held, the subjects often were able to request the assistance of a friend or trusted individual to cast their vote for them. In these cases, the subjects as a whole did not feel that their privacy was being infringed upon. It seems then, that the issue of private voting in organizational and corporate elections is not as big a problem as previously thought, however it is one that should still be addressed.

There were a few methods that were discussed that allowed visually impaired voters to vote in private in organizational elections. The most common methods still involved paper ballots. Many subjects stated that if the vote being held was a simple “yes-no” vote, the simplest method of ensuring privacy and usability was by marking a note card. While marking the ballot may seem difficult for those who are blind, the process can be simplified if a simply dash is used to represent a yes vote, and a blank ballot to represent a no vote. Doing so does not require the ability to see what is being written, allowing visually impaired voters to cast their vote independently and privately.

Elections involving multiple choices require a more complex system. The Danish Association of the Blind uses braille booklets for these types of elections. Each page in the booklets contains a number in both braille and print. When an election is to be held, the person running the election assigns each possible choice a number. The voters then navigate to the page containing the number representing their choice, tear it out, and place it in a bag or envelope. Even though the majority blind people are not braille literate, the braille booklets are still usable, as the only the numbers one through ten need to be learned in braille. Indeed, even the subjects who were not braille literate stated that they had used braille books before with little troubles.

While physical ballots do offer many advantages in smaller organizations, when deal with large memberships, the process of collecting and counting the votes become tedious. Audience response systems (ARS) have often been used at conferences and in universities when presenters are dealing with large groups of people. While the purpose of audience response systems are make presentations more interesting by allowing the audience to interact with the presentation, they can be used to allow visually impaired voters to vote in large organizations and corporations. The most common type of ARS, some examples of which can



(a)



(b)

Figure 12: ResponseCard and Reply Mini Audience Response Clickers (Turning Technologies & TeamTalk)

be seen in Figure 12, uses a handheld remote, or “clicker”, with multiple buttons on its front face. When a presenter asks a multiple choice question, audience members press the button corresponding to their desired choice. The clicker then wirelessly sends the participant’s selection to the main computer that the presenter is using for their presentation, where the results are calculated in real time.

Besides eliminating the need to manually pass out, collect, and count the ballots, ARS can also be modified to be more accessible to the visually impaired. Normally, an ARS clicker will notify the participant that their vote has been received by the main computer by lighting up an LED. Some ARS manufacturers, however, have modified their respective clickers to contain a small vibration motor so that the visually impaired are able to determine if their vote was counted. Furthermore, although we could find no ARS on the market that had the capability to do so, it should be relatively simple to include a headphone jack on the handheld clicker. The clicker could read off what button was pressed by the voter, allowing those who are visually impaired to be certain that their vote was correctly cast.

4.3 Stakeholder Analysis

In order to determine what each of our stakeholders desired in a voting system, we conducted an in depth analysis into the major stakeholders involved in our project. These stakeholders were both visually impaired and sighted Danish voters, the Danish government, and organizations and corporations within Denmark. For Danish voters and the Danish government, we conducted interviews and surveys, in addition to significant background research, in order to determine which voting system each stakeholder preferred. For Danish organizations and corporations, we used interviews with visually impaired voters in order to determine the best methods of voting in organizational elections. We will discuss and analyze our findings in the subsections below.

4.3.1 Visually Impaired Voters

The stakeholder analysis of visually impaired voters was conducted through interviews with seven visually impaired voters. As stated in the Methodology section, we split the interviews into three topics, each covering what we deemed to be an important aspect of our project. The first of these topics focused on the current and previous process for visually impaired voting in Denmark. The second topic involved describing different visually-impaired accessible voting systems and discussing the subject's opinions on such systems. The final topic revolved around how the subject participated in voting in organizations they were a member of. When answering questions about voting in organizations, however, the subjects acted as visually impaired members of organizations, rather than visually impaired voters. Therefore, in the following subsections, we will include an analysis on the subjects' responses to on the first two topics.

Voting in Denmark

All of the visually impaired subjects that we interviewed stated that they were frequent voters in Danish elections, and have participated in elections since they were of legal voting age. While two of the subjects became blind later in life, the responses from these interviews indicate that many visually impaired are not discouraged from an active political life due to their disability. Rather, those with visual impairments take voting just as seriously as those without any disabilities.

Furthermore, all of the subjects stated that they have voted with an election official present. Of the seven subjects, four stated that they were deeply dissatisfied with the requirement that an election official assist visually impaired voters in filling out their ballot. While the most common explanation for this opinion was the breach of privacy, others stated that forcing three people into the tiny voting booth created an uncomfortably “crammed” environment. It was also brought up that, because the voter’s choice had to be heard and confirmed by two people, the visually impaired voter and the election official would often speak in a louder voice. As the voting booths are close together, someone standing in a nearby voting booth could easily determine who the visually impaired voter was voting for.

