

THE POSSIBILITIES ARE INFINITE



**City and County of Denver**  
***2006 Election Technical and***  
***Operational Assessment***

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# TABLE OF CONTENTS

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<b>ABOUT THIS DOCUMENT .....</b>	<b>4</b>
<b>1 EXECUTIVE SUMMARY .....</b>	<b>5</b>
<b>2 CHANGES AND CHALLENGES FACING THE DEC IN 2006 .....</b>	<b>7</b>
2.1 “GIVENS” – MANDATED OR UNFORESEEN CHALLENGES .....	7
2.1.1 <i>New leadership</i> .....	7
2.1.2 <i>Vacant leadership position</i> .....	7
2.1.3 <i>New machines</i> .....	8
2.1.4 <i>New scanners</i> .....	8
2.1.5 <i>Software upgrade</i> .....	8
2.1.6 <i>VVPAT</i> .....	9
2.1.7 <i>Mixed fleet</i> .....	9
2.2 “VOLUNTARY” CHALLENGES .....	9
2.2.1 <i>Voting centers</i> .....	9
2.2.2 <i>The electronic pollbook</i> .....	10
<b>3 POTENTIAL OPPORTUNITIES TO SIMPLIFY 2006 .....</b>	<b>11</b>
3.1 WERE VOTING CENTERS NECESSARY IN 2006? .....	11
3.2 WAS COMMISSIONING A CUSTOM-BUILT ELECTRONIC POLL BOOK THE CORRECT STRATEGY FOR THE DEC? .....	13
<b>4 VIABILITY OF THE VOTING CENTER MODEL IN DENVER .....</b>	<b>15</b>
4.1 THE 70,000-VOTER MODEL .....	15
4.2 THE 90,000-VOTER MODEL .....	15
4.3 INITIAL CONCLUSION .....	15
4.4 VULNERABILITIES .....	16
<b>5 SHORTCOMINGS OF THE EPOLLBOOK .....</b>	<b>17</b>
5.1 PRODUCT DESCRIPTION .....	17
5.2 PRODUCT APPRAISAL .....	17
5.2.1 <i>Inefficient session management</i> .....	18
5.2.2 <i>Inefficient database connection management</i> .....	19
5.2.3 <i>Inefficient retrieval of application data</i> .....	19
5.2.4 <i>Security</i> .....	20
5.2.5 <i>Value</i> .....	20
5.3 INFRASTRUCTURE .....	20
5.4 WARNING SIGNS .....	21
5.4.1 <i>Primary election</i> .....	21
5.4.2 <i>October</i> .....	21
5.4.3 <i>Early voting</i> .....	21
5.4.4 <i>The application itself</i> .....	21
5.5 HOW COULD THIS HAPPEN? .....	22
<b>6 CHALLENGES IN BALLOT-SCANNING .....</b>	<b>23</b>

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<b>7 TECHNOLOGY MANAGEMENT AT THE DEC .....</b>	<b>24</b>
7.1 DATA BACKUPS .....	24
7.2 SERVER MAINTENANCE .....	24
7.3 INFRASTRUCTURE .....	25
7.4 SYSTEM SECURITY .....	25
7.5 PHYSICAL SECURITY .....	25
7.6 LONG-STANDING ITEMS LEFT UNADDRESSED .....	25
<b>8 OPERATIONAL MISSTEPS IN PLANNING AND CONDUCTING THE 2006 ELECTION.....</b>	<b>26</b>
8.1 PROJECT PLANNING .....	26
8.2 CONTINGENCY PLANNING .....	26
8.2.1 <i>ePollBook contingency</i> .....	26
8.2.2 <i>Provisional ballot deployment</i> .....	27
8.2.3 <i>Supply chain</i> .....	27
8.3 QUALITY ASSURANCE AND TESTING .....	27
8.4 TRAINING .....	28
<b>9 RECOMMENDATIONS .....</b>	<b>29</b>
9.1 ELECTION PLANNING AND CONDUCT .....	29
9.2 TECHNOLOGY MANAGEMENT .....	30
<b>10 CONCLUSIONS .....</b>	<b>32</b>

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## ABOUT THIS DOCUMENT

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This document represents the final deliverable of a rapid assessment engagement commissioned by the City and County of Denver (“Denver”) and conducted by representatives of Fujitsu Consulting (“Fujitsu”). The scope of this engagement required Fujitsu, in an expeditious manner, to examine technical, operational, and organizational issues that may have contributed to the unsatisfactory conduct of the general election in Denver on November 7, 2006.

Fujitsu began work on the afternoon of November 15, 2006, and our engagement concludes with the acceptance of this deliverable by the City and County. In conducting this assessment, we relied largely on interviews with staff and leadership of the Denver Election Commission (“DEC”), elected members of the DEC, staff of the Technology Services division, and members of the Mayor’s staff. We also examined relevant information systems and historical documents when provided.

Given the compressed timeframe of the engagement, this document does not purport to represent an exhaustive examination of the many issues, errors, and obstacles that led to Denver’s frustrating experience on the day of the general election (and in the days that followed). It does represent our best effort to synthesize a large amount of information, often colored by the memories or opinions of those providing it, and draw reasoned, supportable conclusions in a rapid manner.

We first presented preliminary findings orally to the Mayor’s Election Commission Investigative Panel on November 29. That presentation was accompanied by a handout of printed PowerPoint slides. This document supersedes that handout, although the findings and conclusions contained in the November 29 handout have changed little, if at all, in the time it has taken to compile this document.

On behalf of Fujitsu, we are honored to have been of service to the City and County of Denver, and we thank the Mayor, his staff, and the Panel for this opportunity.

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# 1 EXECUTIVE SUMMARY

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The general election of November 7, 2006 in Denver was marred by significant technical and operational errors, as well as a seeming lack of needed oversight in some key areas. These errors and omissions led to unacceptably long waiting times for voters and an abandonment rate estimated at 18,000-20,000 voters (approximately 20% of the anticipated physical turnout on Election Day). In addition, seemingly preventable problems with the tabulation of absentee ballots led to significant operational stresses within the DEC and delayed reporting on key races and measures for several days.

The most direct cause of voter inconvenience on Election Day was the repeated failure of the “electronic poll book” (“ePollBook”) software, which hampered the efforts of election judges staffing voting centers to search for voters as they arrived, indicate that they had arrived to vote, and forward them to a machine to cast their votes. The ePollBook, developed exclusively for DEC use by Sequoia Voting Systems, is of decidedly sub-professional architecture and construction and appears never to have been tested in any meaningful manner by either the vendor or by the DEC. This software’s failure to accommodate Election Day traffic led to lengthy lines developing at the registration desks of voting centers while voting machines stood idle. Well-publicized media reports concerning line lengths were broadcast throughout the day and likely contributed to dampening turnout among voters without the time or determination to devote multiple hours to casting their votes.

