OBSERVATIONS OF THE SCOTTISH ELECTIONS 2007

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Abstract

In the recent Scottish elections, an e-counting system was employed to manage the increased complexity of the Scottish electoral system. The elections were also the first to allow members of the public to register as election observers, accredited by the Electoral Commission. This paper discusses some of the issues that arose during observations made by the authors as observers, relating to the use of the new e-counting system.

Keywords: e-Counting, Usability, Scottish Elections, Ballot design

1   INTRODUCTION

During the course of the 2003-2007 session of the Scottish Parliament, legislation was passed which adopted the Single Transferable Vote (STV) electoral system for the election of councillors to Scotland's 32 local authorities [1], replacing the previous system of Single Member Simple Plurality (FPTP - informally known as `first past the post').

For the variant of STV used in Scotland, Weighted Inclusive Gregory (STV-WIG – see [2] for a description), elections take place in multi-member electoral wards, represented by either 3 or 4 councillors. To cast a vote in an STV election, a voter ranks candidates in order of preference (1,2 etc). A more complex process than FPTP is also used to determine winning candidates. Votes are initially distributed amongst candidates according to first preferences, with any candidate receiving more votes than a calculated quota being elected. When a candidate is elected, all of that candidate's votes are re-distributed with a value equal to the proportion of surplus votes that candidate received. If no candidate receives more votes than the quota, the candidate with the current least votes is eliminated and their votes redistributed to the remaining candidates.

Combined with previous legislation, which adopted the additional member system (for which voters are required to cast two single preference votes for a constituency MSP and for a regional list) for the Scottish Parliament [3], the effect of the new electoral system was to significantly increase the complexity of both running an election day operation and the subsequent count. To manage the introduction of the new electoral system, the Scottish Executive decided, in coordination with election officials, to partially automate the voting system for both the Scottish Parliamentary and local authority elections. An e-counting system was procured to scan and count paper ballots. In addition,

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software was procured which implemented the Additional Member and STV-WIG algorithms for electing winning candidates for the Scottish Parliament and local authorities respectively.

A number of changes to the Scottish voting system as a whole were also made, partly as a consequence of the adoption of the e-counting system, which was only one component of the larger socio-technical system. Changes to the voting system included ballot paper layout; security markings for ballot papers; ballot box design; scheduling of the declaration of results; distribution of counting centres; polling station operation; the election timetable; postal ballot papers; and the scale publicity designed to raise awareness of the changes made.

As part of the procurement process for the counting system, the Scottish Executive regularly invited political representatives, journalists and academics to view demonstrations of the e-counting system. In addition, as a result of recent legislative changes [5], members of the public were eligible to register with the Electoral Commission as election observers. This paper is the result of observations made by the authors during several of the system demonstrations and from the authors' experiences as observers on the night of the election. During observations, a range of human factors and other issues were identified with respect to the voting system, some of which have been discussed at length in the media[1]. Despite the difficulties, the voting system as a whole performed adequately, with operators often demonstrating an ability to adapt their interaction with the system to achieve tasks, or adopt "work arounds" for awkward functionalities. The introduction of new systems typically results in some disruption during implementation – elections provide a particularly difficult case, since the processes are enacted only infrequently, reducing the opportunities for incremental change to the system. The purpose of this paper is to describe some of the issues identified with the introduction of the new system to support the process of improvement for future elections.

The introduction to this paper has described the changes to electoral systems in Scotland and outlined the consequential changes for Scotland's voting system. The rest of this paper is organised as follows. Section 2 describes the changes to the Scottish voting system as a result of the introduction of e-counting, including the effect on ballot paper design. Section 3 describes the e-counting system itself, and discusses the human factors issues identified with the e-counting system. Section 4 outlines issues noted during the counts across the three locations observed. Section 5 describes wider issues with regard to perceptions of the system operation during the course of the election. Finally, Section 6 proposes some remedies for the problems identified and draws some conclusions from the experience.

2   VOTING SYSTEM

The introduction of the e-counting system caused several changes to the Scottish voting system as a whole. In addition, several innovations were implemented independently of the change to the e-count system. This section discusses changes to the surrounding voting system and their consequent impact on the election process.

2.1   Overview of Voting Process

From the perspective of the voter, some aspects of the voting process remain unchanged. All European citizens aged 18 or older and resident in Scotland were eligible to participate fully in the Scottish elections. Voting takes place in polling stations distributed across the polling districts of a constituency. For urban areas it is typical for a number of polling stations to be collected together in a single polling place. To participate in the election, voters are required to register on the electoral register, which is used to prepare a polling station's electoral roll for an election. When a voter attends the polling station, they are required to identify themselves to the polling clerk, although no

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[1] See http://www.indeedproject.ac.uk/e-counting/ for an archive of news articles.