Three of the subjects stated that they were satisfied or indifferent with the requirement that an election official be present in the voting booth to assist visually impaired voters. When asked about this, the subjects stated that, while their right to privacy was being violated, they trusted the election officials to not modify their vote, or discuss their vote with others. The subjects did state that if a well-tested voting system that would allow them to vote is implemented, they would prefer such a system over the current one.

Interestingly, all seven subjects stated that they were satisfied with the previous method of voting, where they were able to bring a trusted individual into the voting booth with them, rather than an election official. Many felt that the previous system provided a sufficient level of privacy during the voting process, and one subject even stated that they would prefer the previous system to any of the voting machines or technologies we presented.

What this seems to indicate is that the primary privacy concerns by visually impaired voters over the current system is not based around the fact that someone knows who they voted for. Instead, the issue lies in the fact that it is a stranger, whom the voter may know nothing about nor trust, who is assisting them through the election process. While the previous system still did not allow visually impaired voters to vote independently, they were still able to choose who was to assist them. With the current system, the inability to choose who is to enter the voting booth with the voter only further strips away their independence while voting. This seems to indicate that the frustration with the current voting process stems not only from a lack of privacy, but from a lack of voter independence.

Alternative Methods of Voting

While opinions on each voting system varied from subject to subject, each of the seven subjects stated that braille ballots should not be used as a substitute for the current voting system. Even though five of the subjects were able to read braille, they confirmed that much of the blind population is not braille literate. Indeed, the subjects estimated that only 5-20% of the blind population could read braille. Because of this fact, the subjects universally stated that a braille voting system would be unusable by the majority of the blind population. Furthermore, they felt that a braille system would limit the choice of the voter to voting only for parties, as it would be too large and cumbersome to use if each candidate from each party were to be placed on the ballot. The subjects unanimously agreed that Denmark should not implement braille ballots or braille templates in state elections.

Regarding electronic voting system, opinions among the subjects were far more varied. Five of the seven subjects stated that they would trust a DRE system to be used in state elections if it had been thoroughly tested and approved by the Danish government. They stated that DRE machines would be accessible enough for a visually impaired person to use on their own, and thought it was a step forward from the current method of voting. Others were less trusting on DRE machines. Two of the subjects cited problems with DRE machines in the 2000 US election as evidence that a purely electronic voting system is too insecure to use. Even if the Danish government approved the DRE voting system, the subjects stated that too much was at stake to trust an electronic machine to properly record the votes.

Interestingly, one of the subjects said they were unsure whether they had the technical expertise to navigate an electronic ballot. This concern was addressed when we described DRE systems as computers rather than specialized voting systems. This is important to note, as it is likely that many blind voters, especially older ones, may feel that they lack the technical knowledge to use an electronic voting machine. Many of these voters, however, have used a computer with a screen reader before. If an electronic voting system is to be trusted by these voters, steps must be taken to inform them that using a DRE voting machine is just like using a personal computer. Doing so will likely reduce some of the concerns associated with using electronic machines.

Just as with DRE machines, five out of the seven subjects stated that they would feel comfortable using a ballot marking system, and would trust it to be used in state elections. However, the two subjects who felt that a ballot marking device would not be a sufficient

method of voting were not the same two subjects who would not feel comfortable using a DRE voting machine. Likewise, the reasons given for their disapproval of ballot markers did not stem from security concerns. Rather, both felt that a ballot marker would be too complicated a system for the average visually impaired voter to use. As both subjects supported the use of DRE machines, they felt that the additional steps taken by ballot markers to produce the paper ballot were unneeded and would lead to more problems than they would solve. Just as with DRE machines, this means that steps must be taken to ensure that ballot marking devices are as simple to use as possible. Voters should also be informed beforehand of how to properly operate such systems if they are going to be accepted by visually impaired voters.

It is also important to look at why the two subjects who did not trust DRE machines would feel comfortable using a ballot marker. They stated that the production of the paper ballot was reason for this change. While they did say that they would prefer some method of verifying that the printed ballot was had the correct information printed, this was not absolutely necessary. This change in opinion underlines the importance of a paper ballot in the voting process. Even though the two subjects would not necessarily be able to read the ballot and verify that it was correctly marked, the presence of the paper ballot still improved their trust in the system. This indicates that a voting machine will be more widely accepted if a paper ballot is involved in the voting process.