While the ePollBook’s considerable shortcomings represent the most direct cause of Election Day angst in Denver, we must caution readers against assuming that merely repairing or replacing it will ensure the smooth conduct of future elections. That the ePollBook was deployed at all in such an unready state is symbolic of a consistent pattern of substandard information technology management within the DEC. Given the increasing dependence of election processes on technology, the state of technology management within the DEC must be recognized as an operational risk to the City and County as it looks toward future elections.

In addition to technology concerns, the DEC’s conduct of the 2006 elections suffered from inadequate contingency planning (some technical, some purely operational) and errors in logistical operations and assumptions, especially given the number of significant environmental changes with which the DEC was wrestling in preparing for this election. In 2006, the DEC was coping with new voting machines, new scanning equipment, software upgrades, vacant staff and leadership positions, new leadership, and a fundamental shift from traditional precinct-based polling places to voting centers, at which a voter from any part of the County may vote. These environmental changes, in addition to several others, represent an extremely complex problem set, and one might expect a cautious, if not ultra-cautious attitude to prevail among those responsible for the election’s conduct. Instead, planning and due diligence activities were less thorough than needed.

In analyzing the causes underlying the difficulties of 2006, it is tempting to search for a single factor, act, or error on which to place all blame. The purpose of this assessment, however, is not

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merely to diagnose what went wrong in 2006 but also to surface information of use to Denver in conducting future elections. In that light, it is critical that the failures of 2006 be viewed in an appropriately broad context that takes into account disparate factors such as planning, management, technology, interagency politics, and the degree of environmental change surrounding the conduct of the 2006 election cycle.

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## **2 CHANGES AND CHALLENGES FACING THE DEC IN 2006**

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In preparing for the 2006 election, the DEC was confronted by several significant environmental changes, some mandated or unforeseen and some voluntary.

### **2.1 “GIVENS” – MANDATED OR UNFORESEEN CHALLENGES**

#### **2.1.1 NEW LEADERSHIP**

Most of the DEC’s leadership team has only recently arrived.

- John Gaydeski, the DEC’s Executive Director, arrived in the spring<sup>1</sup>.
- Matt Crane, operations manager, was hired into a fulltime position by Mr. Gaydeski after serving as a contract employee.
- Alton Dillard, communications director, was hired into a fulltime position by Mr. Gaydeski after briefly serving as interim executive director and as a contract employee beforehand.
- Phyllis Bell-Harper, who manages election judge training and recruiting, arrived at the DEC in June.
- Amber McReynolds, absentee ballot supervisor, arrived in late 2005.

Most of this leadership team arrived at the DEC, or moved into their current, permanent positions, only after significant decisions had already been made about the course of the 2006 election cycle and events were well underway.

Further, the DEC has undergone substantial leadership churn in recent years.<sup>2</sup> This condition rarely results in a healthy organization, and there has been, in fact, considerable recent public discussion of DEC staff morale issues and organizational dysfunction.

#### **2.1.2 VACANT LEADERSHIP POSITION**

The logistics manager position is vacant. This vacancy may have contributed to shortfalls in planning and operations during the election.

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<sup>1</sup> Mr. Gaydeski tendered his resignation on December 6.

<sup>2</sup> By one report, Mr. Gaydeski is the seventh permanent executive director of the DEC in the past 10 years.

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### **2.1.3 NEW MACHINES**

Accessibility requirements of the Help America Vote Act (HAVA) necessitated the purchase of approximately 230<sup>3</sup> new voting machines from Sequoia Voting Systems. These new machines, of Sequoia’s “Edge” model, were added to Denver’s existing fleet of Sequoia “Advantage” machines. These machines required additional staff training for maintenance and operation.

These machines were not received until the summer, and some arrived as recently as the period between the primary and general elections. There is a general feeling among those interviewed that training for DEC staff was inadequate due to the compressed timeframe.

### **2.1.4 NEW SCANNERS**

New absentee ballot scanning equipment was received in June. It is reasonable to assume that unfamiliarity with this equipment contributed in some manner to the very serious operational problem that resulted in absentee ballots being hand-sorted by style due to the scanners’ inability to read mixed-style batches.

### **2.1.5 SOFTWARE UPGRADE**

Sequoia’s WinEDS software required an upgrade to correspond with the use of the new Edge machines. It is possible that unfamiliarity with this upgrade also contributed to the absentee ballot scanning problem.

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<sup>3</sup> We were given several different numbers during the course of the assessment and do not know precisely how many machines were purchased. For purposes of this assessment, the precise number is less important than the fact that, due to budgetary constraints, Denver was unable to purchase enough machines to place one in each of its traditional polling places, which necessitated some modification to its polling place strategy.

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### **2.1.6 VVPAT**

The new Edge machines come equipped with paper audit trails. This equipment required implementation of a new maintenance process to replace tape rolls in machines, a procedure that required between 15 and 20 minutes of effort. During early voting, rolls were changed nightly on each machine, a heavier-than-anticipated operational burden on DEC staff.

### **2.1.7 MIXED FLEET**

Deploying both Edge and Advantage machines in the same election introduced complexities in configuring the election within the EDS software. This is not an issue that we examined in detail, but it may also have contributed to the difficulties in scanning mixed-style batches of absentee ballots.<sup>4</sup>

## **2.2 “VOLUNTARY” CHALLENGES**

### **2.2.1 VOTING CENTERS**

When Denver determined to hold voting center elections in 2006, it introduced significant additional logistical complexity into an already complex problem set.

In terms of infrastructure, voting centers require large, open spaces that can accommodate many machines and registration stations, as well as queuing and parking space. They also require certain electrical specifications and network connectivity. In addition, they must meet accessibility requirements.

Voting centers also introduce interesting logistical complexities not encountered in traditional precinct-based models. Determining the number and location of voting centers is difficult because historical residency-based modeling data is no longer valid in a model where voters can vote anywhere in the County without regard to where in the County they live. Voting centers also greatly complicate the task of reporting results by precinct as machines are no longer precinct-dedicated.

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<sup>4</sup> Despite repeated attempts, we were unable to conclusively determine the cause of the absentee ballot scanning issue. We heard three possibilities: misprinted barcodes, an error in configuring the scanners, and an error in setting up the election in the WinEDS software. Based on reports of Sequoia’s pre-election offer to assist in resolving this problem, we assume that the second scenario is most likely to be true, but we cannot say conclusively, and no one at the DEC was able to offer a confident explanation during our interviews. DEC leadership’s vague understanding of technical failures encountered in 2006 is a theme we will return to and amplify later in this report.