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authentication of their identification is required. Once identified, their names are removed from the electoral roll (to prevent double voting); a ballot paper is removed from the packs for the parliamentary and local authority election; the ballot paper numbers are recorded against their electoral roll number; and they are presented with two ballot papers (see below). In contrast to previous elections, the ballot papers are not stamped with an "official mark" device, which punches a perforated pattern in the ballot paper to authorise. The voter completes the ballot papers and places them face down into a hopper on the ballot box. The ballot paper was then pushed into the ballot box to ensure that all ballot papers stacked for counting by the scanner. Voters who spoilt either of their ballot papers were entitled to a replacement.

2.2   Ballot Paper Design

Figure 1 shows the two different types of ballot paper voters used, one for the Parliamentary (AMS) election and the other for the local authority (STV) elections. The parliamentary ballot paper was split into two for the two separate votes for AMS, and colour coded as shown. The right hand column of the Parliamentary ballot paper lists candidates to be elected in a particular constituency. The left hand column listed lists of candidates for parties or independents to be elected as "additional members" of the Parliament.

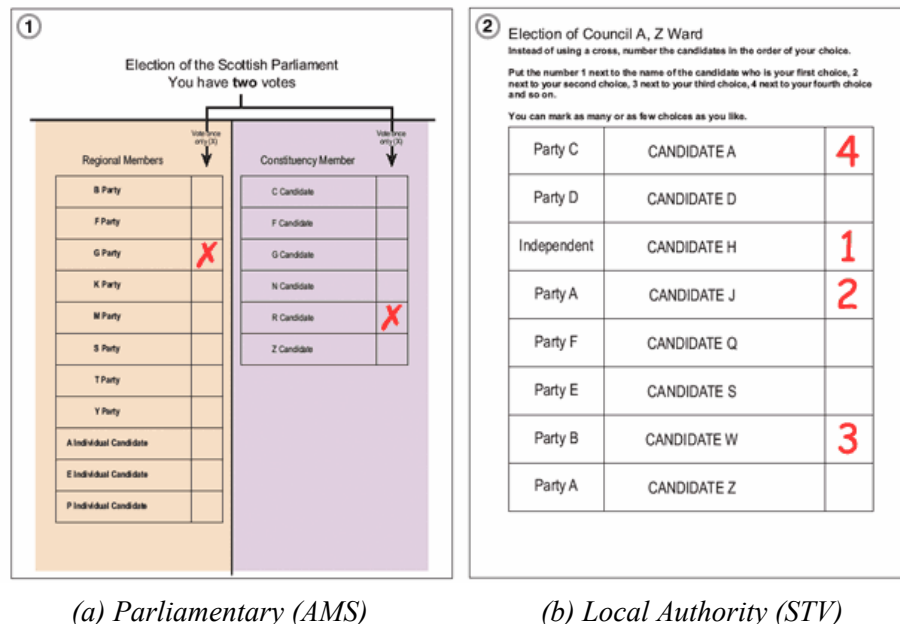*(a) Parliamentary (AMS)*   *(b) Local Authority (STV)*

Figure 1: Ballot paper design

To manage the introduction of preference voting for STV, election officials employed information officers in larger polling stations to explain the process to voters, together with large "pop up" displays explaining the process. Local authorities also developed a variety of information campaigns prior to polling day as part of a national "VoteScotand" theme, including distribution of voting information in booklets to households. Nevertheless, several issues concerning the correct completion of ballot papers became apparent, evidenced by the large number of spoiled ballot papers that were eventually recorded (in excess of 140,000 [X]). The most common mistake encountered was overvoting on the Parliamentary ballot paper. Voters misread the instruction "you have two votes" to mean that they could place two X's anywhere the ballot paper, rather than marking each side of the ballot paper with exactly one X. Voters thus commonly placed two Xs in only one column of the ballot paper, typically against candidates or parties with similar policy platforms (see Figure2). Despite the colour coding of the ballot paper and the flowchart-like instructions, many voters did not distinguish between the two