While all of the subjects felt that that a telephone based system would provide an acceptable level of privacy, only three of the subjects felt that it would be an acceptable method of voting. Only one of the subjects stated that they would be strongly satisfied with using a telephone based voting system. The subject noted that they felt it would be the most usable of all the discussed voting systems because nearly every blind person has experience using telephones. Therefore, it should be easy for a visually impaired voter to use. Others, however, had different opinions regarding voting by telephone. The majority of the subjects felt that such a system would be more complicated than was necessary, and would prefer something much simpler to use. Again, this emphasizes the importance of simplicity in a voting system. If a voting system is too complex or even perceived to be too complicated to use, it is unlikely to be accepted by the voting population.

Just like telephone based voting, few of the subjects stated that they would feel comfortable casting their ballot online. One of the subjects that favored an internet based voting system cited recent elections in Estonia as evidence that such a system, could be effective.

Others were less sure, saying that there were too many security concerns associated with online voting. Many feared that it would be susceptible to hacking or other forms of election fraud. Overall, interviews with visually impaired voters show that significant hurdles would need to be overcome in order for an internet based system to be accepted.

Following the interviews, we compiled all of the gathered data and made a spreadsheet containing each subject's attitudes towards each voting system. We used this data to create a simple graph representing the number of subjects who would accept a given voting system to be used, and the number of subjects who would prefer that voting system be used over any other. This graph, seen in Figure 13, tells us two things.

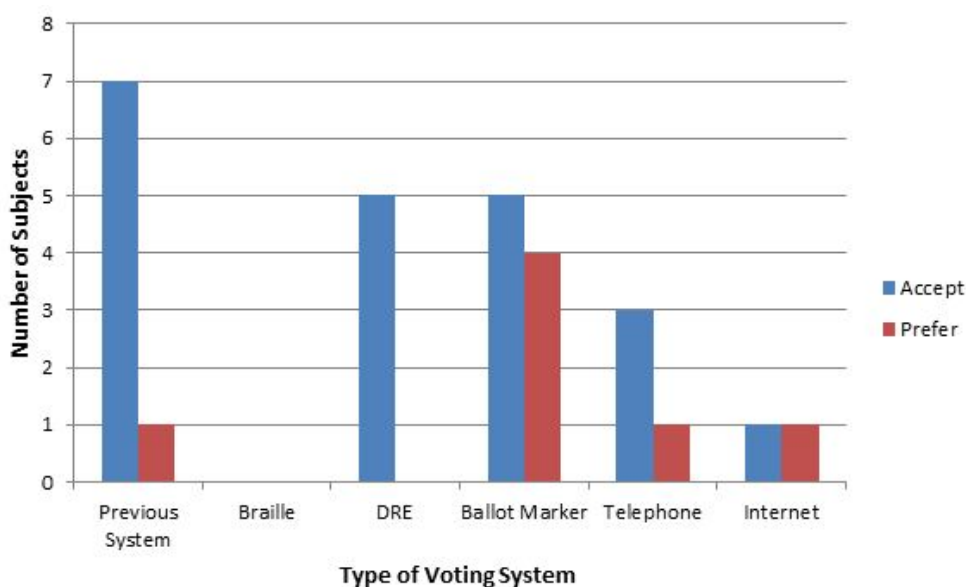


Figure 13: Graph of visually impaired voter opinions for each voting system

First, while all of the subjects consider a move back to voting with a trusted individual acceptable, few prefer it over alternative methods of voting. Therefore, while a quick and easy solution may be to simply revert back to the older method of voting for the visually impaired, doing so is not necessarily the best way to address the problem.

Second, although the number of subject who would find a DRE machine acceptable is the same as the number who would find a ballot marker acceptable, no subject would prefer a DRE machine to a ballot marker. This indicates that, while the presence of a paper ballot is not necessary for visually impaired voters to trust an electronic voting system, having a voting system that produces a paper ballot makes that system far more desirable. Indeed, the ballot markers were the most preferred method of voting overall, with four of the seven

subjects stating that they would rather use a ballot marker than the other voting systems.

From our gathered data on the opinions of visually impaired voters regarding different methods of voting, a few notable findings stand out. First, only three of the voting systems were considered acceptable by the majority of the subjects. These systems are:

- The previous method of voting, where visually impaired voters are able to choose who can enter the voting booth with them.
- Direct Recording Electronic voting machines.
- Electronic machines that print or mark a paper ballot.

While some subjects did favor the other voting systems, overall, the majority of subjects felt that the above three voting systems were preferable alternatives. As this project is focused on finding an acceptable voting method for visually impaired voters, it is likely that our recommendations will involve at least one of these three voting systems.