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Although Denver ultimately decided not to report results by precinct in 2006<sup>5</sup>, it appears that considerable effort was expended in unsuccessfully trying to accommodate this need. It is reasonable to assume that these efforts diverted energy that could have been more profitably invested elsewhere.

Finally, voting centers, in Denver's case, may have represented a political distraction for DEC leadership. Although a stakeholders' committee had been established for the purpose of selecting voting center sites, we were told that other entities attempted to influence this process and consumed DEC leadership time with meetings on this topic.<sup>6</sup>

## **2.2.2 THE ELECTRONIC POLLBOOK**

A consequence of adopting a voting center model is the need, according to State mandate, for a real-time method of updating the poll book to indicate when a voter has voted. Absent a traditional voter-precinct affiliation, where a voter is restricted to a single polling site and his activity is recorded in a precinct-specific poll book, voters are free under a voting center model to vote at any site and are capable, unless otherwise prevented, from voting once at each site. An online poll book, updated at the time the voter votes and accessible by all polling sites, prevents fraud of this nature.

During 2004 early voting, when Denver adopted a limited voting center model, County-wide poll books were maintained separately at each location. These poll books were rationalized into a centralized database each night. This tactic would have prevented voters from voting on multiple days but would not have prevented voters from voting in multiple locations on the same day. Under more recent State requirements, this method is no longer permissible.

Therefore, Denver was required to implement some form of electronic poll book capability for deployment in 2006. Denver chose to contract with Sequoia to develop a custom-built application rather than adopting and adapting software in use elsewhere (such as Larimer County, whose software was offered free of charge to all counties). This decision added a ground-up software development effort to the growing list of complexities confronting the DEC as it planned for the 2006 elections.

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<sup>5</sup> We were told that Denver will need to resolve this problem for 2007 or 2008, however, which will complicate preparations for those elections.

<sup>6</sup> In the course of our work, interview subjects provided inconsistent or vague accounts of the process by which voting center locations were selected. While some subjects did allude to the stakeholders' committee, others did not, and enough variants of the selection process were provided to make it clear that voting center site selection was to some degree a politically interesting topic that involved many participants.

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## 3 POTENTIAL OPPORTUNITIES TO SIMPLIFY 2006

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Given the lengthy list of changes and challenges facing the DEC in 2006, were there opportunities to simplify election planning by eliminating either or both of the “voluntary” challenges described above? We believe that one challenge was very likely avoidable, while the other may have been.

### 3.1 WERE VOTING CENTERS NECESSARY IN 2006?

In raising this question, we are not criticizing the concept of voting centers per se. The voting center model features certain attractive attributes, principally the convenience to voters of permitting them to vote in any of a large number of locations spread throughout their county.

In addition, during our interviews, advocates of the voting center concept cited eventual cost savings to be realized from this model, although we believe this benefit is less clear and more debatable. Cost savings were generally expressed by advocates in terms of a lower requirement for election judges, but the consensus is that in 2006 Denver employed fewer judges than it actually needed. In addition, network connectivity costs required in each center during voting are not insignificant<sup>7</sup>. Still, it is reasonable to assume that some economies of scale would obtain under the voting center model, and an assumption of some savings in the future, as one-time implementation costs are amortized, may well be valid.

However, we noted that interview subjects frequently defended the transition to vote centers not in terms of the concept’s benefits but rather as a non-negotiable necessity for Denver to meet accessibility requirements under HAVA. We were told that Denver’s traditional polling places, as a population, were sufficiently far out of HAVA compliance that Denver was compelled to adopt the voting center model to avoid litigation.

As an alternative to introducing the complexities of voting center in 2006, we asked whether Denver could have adopted a modified traditional model in which one new HAVA-compliant Edge machine was placed in each polling place and some polling places were collapsed to account for the insufficient number of Edge machines purchased.<sup>8</sup> We were told by some

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<sup>7</sup> The DEC commissioned dedicated T-1 circuits for each voting center at considerable expense. In addition to this one-time cost, these circuits must be activated for each election, thus introducing significant recurring cost to the voting center infrastructure. Technology Services representatives have questioned the necessity of implementing T-1 circuits and have suggested that less expensive alternatives may be practical. The DEC should investigate this possibility should new voting center locations be selected for future elections.

<sup>8</sup> Denver had 292 (or 289 or 290 – the number provided varied) polling places prior to 2006, and an insufficient number of HAVA-compliant Edge machines was purchased to place one in every polling location. This would have necessitated the consolidation of some number of polling places to ensure that each contained an Edge machine.

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interview subjects that this approach was unworkable because of accessibility requirements under HAVA. Denver's old polling places, we were told, were sufficiently out of HAVA compliance that they could not be practically used for voting anymore.

We question whether this interpretation is true. In our November 29 oral presentation to the Mayor's Election Commission Investigative Panel, we noted that we uncovered no evidence indicating that Denver had ever conducted any comprehensive survey of its polling places to determine HAVA compliance. Certainly, no one had evinced knowledge of any such survey, even in response to direct questioning on the topic.

Since that presentation, we have been told that the DEC did in fact conduct a survey of its polling places in 2004. We have not yet seen this survey as it could not be located within the DEC's files (we're told that attempts are underway to retrieve it from the Secretary of State's office), and it remains unclear why its existence wasn't communicated to us during the course of our engagement.

In addition, during our November 29 presentation, we cited the behavior of other jurisdictions conducting elections as evidence against the necessity of Denver's adopting the voting center model in 2006. Adoption of the voting center model, we noted, is quite limited to date, indicating that other jurisdictions did not feel the same sense of urgency that Denver did with regard to meeting accessibility requirements.

Since that time, we have been informed that voting center adoption nationwide requires state legislatures to act and that this model is currently limited to Colorado, where several counties did in fact adopt this model. These are valid counterpoints, and we will stipulate them for purposes of argument.

Nonetheless, we believe it remains an open question as to whether Denver's feeling of compulsion to adopt the voting center model in 2006 was justified.

- Even in Colorado, not all counties adopted this model
- It is not clear that all counties that did adopt this model were motivated primarily by the need to meet strict accessibility requirements
- We heard sufficient counter-argument from attorneys (some employed by the City and County) and election officials from other counties with regard to the definition of accessibility under HAVA

Were Denver's traditional polling places so far out of compliance with accessibility requirements that they were unusable (or practically so) moving forward? At least some members of the City Attorney's office question this view.