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separate votes, misunderstanding the ballot paper to be for a single choice, with two votes permitted and with candidates arranged in two columns. Interestingly the same issues occurred with the Local Authority Ballots. Voters placed X's next to each name instead of numbers, effectively spoiling their ballot in their enthusiasm to elect a given party (as no clear first preference was indicated).
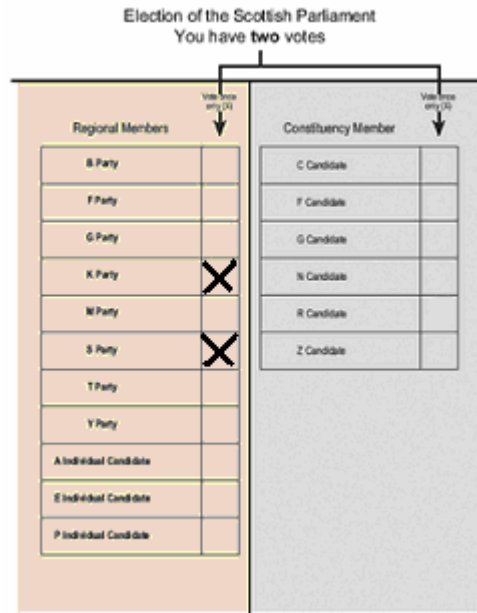

Figure 2: Ballot paper over-voting (Parliamentary)

Some Voters also completed the STV ballot paper in unanticipated ways. Instead of marking the ballot paper in order of preference of candidates, some voters placed a single number on the ballot box, which matched the row of the candidate they wished to vote for, see Figure 3:

Figure 3: An incorrectly completed local authority ballot paper

Initially, observers noted that ballot papers completed in this manner were rejected as void under rule 43(1)(b), no first preference [X]. Officials eventually realised that voters were writing the row number of their first preference candidate in the box. As a consequence, it was decided that such ballot papers could be corrected so that the voter had voted 1 for candidate 'H' only (first preference). The reasons

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behind this misinterpretation were not discovered during observations. Observers were unable to ascertain whether votes that had already been rejected were re-examined.

2.3   Voting Privacy

One consequence of the use of an e-counting system was that voters were asked not to fold their ballot papers, but instead lay them flat, face down into the ballot box (to ensure neat stacking of the papers). Whilst most voters complied with the change, a number insisted on folding their ballot papers. In addition, many of the ballot papers which were not folded were observable to polling station staff, since voters did not think to hold their ballot paper face down when approaching the ballot box, thus violating the privacy of their vote. In many cases the polling clerks could see that the voter had filled in the ballot paper incorrectly, but could not tell them their vote would be spoiled, and issue them a new ballot paper, in order to maintain the pretence of voting privacy.

2.4   Ballot Paper Production

Two issues were observed with respect to the production of ballot papers. In one constituency there were a number of books of ballots with the front and back reversed. This meant that when the ballot book was opened to remove a ballot paper, the back of the ballot paper was visible rather than the front. Fortunately, this appears to have eased the ballot paper preparation process, as the polling clerk did not have to reverse the ballot paper to obtain the balllot serial number from the back of the paper (which is recorded against the voter's electoral roll number). All the clerks who discussed this phenomena were pleased with the result of the 'accident.' As such, this may well prove to be a possible improved design for future elections. In addition, several clerks noted that discontinuing the requirement to stamp ballot papers with the official mark also eased the ballot paper preparation process and reduced the likelihood of a ballot paper being rejected due to clerical error.

A second issue was that a number of ballot books were printed slightly too long in length. This mean't that a thin strip of white paper remained at the bottom of the ballots. The scanning machines were unable to record votes on ballot papers from these books because the barcoded serial number on the reverse of the paper was not in the expected location (relative to the shape of the ballot paper). To manage this problem at the count, a group of election officials had to manually tear off the strip from the bottom before then feeding the ballot papers through the counting machines. Due to a lack of scissors at the count, officials had to repeatedly fold the papers along a tear line, then slowly try to tear down the folded lines. As such a number of ballots ended up in manual entry due to unfortunate rips during this preparation process.

2.5   Ballot Box Design

The ballot box design for the May 2007 elections was different to the black metal boxes used previously, a consequence of the introduction of the e-counting system. The scanning machines used for the e-counting process required ballot papers to be stacked and unfolded. Consequently, the new ballot boxes were designed with wide apertures (so that folding was not necessary) and a shute which ensured that ballot papers were stacked in the ballot box, rather than mixed. The observability of votes as ballot papers were placed in the ballot box is discussed above; however it is also notable that the new design changes the purpose of the ballot box as an anonymiser. The typical purpose of the ballot box is to make establishing links between ballot papers and voters a hard problem[2], as modelled by a

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[2] The task of linking ballot papers to voters is said to be hard rather than intractable because, in the UK, ballot paper numbers are recorded against voter's electoral roll numbers as a means of correcting electoral fraud [X,X].