Second, the majority of the concerns over DRE and internet based voting systems focused around the security of the system. Indeed, when we asked the subjects if they would feel comfortable or trust using a DRE machine, the common response was that they would feel comfortable only if the government had extensively tested the system beforehand. Similarly, while one subject was enthusiastic about the possibility of voting online, the majority stated that they felt that online voting would not be secure from hacking or tampering. Therefore, it is clear that if a voting system is to be accepted by visually impaired voters, significant measures must be taken to ensure that the voting system is not vulnerable to external threats.

Finally, if a voting system is not easy to use, it is unlikely that it will be accepted by visually impaired voters. The majority of concerns with ballot marking and telephone based systems originated from their complexity. The subjects felt that the voting systems would be too complicated for a visually impaired voter to easily operate. Therefore, it is not enough that a voting system be accessible to visually impaired voters. Instead, visually impaired voters must be able to use a voting system just as easily as a sighted voter would. This includes not only implementing an interface that is straightforward to visually impaired voter, but also simplifying the entire voting process by minimizing the number of steps that need to be taken in order to vote. Furthermore, visually impaired voters must be informed of the voting machines simplicity or ease of use beforehand. It is important, however, that

the explanation of how to operate the voting machine is likewise, simple and easy to follow. Rather than describe every single step in the voting process for ballot marking devices, we found that subjects were more favorable towards such voting machines when we only described the major steps. We can therefore infer that it is not only important that the voting system itself be simple, but visually impaired voters must perceive it to be simple if it is to be a successful voting system.

4.3.2 Non-Blind Danish Voters

If an electronic voting system is to be implemented in Denmark, it is likely that it will affect all Danish voters, not just the visually impaired. Therefore, we surveyed a large number of sighted Danish voters on their opinions of different methods of electronic voting, including DRE systems, ballot markers, and internet based voting.

While we were only able to survey 17 non-blind voters, the gathered data was consistent. Simply stated, many Danish voters did not care whether or not they voted through any sort of electronic voting system, so long as it was deemed secure by the Danish government. Indeed, 15 of the 17 surveyed voters stated that they would trust using all three systems in a state election. Interestingly, the two other voters stated that they would not trust any of the three voting systems, even if the government considered them secure. The responses from the survey indicate that the many Danish voters would be perfectly content with voting through an electronic voting system. Still, not all Danish voters would feel comfortable casting their ballot on an electronic voting system. We must make sure, then, that when we recommend a system of voting to the Danish Association of the Blind, that we are not enabling one group of voters to vote while disenfranchising another.

4.3.3 The Danish Government

A stakeholder analysis on the Danish government was completed to not only determine which methods of voting the government found acceptable, but also to ascertain what needs to be done in order to make other voting systems acceptable for use in Denmark. This analysis was completed through two methods: background research and discussions with members of the Danish government.

We conducted significant background research into the Danish government's positions towards different methods of voting. These positions were gathered by researching publicly

released statements and documents, such as “Parliamentary Electoral System in Denmark”, released by the Ministry of the Interior in 2011. While this document did not specifically state the Danish government’s views towards each method of voting, we were able to come to a number of conclusions by analyzing the information in the document.

While the Danish national government trusts and uses electronic logbooks to keep a count of the number of registered voters that participate in each election, they do not share the same level of trust for electronic voting machines. Indeed, while mayors of eight different Danish municipalities requested that electronic voting systems be allowed in national election, the Danish Ministry of Social Welfare refused, stating that they were opposed to “a replacement of the current public control” of the vote counting with a “more sophisticated control of the electronic counting of votes that only specialists knowledgeable of IT-systems could reasonably undertake (MISA, 2009).” The Ministry of Social Affairs went on to state that they would need to see electronic voting systems used successfully in other countries before they would consider “embarking on pilot projects” for electronic voting systems.

The government’s primary concern with electronic voting machines seems to be the required change in infrastructure due to the lack of a paper ballot. This indicates that the Ministry of Social Affairs is concerned primarily with DRE voting systems, as the paper ballots produced by ballot marking devices address this concern. Still, the Ministry of Social Affairs has made it clear that they do not want to see any overly complex or technical voting systems used in elections, and ballot markers still would require some technical knowledge to set up or repair should one break down during an election. While some of the concerns with electronic system may be addressed by having the voting machine produce a paper ballot, the Danish government is still likely to be wary of their use.

Similarly, the Danish Ministry of the Interior is opposed to remote electronic voting systems, such as through internet voting systems. In the Ministry’s remarks on the law that allowed for electronic registers to be used, they discussed the possibility of internet based voting. In these discussions, the Ministry of the Interior concluded that online voting was not a possibility in the near future due to the inability of the government to securely verify the identity of the voter. There is no way to ensure that the person casting the vote is who they say they are. Furthermore, it cannot be certain that the voter casting their vote is doing so in private. The Ministry of the Interior stated that the inability to guarantee that the voter will cast their vote in private precludes the usage of online voting, and that “secret

balloting is not only a right for the voter but also a duty.”