Did Denver election officials interpret accessibility requirements with unusual strictness? Some election officials from other counties would likely say so, as they interpreted facility access

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requirements under HAVA to be equivalent to those under the Americans with Disabilities Act (ADA), which has been in effect since 1990.

This debate may simply be one with no clear answer. Well-intentioned people can interpret regulations differently.

Assuming, however, for the sake of argument that Denver's adoption of the voting center model in 2006 was a voluntary initiative, choosing not to adopt it would have simplified the 2006 problem set in these ways:

- No electronic poll book would have been required
- Considerable expense and logistical effort to locate and prepare facilities would have been avoided (or deferred)
- No time and energy would have been expended on unsuccessful attempts to report results by precinct in a non-precinct-centric model

### **3.2 WAS COMMISSIONING A CUSTOM-BUILT ELECTRONIC POLL BOOK THE CORRECT STRATEGY FOR THE DEC?**

Assuming the decision to transition to a voting center model for 2006, Denver was required to implement some form of online electronic poll book. The DEC chose to commission construction of a custom-built application from Sequoia Voting Systems. The most obvious alternative to this tactic was to adapt existing software from Larimer County, which was offered free of charge to all counties wishing to employ the voting center election model.

DEC's stated reasons for not adapting the Larimer County solution were based on fears that it would prove insufficiently robust to handle Denver's greater population of voters. Time did not permit us to examine the Larimer solution firsthand, and there may in fact be legitimate reasons why this software is inappropriate for Denver's needs. Nonetheless, the stated reasons underlying Denver's rejection of the Larimer solution do not bear scrutiny.

Larimer's software was thought to be insufficiently robust to handle Denver's population of voters, and its underlying technology was derided as "an Access database." In fact, the Larimer solution employs substantially superior technology to that employed by the DEC in 2006 and was deployed on a far superior hardware infrastructure.

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The Larimer solution is not “an Access database”<sup>9</sup>; it is a server-resident Access front-end accessed via Citrix. It employs an Oracle database, which is an exported copy of the production poll book database. Five application servers are employed, and the database resides on a dedicated server. Due to the lightweight nature of the client architecture, election judges use decommissioned County desktop computers to access the user interface.

In contrast, the DEC solution developed by Sequoia operates on a single application server<sup>10</sup>, which also houses the database. Election judges access the application via rented laptop computers. Transactions are posted directly into the production Integrity database rather than an exported copy.

Larimer’s solution is also superior in terms of redundancy. Larimer has tested the application by removing Citrix servers one by one to ensure that the application continues to operate satisfactorily. A redundant database server is also prepared and available.

In terms of robustness, Larimer has tested the application against a 1 million voter poll book with satisfactory results.

Again, there may be legitimate reasons why the Larimer solution is inappropriate or impractical for Denver, but none of stated reasons presented so far is convincing. Had Denver chosen to adapt the Larimer solution in 2006, the effort of planning the election would have been simplified by removing a long-running and troubled software development project from the landscape. Experienced help would have been readily accessible to the DEC if it were needed, and a tested solution would have been implemented.

It should be noted that adoption of the Larimer solution was unlikely to be completely cost-free to Denver. At minimum, Denver could have expected to incur some expense with regard to integration. It is very likely, however, that this solution would have proven to be considerably less expensive than the ePollBook solution that Denver pursued.

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<sup>9</sup> It’s possible that the original version of this application was in fact constructed in Microsoft Access. This version would have predated the State mandate requiring an online centralized poll book database and would have been deployed as a local poll book copy in each voting center (similar to Denver’s approach in 2004 early voting). Larimer County still deploys an Access poll book database as a local copy in each of its voting centers; this copy serves as a contingency against system failure.

<sup>10</sup> In an attempt to mitigate performance issues sometime on Election Day, Anthony Rainey, the DEC’s technology manager, attempted to augment its infrastructure by adding a second (weaker) server and a desktop computer pressed into service as a server.

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## 4 VIABILITY OF THE VOTING CENTER MODEL IN DENVER

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One of the unfortunate results of the 2006 election chaos is that technological failures (and, to some extent, operational errors) cloud any objective assessment of the viability of the voting center model for future elections in Denver.

In an effort to test the validity of the voting center model in Denver, we ran two turnout simulations that removed the ePollBook failure as a variable and assumed that it had functioned properly. Our simulations mimicked physical turnouts of 70,000 (approximately that seen on Election Day) and 90,000 (in line with DEC expectations for Election Day) voters.

We assumed 55 voting centers with an average of 20 machines each and four registration stations each. We assumed a voting time of nine minutes (eight minutes of actual voting plus transition time between voters) and a registration time of one and a quarter minutes (one minute of actual registration time plus 15 seconds of transition time between voters).

We also assumed that 80% of voters arrived at the voting centers during the busiest six hours of the day (7 AM – 9 AM, 11 AM – 1 PM, and 5 PM – 7 PM).

### 4.1 THE 70,000-VOTER MODEL

From our simulation, it appears that a physical turnout of 70,000 voters would have been comfortably accommodated with the number of centers, machines, and stations deployed in 2006.

### 4.2 THE 90,000-VOTER MODEL

The simulation of a more realistic turnout of 90,000 voters proved more problematic. There were periods of lengthy lines (approximately 90 minutes), and one can reasonably conclude that the infrastructure deployed for this election was slightly undersized for the turnout projected.

All in all, however, had the ePollBook functioned properly, the sizing efforts undertaken by the DEC for 2006 appear to have been reasonably accurate given the newness and uncertainty of the model.

### 4.3 INITIAL CONCLUSION

From these simulations, one can reasonably conclude that the voting center model is viable for Denver, at least in the abstract. Practical success, of course, will depend on locating an adequate number of facilities of sufficient size and with sufficient queuing space, as one would expect significant additional capacity to be required for the 2008 election cycle.

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To assist Denver in future planning, Fujitsu will provide, as part of its work product for this engagement, a simple capacity planning model that will allow the DEC to enter variables such as machines and stations deployed, turnout, and voting time to simulate waiting times and capacity needs.

## **4.4 VULNERABILITIES**

Our simulations did highlight the remarkable vulnerability of the vote center model to inefficiencies in the voter registration process. In the 90,000-voter model, if registration time was increased from one minute to two minutes (with no increase in registration stations), the average waiting time tripled, and the number of voters remaining in line at 7:00 PM increased tenfold.

Given these results, there is little reason for surprise at the impact of the ePollBook failure on Election Day.