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plethora of cryptographic/digital based voting systems [X,X,X,X]. For the e-counting system, the new design of the ballot box reduced the purpose of the box to storage.

The material robustness of the boxes was also problematic, since they were constructed from corrugated plastic. One, well reported, incident demonstrated the weakness of the boxes, when one polling place was attacked by a man with a golf club, who broke open the boxes before then ripping up the papers. The security of the boxes seals (which were stickers) was also questioned by polling clerks. There was a general belief that the boxes could be opened easily, and that this undermined the voters confidence in the system. There were instances of security tags coming loose and there were also *anedoctal* accounts of staff opening boxes to unfold folded ballots prior to the close of the polls. This compares to previous elections in which plastic tags were used to seal ballot boxes at the opening of polls; plastic tags provided better tamper evidence, since they needed to be damaged in order to be removed.

3   E-COUNTING SYSTEM

The counting system procured by the Scottish Executive consists of several stages from the opening of ballot boxes to the declaration of a result, all of which require human intervention. This section describes the aspects of the counting system relevant to this paper. The hardware provided for the count consists of a central database server, a number of paper scanning machines, a number of work stations with twin mirrored monitors; and several shelf areas used to store ballot papers at different stages of the counting process. The second monitors on work stations permitted political representatives (candidates, agents and counting agents) and observers to view the operation of the counting system and decisions made from a public area (see Figure 4). Work stations are operated by pairs of local authority staff and scanning machines by the vendor's staff. A number of count 'marshals' were responsible for moving ballot papers between stages of the count.
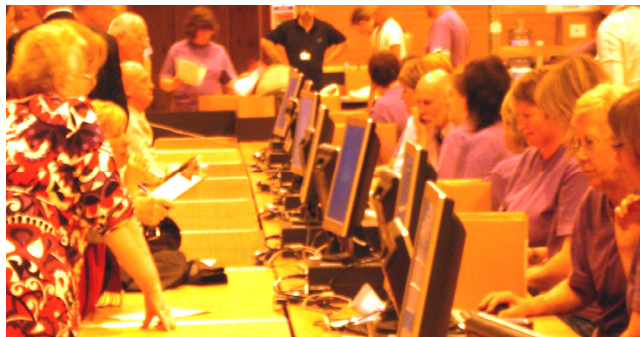
Figure 4: Operators, political representatives and

observers at the twin monitor work stations.

Initially, a ballot box is opened and the papers transferred to a cardboard *batch box*, together with a *batch control sheet* which records the number of ballot papers that were in the batch's ballot box when the box was sealed at the polling station. Ostensibly the reasoning for this simply being that the ballot boxes are large, cumbersome and not designed for situations where ballots are likely to be repeatedly loaded and unloaded. The batch box is then transferred to a shelf labelled "Awaiting Registration", before being transferred to a work station. At the work station, a bar code on the batch control sheet is scanned, which results in the work station displaying a form for the number of ballot papers in the batch to be recorded. The batch is then transferred to a shelf labelled "Awaiting Scanning" and from there to a scanning machine.

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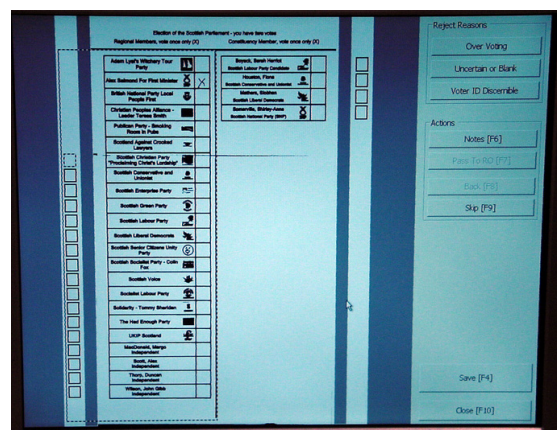Leeds Metropolitan University, Leeds LS6 3QS.

Figure 5: Scanning Machine

The scanning machine is illustrated in Figure 5. First, the batch control sheet is scanned to record which batch is to be scanned. The ballot papers are then loaded into the input hopper (top left tray) and passed through the scanner. Ballot papers that are accepted by the scanner are moved to the output hopper (lower left), whilst ballot papers that can't be scanned are moved to the reject hopper (lower right). Ballot papers that are rejected may be re-entered through the scanner, since each ballot paper is marked with a unique barcode (preventing double counting of votes). Ballot papers that are repeatedly rejected are placed into a red wallet in the batch box for later manual entry. The batch is then moved to a shelf labelled "Awaiting Verification" and from there to a work station.