Indeed, the Ministry of the Interior notes that it is the duty of the election officials to “ensure not only the identity of the voter” but to guarantee that “the vote is cast without giving others the opportunity to see how the voter has voted.” The idea that secret ballots must be mandatory is common throughout the document. While a postal voting system is present in Denmark, two election officials must be present when the voter is filling out the ballot, even if they are perfectly sighted. The Danish government places a high level of importance in the secrecy of the voter’s ballot, and because of this, the Danish government is opposed to voting systems where either the identity of the voter cannot be confirmed, or where the voter’s ballot may become public.

The opinions in the above document were echoed by members of the Ministry of the Interior when we met with them to discuss electronic voting machines. Members of the Ministry of the Interior stated that one of the primary concerns with electronic voting systems stems from the lack of a paper ballot. Indeed, while they noted that there were many benefits to DRE systems, the absence of a physical paper trail likely ensures that DRE systems will not be accepted by the Danish government in the near future.

Members of the Ministry of the Interior did, however, seem more open to the possibility of accepting an electronic voting machine that produced some sort of voter verifiable paper trail, as is the case in ballot marking devices. Indeed, one member of the Ministry of the Interior stated that the likelihood of the government testing some sort of electronic voting system is growing, and that if the government was to use an electronic voting machine, it would have to produce a paper ballot. While it is important to note that these statements cannot be taken in official capacity, it does validate the concerns that the Ministry of the Interior has over DRE systems. Furthermore, it does show that the Danish government is open to implementing newer, more accessible voting machines, provided they meet all of the requirements put forth by Danish law.

4.4 Critique of Voting Systems

In this section, we compare and critique the different methods of voting with the respect to the information gathered during our stakeholder analysis. By looking at what qualities each stakeholder would like to see in a voting system, we are able to determine which method of voting is most suitable for use in Danish elections.

4.4.1 Paper Ballots

While both the Danish government and sighted voters find the current method of voting, wherein a traditional paper ballot is used, to be acceptable, a paper ballot does not allow the visually impaired to vote in private. In order to vote with a paper ballot, a visually impaired voter requires outside assistance. Visually impaired voters did, however, state that this requirement would be acceptable if they were allowed to choose who was to assist them. Allowing visually impaired voters to once again choose a trusted individual to enter the polling booth with them would be the least expensive and simplest method of meeting the privacy desires of visually impaired voters. Still, paper ballots do not allow visually impaired voters a secret ballot, and the majority of the visually impaired voters interviewed stated that they would rather vote through a system that allows them to vote independently and privately. Therefore, we believe that the Danish Association of the Blind should only push for a return to the previous system, where blind voters could choose someone to enter the booth with them, if electronic voting systems are not approved by the Danish government.

4.4.2 Braille Ballots

While braille ballots may seem like a viable option for providing visually impaired voters with a means to vote in private, background research and an analysis of the opinions of visually impaired voters reveal the inadequacies of braille ballots. The largest problem associated with braille ballots is that only 10% of the blind population is braille literate. This means that if a braille ballot is used in elections, it will be inaccessible to the majority of blind voters. Furthermore, the length of a braille ballot or template would limit the choice of those voters who are braille literate by only allowing for a party to be chosen, not an individual candidate. For these reasons, we do not believe that a braille ballot would be an acceptable replacement to the current method of voting in Danish elections.

4.4.3 Mechanical Voting Systems

Although mechanical voting systems are still used in some parts of the world, they are widely considered to be obsolete and outdated. Furthermore, they would be unable to offer any real improvement over the current method of voting to any of our stakeholders. They are not accessible by the visually impaired and offer no paper trail that can be audited. Because background research into mechanical voting systems returned so many negatives, and very

few positives, associated with using them, we did not feel it necessary to ask stakeholders about mechanical voting systems. Therefore, we cannot recommend that mechanical voting systems be used in Denmark.

4.4.4 DRE Systems

Direct Recording Electronic voting systems present a potential solution to the challenge of providing private voting to the visually impaired. DRE systems are fully accessible by those who are blind or partially sighted, as well as those who are afflicted with a number of other physical and mental disabilities. Furthermore, DRE systems can prevent voters from accidentally over-voting or under-voting, resulting in a spoiled ballot. DRE systems also have the advantage of being able to calculate election results instantly and automatically, eliminating the need to hire election officials to count votes by hand.