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## 5 SHORTCOMINGS OF THE EPOLLBOOK

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### 5.1 PRODUCT DESCRIPTION

The ePollBook application was developed as work-for-hire<sup>11</sup> for the DEC by Sequoia Voting Systems. It is essentially a web interface to Sequoia's existing Integrity database (along with some specialized tables) and is intended for use primarily by election judges staffing voting centers.

The software's most common purpose is to prevent multiple voting by allowing a judge to search for a voter and indicate that he or she has voted. It also records the issuance of provisional ballots and produces a limited number of reports.

As no source code repository is present on the server,<sup>12</sup> we were unable to determine conclusively the development technology employed, but there is reason to suspect that Delphi was used. Microsoft's .NET 1.1 framework is also installed on the server but to no clear purpose.

The application includes a server component (an .exe file) that must be invoked before the web interface will function. The underlying database (the Integrity database) is Microsoft's SQL Server 2000.

The application employs the IntraWeb web server (from Atozed). IIS is also in use, but seems to be limited to serving image files.

The DEC agreed to pay Sequoia \$85,000 for the ePollBook, with functionality to be delivered in three phases. Media reports indicate that the DEC has paid Sequoia \$35,000 so far.

### 5.2 PRODUCT APPRAISAL

The ePollBook is a poorly designed and fundamentally flawed application that demonstrates little familiarity with basic tenets of web development. Due to unnecessary and progressive consumption of system resources, the application's performance will gradually degrade in a limited-use environment and will be immediately and noticeably hampered with a high number of concurrent users.

Moreover, it appears that this application was never stress tested by the DEC or Sequoia. No DEC staff interviewed were aware of stress testing having been conducted, and some directly reported that the Primary election served as the stress test. A Sequoia representative claimed<sup>13</sup> that the DEC intended to use the Primary election as its stress test.

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<sup>11</sup> According to a November 22, 2006 email from Waldeep Singh of Sequoia.

<sup>12</sup> The DEC should ask Sequoia to provide this.

<sup>13</sup> According to a November 22, 2006 email from Waldeep Singh of Sequoia.

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It is at best naïve to deploy enterprise software in an untested state. It is remarkably poor practice to deliberately choose a critical production event to serve as a test cycle.

As the application’s underlying database was in use by DEC staff during our engagement, we did not thoroughly test the ePollBook for fear of updating production data or otherwise hampering DEC operations. The ePollBook, however, features a sufficient number of fundamental flaws that thorough testing is not necessary to surface them.

### **5.2.1 INEFFICIENT SESSION MANAGEMENT**

Web sessions created by ePollBook appear never to expire<sup>14</sup> unless the user clicks an “exit” button to close the application. If users close the application by clicking the standard “x” control in the upper-right corner of the browser, their sessions appear to remain alive indefinitely until they are manually closed on the console or the server is rebooted.

The application’s user activity log indicates that 90% of user sessions initiated on Election Day were terminated by means other than clicking the designated “exit” button. Resource-consuming sessions therefore remained alive, increasing in number as users exited and re-entered the application.

Since the standard “x” control is actually a function of the browser rather than the application, it is not possible for any application to anticipate and correct for this user behavior. Consequently, typical web application architecture calls for this behavior to be accommodated by having dormant sessions expire after a designated period, thereby releasing their resources. In the ePollBook, it does not appear that sessions ever expire.

In media reports following the election, Sequoia defended this flaw by stating that the DEC had not requested that a session timeout feature be implemented. This is a weak and puzzling defense. In typical web application architectures (using web server products more mainstream than IntraWeb, such as IIS), there is a default session timeout value within the web server that will close idle sessions even if the application developers do not think to specify a timeout value of their own. IntraWeb message boards indicate that a 10-minute default value timeout value is provided by that product. It is unclear why ePollBook sessions did not expire in accordance with that default value.<sup>15</sup>

In any case, session management is a fundamental responsibility that developers of web applications are expected to fulfill. Describing session management as a special feature that must be requested by the client is not a reasonable position to adopt.

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<sup>14</sup> We tested up to three hours.

<sup>15</sup> It’s possible that the ePollBook developers intentionally overrode this default value. It’s also possible that a programming technique employed by the developers inadvertently rendered this default value ineffective.

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We have also seen post-election media reports in which ePollBook users are criticized for having exited the application “improperly.” The user action of clicking the “x” control to exit is normal, expected behavior and cannot reasonably be characterized as “user error.” This is what web users are conditioned to do, and properly-written web applications accommodate this conditioned behavior.

## **5.2.2 INEFFICIENT DATABASE CONNECTION MANAGEMENT**

The ePollBook opens a database connection upon presentation of the log-in page and leaves this connection open throughout the user’s session. This is an unusual and unnecessarily resource-intensive approach. Properly-constructed web applications open database connections only when needed for database interaction and close them when the interaction is complete.

Further, the application appears to maintain a one-to-one relationship between web sessions and database connections. As with web sessions, if the user exits “incorrectly” by clicking the “x” control, the database connection appears to remain alive indefinitely, thereby consuming unneeded resources.

This is a very basic and expensive flaw.<sup>16</sup>

## **5.2.3 INEFFICIENT RETRIEVAL OF APPLICATION DATA**

Upon presentation of the log-in page, the ePollBook opens a connection to the database and issues queries to retrieve data – a list of Denver street names and a list of valid identification methods. Note that this retrieval occurs before the user has logged in to the application. Oddly, it appears to retrieve this data not once, but twice, to no apparent purpose.

This data will be used by all users for common purposes such as dropdown list population.<sup>17</sup> This is an extremely inefficient means of retrieving such data. Well-constructed applications retrieve commonly needed data once at application start-up and place it in memory in application variables for use by all users. Requiring each user to retrieve this data individually places unneeded burden on the database and is very poor practice.

The effect of this inefficiency can be readily demonstrated with a cursory test. We simulated 100 users invoking the application and viewing the log-in screen. This is a reasonable approximation of what would have been happening moments before the polls opened on Election Day. We then logged in a single user and measured response times within the application. Under the strain of

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<sup>16</sup> This error would have prevented Mr. Rainey’s desperate Election Day maneuver of adding two additional application servers from having much in the way of beneficial effect. While the additional servers would have provided increased capacity for the creation of web sessions, they would not have remedied a database already overloaded with connections.

<sup>17</sup> Actually, the street name list appears to be used only in the exception case of provisional ballot issuance, rendering this inefficiency even less justifiable.

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the 100 open connections and sessions (only one of which was actually logged in), search operations slowed from less than a second to 15-20 seconds.