Unfortunately, there are many issues with DRE systems that must be addressed before they can be used in Denmark. The primary criticism of DRE machines is security, in particular the lack of a voter verifiable paper trail. We have found in our research that the absence of a paper ballot results in the system being vulnerable to hacking or tampering without the knowledge of the voter. Furthermore, the Danish Ministry of the interior confirmed that any voting system that lacked a paper trail would almost certainly be rejected by parliament. Therefore it seems unlikely that DRE systems would be accepted by the Danish government, were we to recommend them.

4.4.5 Ballot Markers

While ballot markers are not yet as widely used as DRE machines, the advantages that they have over paperless electronic voting systems cannot be understated. Simply put, the production of a paper ballot solves most of the problems attributed to DRE machines, while retaining nearly all of the benefits that make DRE machines attractive. Because they are electronic, ballot markers are able to reduce or eliminate common voter errors that result in spoiled ballots. Furthermore, they are just as accessible to voters with disabilities as DRE machines. But by printing a paper ballot, ballot markers offer the security and trust that DRE machines lack.

Our research and analysis has led us to conclude that ballot marking devices are more secure than DRE machines because any error can be clearly seen by the voter. In effect,

ballot markers are simply a high-tech and accessible pencil. Any tampering with a ballot marker that leads to an incorrect printing of the ballot could easily be detected by the voter before their choice is cast. For visually impaired voters, it would be trivial to print a barcode on the ballot that could be read by any barcode scanner to ensure that the vote was properly printed. Because of the ability to ensure that their vote is properly counted, ballot marking devices were the most popular of all the research voting systems among visually impaired voters.

The Danish government agrees with the importance of a paper ballot in the voting process. Indeed, members of the Ministry of the Interior made it clear that any electronic voting system would likely need to produce a voter verifiable paper trail if it was to be accepted by the Danish government. This requirement stems not only from the general trust of the paper ballot, but also from the fact that the current electoral infrastructure is based around the paper ballot. Ballot markers would require a minimal change to the electoral process and could even be used side-by-side with the traditional method of voting.

While the issue of printers jamming would need to be addressed if ballot markers are to be used on a national level, we believe that this problem is one that can be resolved. Overall, however, the benefits associated with ballot markers far outweigh the downsides, a belief that many of our stakeholders share. Therefore, we believe that the Danish Association should push for ballot markers to be used in Danish elections.

4.4.6 Postal Voting

There are several aspects of postal voting that could help in accommodating the needs of visually impaired voters. By being able to vote in the comfort of one's own home, visually impaired voters would no longer need to find transportation to polling stations. Nor would they need to vote at a specified time. Instead, they could take as long as they wished to complete the ballot. Furthermore, because postal ballots are a paper system, they are both inexpensive and auditable.

Being a paper based system, however, postal ballots are still not entirely accessible to the visually impaired. A visually impaired voter would still require assistance in filling out the ballot. While this could be done by a trusted individual, given that current Danish law requires that an election official be present if any Danish citizen, even a perfectly sighted one, wishes to fill out a postal ballot from their own home, it is unlikely that the Danish

government would allow visually impaired voters will be able to choose who assists them. Therefore, postal ballots would present no real change in the level of privacy afforded to visually impaired voters.

4.4.7 Telephone Voting

Our original research suggested that telephone based voting systems were potentially an acceptable solution to the issue of visually impaired voter privacy. Furthermore, because some telephone based voting systems, such as the one used in Australia, involve multiple election officials throughout the voting process, we believed that a telephone based voting system would be acceptable by the Danish government.

Our stakeholder analysis, however, demonstrated that a telephone based voting system would likely not be well-received by visually impaired voters. While some visually impaired voters did feel that it provided an adequate level of privacy, many were concerned over the complexity of telephone based systems, and felt that they provided limited benefits when compared to other voting systems. Furthermore, the implementation of a telephone based voting system would likely be too cost-ineffective if only a small fraction of the population would benefit from using it.

4.4.8 Internet Voting

Our research has indicated that, while internet voting has many benefits associated with its use, significant challenges will need to be overcome if it is to be implemented in Denmark. The largest of these challenges is making sure the system is absolutely secure. While Estonia has successfully used a secure internet based voting system, such systems have been met with mixed success in other countries.

Visually impaired voters, however, did not believe that an internet based voting system would be acceptable. Trust and security issues associated with the internet led online voting systems to be among the least popular of the researched methods among visually impaired voters. As this project is aimed towards visually impaired voters, if so few of them would accept an internet based voting system, it is unlikely that implementing such a system would be successful if it is so ill-received by blind voters.

Interestingly, though, sighted Danish voters responded favorably to the possibility of voting online. Indeed, the majority of sighted voters surveyed stated that they would prefer

to vote online over other forms of electronic voting machines, such as DREs or ballot markers. The one stipulation was that they would only trust such a voting system if testing by the Danish government had proven it to be secure. This indicates that the Danish people place a great deal of trust in their government, and if the government trusts a voting system, the Danish populace will too.

Unfortunately, the Danish government does not seem to trust online voting schemes at this time. The Ministry of the Interior stated, in their 2011 report on parliamentary elections in Denmark, that they do not believe an internet based voting system should be used in Denmark, at least for the time being. Therefore, it is unlikely that an online voting system would be accepted by the Danish government if we recommend it to the Danish Association of the Blind.

5 Conclusions and Recommendations

The primary goal of this project was to recommend a method, or methods, of voting that allow visually impaired individuals in Denmark to vote in state and organizational elections in private. Following the background research into different methods of accessible voting, a detailed stakeholder analysis, and a thorough critiquing of the voting systems with respect to our stakeholders desires, we have provided some recommendations to the Danish Association of the Blind. These recommendations, seen below, offer a course of action for the Danish Association of the Blind to follow to help implement an accessible method of voting in state elections. Furthermore, we recommend a series of best practices for voting in organizations with visually impaired members present.

5.1 Voting in State Elections

While ballot markers are not yet as widely used as DRE machines, the advantages that they have over paperless electronic voting systems cannot be understated. Simply put, the production of a paper ballot solves most of the problems attributed to DRE machines, while retaining nearly all of the benefits that make DRE machines attractive. Because they are electronic, ballot markers are able to reduce or eliminate common voter errors that result in spoiled ballots. Furthermore, they are just as accessible to voters with disabilities as DRE machines. But by printing a paper ballot, ballot markers offer the security and trust that DRE machines lack.

Our research and analysis has led us to conclude that ballot marking devices are more secure than DRE machines because any error can be clearly seen by the voter. In effect, ballot markers are simply a high-tech and accessible pencil. Any tampering with a ballot marker that leads to an incorrect printing of the ballot can easily be detected by the voter before their ballot is cast. For visually impaired voters, a barcode containing the voter's choices could be printed at the top of the ballot. This barcode could be read back to the voter by a barcode scanner to ensure that the vote was properly printed. Because of the ability to ensure that their vote is properly counted, ballot marking devices were the most popular of all the voting systems that visually impaired voters were asked about.

The Danish government agrees that the paper ballot is an important part of the voting process. Indeed, members of the Ministry of the Interior made it clear that any electronic

voting system would likely need to produce a voter verifiable paper trail if it was to be accepted by the Danish government. This requirement stems not only from the general trust of the paper ballot, but also from the fact that the current electoral infrastructure is based around the paper ballot. Ballot markers would require a minimal change to the electoral process and could even be used side-by-side with the traditional method of voting. While the issue of printers jamming would need to be addressed if ballot markers are to be used on a national level, we believe that this problem is one that can be resolved by having back up printers present at each polling station.

Overall, we have found that the benefits associated with ballot markers far outweigh the caveats, a belief that many of our stakeholders share. Therefore, we believe that the Danish Association should push for ballot markers to be used in Danish elections.

5.2 Voting in Organizational Elections

From our findings, we have determined that visually impaired accessible voting methods can easily be implemented in organizations and corporations. There is, however, no one method of voting that is suitable in every type of organization for every type of election. Therefore, we will explain the best voting practices given several types of voting scenarios.

If the organizations is small (consisting of less than 30 members) and the vote is based around a simple yes-no topic, a basic pen and paper method should be employed by the organization. Even though blind members of the organization will not be able to see the pen or paper, any marking on the paper could be used to represent either a yes or a no. Furthermore, because the only materials required are pens, papers, and a ballot box, this method of voting is not only accessible to the visually impaired, but also simple and inexpensive.

If the organization is still small, but the vote involves more than one possible choice, then the braille booklet method should be used. While our research has shown that not all visually impaired people can read braille fluently, only number one to ten would need to be known to use a braille booklet. Indeed, in the interviews with blind voters, we learned that even those who were not literate in braille were able to use the braille booklets with relative ease. Furthermore, because the number is printed in both braille and ink, braille booklets are also usable by sighted voters.

If the organization is large (over 30 members) than we believe that the organization should investigate the possibility of using audience response systems in private elections.

While audience response systems can be expensive (costing anywhere from US\$30 to US\$150 per clicker), they can significantly improve the process of voting in large organizations and corporations, even if visually impaired members are not present. Audience response systems reduce the time associated with collecting and counting votes because they are completely electronic in nature. The ability to instantly tally results will be very useful in organizations where a large portion of the membership is blind or visually impaired, as no manual counting would be needed.