Even in the absence of a comprehensive stress or load test, these cursory results demonstrate unacceptable limitations in the scalability of this application.

#### **5.2.4 SECURITY**

Of less concern but worth noting are poor decisions that leave the ePollBook and its underlying database somewhat vulnerable to intrusion. The application accesses the database with an administrator account whose password is identical to that of the “SA” account<sup>18</sup>. Further, the “SA” password is weak and guessable. In addition, the application and the database are both referenced from the same URL.

Armed with the URL, a hacker could camp on the network connection, guess the database password, and intrude into the underlying Integrity database. This would require some determination and skill, and the chances of this happening are somewhat remote. This remote chance is made possible at all, however, by the sloppy conventions described above. Repairing any or all of these oversights would sharply reduce the already limited opportunities for hacking.

#### **5.2.5 VALUE**

Errors aside, functional scope of the ePollBook is quite limited, and we question whether the functionality promised and the complexity of its implementation justify a cost of \$85,000. Based on our knowledge of this application to date, this price tag appears to be unreasonably high.

### **5.3 INFRASTRUCTURE**

ePollBook and its database reside on a Dell PowerEdge 2600 dual-processor 2.8 GHz server with 4 GB of RAM and a single 73 GB SCSI hard drive. This is a reasonably powerful server, although its adequacy for hosting ePollBook cannot be conclusively determined due to the application architecture flaws that so quickly hamper server performance.

We did find three weaknesses in this server configuration that we believe should be addressed:

- The application and database currently share a server. A dedicated database server would be preferable.
- For a highly-available application such as ePollBook, multiple application servers should be employed to provide additional capacity and redundancy.

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<sup>18</sup> The “system administrator” account – a default “master” account to SQL Server databases.

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- Implementation of a hard drive array (RAID 5, for example) would provide enhanced redundancy and fault tolerance.

## **5.4 WARNING SIGNS**

It appears that there is little justification for surprise at the collapse of the ePollBook application on Election Day. Numerous warning signs presented themselves in the months leading up to the general election.

### **5.4.1 PRIMARY ELECTION**

There were public hearings following the Primary at which ePollBook failures were discussed. In addition, we have seen an email thread indicating that a representative of the Technology Services division was dispatched to consult with the DEC over an ePollBook performance issue on or about the day of the Primary.

It is unclear whether the issues alluded to in these events were identical to or different from those seen during the General Election.

### **5.4.2 OCTOBER**

Election judge training was hampered by instability of the ePollBook application, necessitating that much training be conducted using paper images. It is reasonable to suspect that the application was unfinished as late as October, therefore, despite earlier assurances given to the Mayor that it would be ready in early July.

### **5.4.3 EARLY VOTING**

A much-publicized slowdown of the application occurred on the last Thursday of early voting. The server was ultimately rebooted to clear the condition. The symptoms described appear to mirror those later seen on Election Day.

### **5.4.4 THE APPLICATION ITSELF**

The ePollBook contains a menu entry that invokes a function called “Clear all sessions.” It is unusual, to say the least, for a web application to contain this sort of housekeeping function and indicates that the developer of the software was aware of the session management issue.

It is not possible to determine whether this function was a late addition to the application or had been present all along. During our engagement, we heard several reports of a “patch” or “button” added to the ePollBook (though perhaps never used) on Election Day in an attempt to resolve the performance issues encountered. We do not know whether this “Clear all sessions” command is that last-minute patch or if the rumor is true at all.

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## 5.5 HOW COULD THIS HAPPEN?

We can only speculate as to the reasons that a new and mission-critical software product was deployed into production in such an untested and obviously unready state. The underlying factors may relate to organizational dynamics within the DEC and the late arrival of individuals in key management positions.

Responsibility for information technology management within the DEC resides with a single individual, Mr. Rainey, who is of greater tenure than most other leaders in that organization. It is possible that Mr. Gaydeski, new in his position, was overly deferential to Mr. Rainey's presumed expertise and hence did not exercise sufficient oversight or intervene with sufficient firmness when it became clear that this critical project was in trouble. That the topic was information technology may have heightened this tendency as technology is sometimes intimidating or confusing to outsiders.

Whatever the specific reason for this lapse, the conduct of the ePollBook project and the collapse of the resulting product on Election Day illustrate three key themes that the DEC must address moving forward:

- Generally substandard information technology operations and management
- Dysfunctional communications between the technology function and other leadership
- A general and pervasive insufficiency of oversight, due diligence, and quality assurance

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## 6 CHALLENGES IN BALLOT-SCANNING

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Several weeks before the general election, Amber McReynolds, the DEC's absentee ballot supervisor, was informed that all incoming ballots would need to be pre-sorted by ballot style prior to scanning by the DEC's new scanners. The scanners were reportedly unable to read mixed-style batches of ballots.

This condition had an enormously detrimental operational impact on the DEC. The processing of absentee ballots was substantially hindered, ultimately delaying the resolution of statewide and local races and initiatives. Police officers were reportedly brought in to provide additional ballot-sorting assistance, and Ms. McReynolds expressed to us her discomfort that this additional ballot-handling broke the "chain of custody" her well-documented procedures required.

The causes underlying this fiasco are unclear to this day, and it is telling that no one at the DEC can confidently offer a conclusive explanation. Several alternative explanations have been offered:

- A barcode printing error
- An error in configuring the scanner software
- An error in configuring the election in Sequoia's WinEDS software

Apparently, mixed-style batches were scanned successfully during the Primary after some intervention from Sequoia. DEC leadership could offer no explanation as to why this solution could not have been implemented for the general election.

Sequoia claims to have offered assistance to the DEC to resolve this issue and saw its offer rebuffed by Mr. Rainey. We cannot confirm whether this occurred.

DEC leadership's vague understanding of this problem's causes is further evidence of that group's unhealthy estrangement from the information technology functions of the DEC. Management should not be confused, weeks after the fact, about a technological failure that led to such catastrophic operational impact. A clear explanation should have been demanded and provided.

That the problem was not addressed with all due speed and with all available resources when discovered is further evidence of endemic substandard management of information technology within the DEC.

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## 7 TECHNOLOGY MANAGEMENT AT THE DEC

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The less-than-rigorous conduct of the ePollBook development project and the ultimate failure of the product on Election Day, along with failure to correct or mitigate the absentee ballot scanning problem, should be viewed in a broader context of substandard technology management within the DEC. Given the increasing criticality of technology in conducting elections and the sensitivity of personal data in the DEC's possession, this casual approach to technology cannot be permitted to continue.

The DEC has traditionally insisted on a high degree of independence from City and County Technology Services, although this attitude appears to be a legacy condition of previous management. In any case, the City and County can no longer afford to indulge this attitude. Technology management is a DEC function badly in need of professionalization.

Fundamental best practices are not followed, and aspects of the infrastructure are in a state of disrepair or decay.

### 7.1 DATA BACKUPS

The Integrity database, as best as we can determine, is backed up only onto the same hard drive as its production version, making data loss certain in the event of a disk failure.<sup>19</sup>

A supposed additional tape backup was not run for some indeterminate period, as the tape drive was at the warehouse several miles from the server.<sup>20</sup> There is no offsite storage of voter data; rumors of hard media stored at Arapahoe County are untrue.

### 7.2 SERVER MAINTENANCE

A post-election audit by Technology Services revealed that DEC servers had not been updated with current operating system and security patches. In addition, a check of Dell's web site revealed that the Integrity server has been out of warranty since March, contradicting an email sent to Technology Services in August giving assurances that server support was current.

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<sup>19</sup> Since the election, Technology Services has begun to copy an Integrity backup onto City and County servers.

<sup>20</sup> The tape drive was retrieved from the warehouse following the election by Rocky Rushing of the DEC staff. At the time of our engagement, however, the drive had not yet been reconnected to the server.

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## 7.3 INFRASTRUCTURE

The server room is a converted storage area with inadequate climate control and unreliable power. We witnessed a power surge shut down and reboot the Integrity server during the course of our work.

## 7.4 SYSTEM SECURITY

A post-election audit by Technology Services found dozens of active Integrity user accounts for departed employees and election judges.

## 7.5 PHYSICAL SECURITY

Access to the DEC facility is controlled by a staffed reception desk and a locked door requiring that visitors be intentionally admitted. During our engagement, this security was unevenly enforced, and the doors to the DEC offices were sometimes propped open.

The DEC facility includes two external doors that open onto the street. Although locked from the outside, these doors are often used by DEC staff to exit the facility and do not lock if they are closed gingerly.

These issues appear to have already been addressed by DEC management.

The server room is secured by a keyed door lock and appears to be regularly locked at night. Even so, the server room itself includes a street-level window, and servers are in plain view of passersby if shades are left open.

## 7.6 LONG-STANDING ITEMS LEFT UNADDRESSED

A dedicated T-1 line connecting the DEC with its warehouse has reportedly not worked since the DEC moved into its currently facility. This condition necessitated employees transporting one of the Sequoia servers between the warehouse and the DEC in private vehicles.

Provisional ballot verification, which requires connectivity to the State's DMV database, was accomplished via a dial-up connection rather than a more modern method, slowing the process considerably and frustrating staff.<sup>21</sup>

It is unclear why these issues were not addressed. To the detriment of DEC operations, there appears to have been a strong cultural reluctance to engage Technology Services for assistance in resolving technical challenges.

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<sup>21</sup> This condition has since been rectified by Technology Services.

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## **8 OPERATIONAL MISSTEPS IN PLANNING AND CONDUCTING THE 2006 ELECTION**

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Given the number of substantial changes and challenges surrounding the 2006 election cycle, the DEC appears to have approached planning and operational tasks with an insufficient degree of oversight, testing, and due diligence. From the standpoint of future elections, most of the missteps observed are easy to correct.

### **8.1 PROJECT PLANNING**

Reports from the City Auditor during the summer and fall criticized DEC management for inadequate documentation of operational plans. DEC management admitted to inadequacies in this area and is planning to ask Technology Services for assistance in acquiring and implementing Microsoft Project or some similar tool.

### **8.2 CONTINGENCY PLANNING**

DEC leadership drafted a contingency plan in June, but it is insufficiently detailed and actionable. In addition, it focused more on disaster scenarios than more likely operational breakdowns. The DEC would be well advised to draft a more explicit plan for 2007 and to rehearse, where practical, key provisions.

#### **8.2.1 EPOLLBOOK CONTINGENCY**

Contingency measures to mitigate a failure of the ePollBook application were documented, though not very explicitly, in the contingency plan. They called for the use of phone calls from election judges to a judges' help line as a first line of defense, and the use of a local poll book copy as a backup measure.

The reliance on help line staffing proved sadly inadequate as a limited number of judge line volunteers were overwhelmed with calls. The judge line staff was also impacted by the ePollBook failure and could be of limited assistance to frustrated judges.

The second line of defense, abandonment of the ePollBook in favor of a local poll book copy, was never executed, although circumstances arguably warranted that this drastic measure be taken. We consider it likely, and DEC leadership concurs, that the laptops distributed to voting centers were never equipped with this local poll book copy. As these rented laptops have been returned to the vendor and their hard drives have been wiped clean, there is no way to verify this.

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That leadership was unaware of this oversight prior to the election again speaks to unacceptably dysfunctional communications between the technology function and operational management. Clear information should have been both demanded and provided.

## **8.2.2 PROVISIONAL BALLOT DEPLOYMENT**

An inadequate number of provisional ballots was deployed to voting centers. Centers ran out of certain styles, and sample ballots and incorrect styles were substituted.

There was a general feeling within the DEC that the transition to voting centers would sharply reduce the need for provisional ballots by eliminating the previously common problem of voters arriving at the wrong polling center. In fact, the DEC's experience during the Primary election supported this assumption, as shortages of provisional ballots, also thinly distributed for that election, did not materialize.

It should be noted that provisional ballot shortages during the General election were exacerbated by the ePollBook failure, as a result of which election judges distributed provisional ballots to frustrated voters who didn't wish to remain in line. Nonetheless, a more cautious approach to provisional ballot deployment would easily be justified given the number of environmental changes faced by the DEC in this election. Douglas County, also debuting voting centers in 2006, reportedly distributed an enormous number of provisional ballots.<sup>22</sup>

## **8.2.3 SUPPLY CHAIN**

Inadequate numbers of runners were available to ferry supplies to voting centers. This issue is closely related to the problem of provisional ballot shortages and hence was also exacerbated by the ePollBook failure.

## **8.3 QUALITY ASSURANCE AND TESTING**

Many logistical or operational issues encountered by the DEC in 2006 were preventable and could have been avoided with more oversight and due diligence. It is unclear, for example, how misprinted absentee ballots were mailed without someone at the DEC catching this error. On a larger scale, we have discussed at length the failure to execute any form of meaningful testing on the ePollBook.

In general, the DEC needs to implement far more thorough testing and quality assurance procedures to prevent avoidable errors from disrupting operations.

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<sup>22</sup> It's possible that these ballots represented that county's contingency plan in case of electronic poll book failure.