Furthermore, there are some blind accessible ARS systems currently on the market. The ResponseCard Accessibility, manufactured by Turning Technologies, includes a vibration feature that vibrates when the voters vote is counted. These ResponseCards can be purchased from the Swedish company AV-Huset at a price of approximately US\$130 per clicker. While this is expensive, it is a proven technology that is readily available. A less expensive clicker system, known as Reply, is distributed by a British company known as TeamTalk. One of these systems, the Reply Mini, costs only US\$35 per clicker. It does not, however, include any accessibility features for the visually impaired. For this reason, if the Danish Association of the Blind wishes to use the Reply Mini, we would recommend that they set up a demo with TeamTalk first.

As previously mentioned in our report, we found that no ARS offers an audio feedback feature on their clickers. The addition of this feature would allow visually impaired users of the clickers to be certain in their vote, and would greatly improve the usability of the device. We also believe that, because no audience response system provides audio feedback, there exists an untapped market for ARS with such a feature. As including an audio feedback system would be relatively inexpensive in the long run, we believe that doing so could be a rewarding investment for the first company to create an ARS with one. We therefore recommend that the Danish Association of the Blind push for the development of audience response systems with an audio feedback system.

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Appendix A: Interview Request

Hello,

We are students from Worcester Polytechnic Institute, located in the United States, working with the Danish Association of the Blind to improve voter privacy for the visually impaired. We have already conducted a preliminary analysis on different methods of voting used around the world, but would like to discuss these voting systems with visually impaired voters in Denmark. To do this, we will be conducting a series of interviews and focus groups during the week of March 28. If you are able to participate in either an interview or focus group, we would greatly appreciate it.

Interviews will last from 20-30 minutes and be conducted throughout the entire week of March 28, and on to the next week if needed. The focus group will consist of 6-15 participants and last roughly 1 hour, however light refreshments will be provided. A specific date and time will be determined when we see the dates and times that participants will be free.

Topics of discussion for the interviews and focus groups will include:

- Opinions on the current method of voting used in Denmark, and what can be done to improve it.
- Opinions of different voting systems used throughout the world, and any comments, concerns, or insights regarding such systems.
- How voting is conducted in organizations or corporations and how it can be improved.

If you would like to participate in either an interview or the focus group, please email us at denmark11-voting@wpi.edu. Include a time and date that you would be able to participate, as well as which type of discussion (interview, focus group, or both) you would be interested in participating in. Anything said during the interview will be kept private, and will only be used to assist us in analyzing and determining which voting system should be used in Denmark.

Sincerely,

Joseph Amato j.l.amato@wpi.edu

Blaise Leeber blaiseleeber@wpi.edu

Appendix B: General Interview Plan for Visually Impaired Voters

Details:

- Date:
- Time:
- Method of Contact:

Roles:

- Introduction and Questions:
- Note Taker:
- Summary:

Topics:

1. Visually Impaired Voting

- Do you feel that the current system provides you with an acceptable amount of privacy?
- How do you feel that the current system could be improved?
- Do you feel that the previous system was acceptable?
- What do you feel is an acceptable amount of privacy?
- Have you felt discouraged from voting due to the level of privacy in the current system?

2. Accessible Methods of Voting

- Braille
 - Would you feel comfortable voting with a braille ballot?
 - Do you feel that braille ballots or templates would be an acceptable solution to the problem of visually impaired voter privacy?
- Electronic Voting Machines

- Would you feel comfortable voting with an electronic voting machine?
- Would you feel more comfortable about using them if they produced a paper trail?
- Do you believe that electronic voting system would be an acceptable solution?
- Telephonic Systems
 - Do you believe that a telephone based voting system would provide an acceptable level of privacy?
 - Would you feel comfortable voting with a telephone based voting system?
 - Do you feel that a telephone based voting system of voting would be an acceptable solution?
- Internet Based Systems
 - Would you feel comfortable voting online?
 - Do you feel that internet based voting would be an acceptable solution?
- Which of the above systems would you prefer? Why?

3. Voting Within Organizations

- How have you voted within organizations that you are a member of?
- Was this an acceptable method of voting?
- Would you feel comfortable using an audience response system in organizational elections?

Appendix C: Verbal Consent Form

To be read to all participants:

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting an interview among Danish voters and members of the Danish government to learn about Danish perceptions of visually impaired accessible voting systems. We strongly believe that this kind of research will help us to determine a method of voting that allows visually impaired voters to vote privately and will be considered acceptable for use in Danish elections.

Your participation in this survey is completely voluntary and you may withdraw at any time. Please remember that your answers will remain anonymous. No names or identifying information will appear on the questionnaires or in any of the project reports or publications.

This is a collaborative project between the Danish Association of the Blind and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study.