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Basic project management training might benefit DEC staff in positions of responsibility. Fundamental techniques of project planning and risk management would likely have prevented at least some avoidable errors.

## **8.4 TRAINING**

Election judge training, as previously noted, was hampered by the instability of the ePollBook software that reduced most system training to using paper mockups. This may or may not have impacted voting center operations on Election Day; it may be that the software failed so utterly that judge unfamiliarity with its use might not have mattered.

Cross-training among judge roles was not done to any significant degree, and this limitation leaves voting centers unnecessarily vulnerable to no-show judges. Training judges in multiple roles would provide more flexibility in staffing voting center operations.

Election judge recruiting was hampered by the late (June) arrival of Phyllis Bell-Harper as training manager. Due to schedule pressures, Ms. Bell-Harper was forced to rely on judge pools from prior elections. Finding novel ways of recruiting election judges is challenging due to statutory nomination rights afforded the major political parties.

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## 9 RECOMMENDATIONS

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In addition to recommendations included within the body of this document, we offer the following suggestions to assist the DEC in managing future elections more smoothly.

### 9.1 ELECTION PLANNING AND CONDUCT

- Follow basic project management principles. Implement a shared project planning tool, and use it rigorously. Develop and, where at all practical, rehearse actionable contingency and mitigation strategies. Conduct proper risk management, revisiting risk factors at least weekly. In general, test, verify, and take nothing for granted. Nothing becomes a good project manager like a well-developed sense of paranoia.
- Invite a third-party auditor, perhaps another County’s election staff, to verify readiness prior to the next election, and do so in time to permit course correction.
- Simulate turnout and capacity of projected voting centers well in advance of the next election. Solicit consensus opinion from elected officials and stakeholders as to what appropriate success metrics (acceptable waiting time, for example) are for this model.
- Provide significantly enhanced communications methods for election judges to contact the DEC with problems or emergencies. Certainly, staff an increased number of help lines. Perhaps provide email and instant messaging capabilities in addition to telephones.
- Provide a reliable source of waiting time information at each polling place for use by the public. Have supervisory judges report waiting times every half-hour to the DEC. Post these times on the DEC’s web site, provide them to voter help line volunteers, and encourage local media to publicize them.
- Improve responsiveness of the voting center supply chain by increasing delivery capacity.<sup>23</sup>
- Train election judges in multiple roles to reduce voting center staffing vulnerability to attrition and no-shows.<sup>24</sup>

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<sup>23</sup> DEC management is discussing a plan along these lines that would stage supplies in vans located in quadrants of the City.

<sup>24</sup> DEC leadership is considering training some 2007 judges as “floaters” who can serve in multiple roles.

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## 9.2 TECHNOLOGY MANAGEMENT

- Repair or replace the ePollBook.

The most critical tactical issue facing the DEC is resolving the problem of the flawed ePollBook application. Assuming that Denver chooses to employ the voting center model in 2007, some form of online poll book will be required, and there is little time to waste in addressing this issue.

There are three possible strategies available to the DEC:

- 1) Repair the existing application.
- 2) Replace it with Larimer County's solution.
- 3) Replace it with a newly-built solution.

Repairing the ePollBook appears to be a practical alternative. The surface session management and connection management flaws are repairable within a couple of days of effort. The risk of this approach is that this application may contain deeper flaws that have not yet surfaced.

Should the DEC wish to pursue this option, Sequoia, a Technology Services employee, or an outside contractor may be employed. Since the DEC owns the rights to this software, it may modify it in whatever manner it wishes.<sup>25</sup>

We recommend that the first course of action, however, be to assess Larimer County's solution for fit and to ascertain the degree of effort and expense required to adopt it for Denver's use. The DEC can assess that solution for functional appropriateness. The technical effort required to adopt it can be estimated by any experienced application developer within a day or so of work.

Developing another custom poll book application, especially given the constraints of an upcoming election in the spring, should be avoided if at all possible.

- Outsource "vanilla" technology needs to Technology Services.

In terms of ongoing technology operations, the DEC should strongly consider outsourcing mainstream functions such as server and desktop maintenance to Technology Services<sup>26</sup>. There is no need for the DEC to be distracted by these requirements, and SLAs can be established with Technology Services to provide adequate service.

Since budget and staffing within Technology Services have likely been allocated to other matters, there will likely need to be some transition period in which this migration is properly planned before it is executed.

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<sup>25</sup> It is critical, however, that the DEC secure the application's source code from Sequoia.

<sup>26</sup> Discussions with Technology Services in pursuit of these goals are reportedly already underway.

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- Retain election technology expertise within the DEC.

It is unlikely that Technology Services will furnish the domain expertise in election technology that the DEC requires. The DEC should appoint members of its leadership team to stay abreast of advances and changes in available technology that might be of use in Denver. There is no requirement that this role be filled by an information technology professional as customarily defined. An interest in election technology, the ability to liaise with Technology Services, project management skills, and an aptitude for vendor management will suffice.

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## 10 CONCLUSIONS

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In organizational assessments of this sort, it is unusual for such strong emphasis to be placed on technology issues. Typically, organizational, cultural, and operational issues are in the forefront, with technology occupying a role of less prominence.

In the case of the DEC, especially when viewed with an eye toward smoother conduct of future elections, the emphases are reversed. While the DEC did commit errors in logistics, planning, and (especially) quality assurance and oversight, these mistakes are by and large easily preventable with additional effort, diligence, and some tactical procedural modifications. While significant factors in 2006, there is no intrinsic reason why these missteps need be repeated in 2007 if practical, prudent steps are taken to prevent them.

In contrast, however, the DEC's substandard management of information technology is more difficult to correct and poses a greater threat to the smooth conduct of future elections. The increasing dependence of elections on information technology will no longer permit the DEC to indulge in its customarily casual approach to technology management or its traditional insistence on independence from City and County resources. This needs to change fundamentally.

To summarize the most critical points from this assessment:

- The proximate cause of voter inconvenience on Election Day was the failure of the ePollBook application to efficiently process voters as they arrived at voting centers.
- This failure, along with the inability to efficiently scan absentee ballots, is symptomatic of an unacceptably casual and substandard tradition of technology management at the DEC that requires fundamental correction.
- In general, planning, operations, and logistics suffered from an inadequate degree of testing, quality assurance, due diligence, and oversight in a risky environment featuring many significant changes and challenges.
- Despite the problems encountered on Election Day, the voting center model appears to be viable for Denver at least in the abstract, and its future success will depend largely on locating sufficiently large spaces to accommodate higher-turnout elections.