The verification process provides a check that the total number of ballot papers scanned and rejected by the scanning machine matches the number expected in the batch as recorded on the control sheet. At the work station, the control sheet bar code is again scanned, and the number of ballot papers in the red wallet recorded. If the batch is verified, it is transferred to a shelf labeled "Storage", otherwise the batch is transferred to a shelf labelled "on hold" for investigation by the Returning Officer (RO the chief election official). Batches containing unscanned ballot papers (in the red wallet) are placed on a shelf labelled "Awaiting Manual Entry"), from where they are transferred to a Returning Officer's workstation. The RO (or a depute) may enter a vote manually in a similar fashion to adjudication (see below).
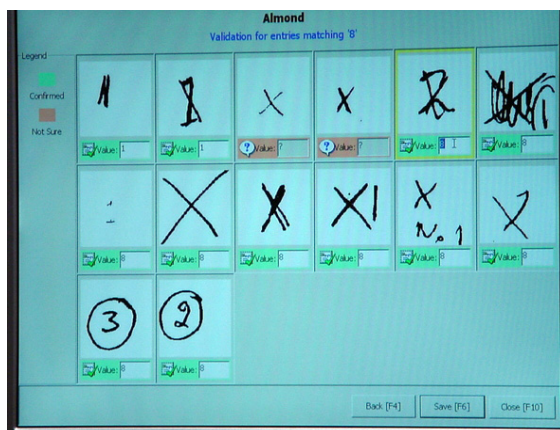
(a) Key correction (Local Authority)   *(b) adjudication (Parliamentary)*

Figure 6.

The key correction (STV only, see Figure 6a) and adjudication process provides for human correction of the character recognition decisions made by the e-counting system; typically where a voter has not marked the ballot paper in a manner that could be confidently interpreted by the software. A sizeable

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proportion of ballot papers were subject to this process. Electronic representations of batches are available for key correction and adjudication once they have been verified. The work station operator selects a batch from an available "queue" of batches listed by area name on the user interface. For key correction (the first stage), an operator is presented with a page of glyphs which the character recognition software has determined represent a particular character. The operator can choose to accept the choice made by the software, correct it, or mark the glyph as uncertain. For standard adjudication (the second stage), the operator is presented with electronic representations of the full ballot papers, the operator can correct the vote on the ballot paper, or reject the vote. For situations where a decision still cannot be made, the ballots are placed in a special Returning Officers queue for further scrutiny.

The entire process is monitored by the server which is aware of which stage individual batch boxes have reached. In addition all users log into and out of their stations in order to provide a comprehensive audit trail of operations.

Once all batches of ballot papers have been processed, the electronic representation of votes is extracted from the central database and passed to tallying software, which computes the results of the election. The Returning Officer is presented with these results for declaration.

4   COUNT ISSUES

This section discusses examples of human factors problems associated with the e-counting system observed across a number of counts.

4.1   Postal ballots

Scotland (alongside the rest of the UK) has experienced a considerable increase in the use of postal ballots and their integration with the e-count system was an anticipated issue for the count officials. In order to fit ballot papers into envelopes voters were instructed to fold them in a particular manner, which resulted in two difficulties. The folding of ballot papers introduced imperfections in the integrity of the paper, which could in turn jam the counting machines, albeit temporarily. The counting machines themselves rarely ripped ballots, and the extrication of jammed papers was clearly a design consideration, and hence this issue was containable. Secondly, the scanning process itself often picked up the fold lines on ballots as drawn lines, causing an adjudication to occur (see Figure 6b for an example, one third the way down the ballot paper). Potential remedies include the use of larger envelopes for posting ballot papers (although this may incur extra costs).

4.2   Ballot Paper Adjudication

The process of ballot paper adjudication raised a number of issues associated with the usability of the work station user interface. One of the most significant causes of frustration and wasted effort was that of the adjudication queues. These are a user interface feature which list ballot batches awaiting adjudication by constituency or ward name. There was no separation of Parliamentary and Local Authority ballots in the adjudication queues (see Figure 7), further, operators didn't have a list to tell them which were which. Initially, operators were only permitted to complete the Parliamentary count on the first night, so they had to check each queue, often, inevitably going into a local election queue by mistake, until they managed to memorise the names for the local and parliamentary areas. There was a list of areas for both elections on posters next to the declaration area as publicity within the counting halls, but the operators were unable to see these from their desks.
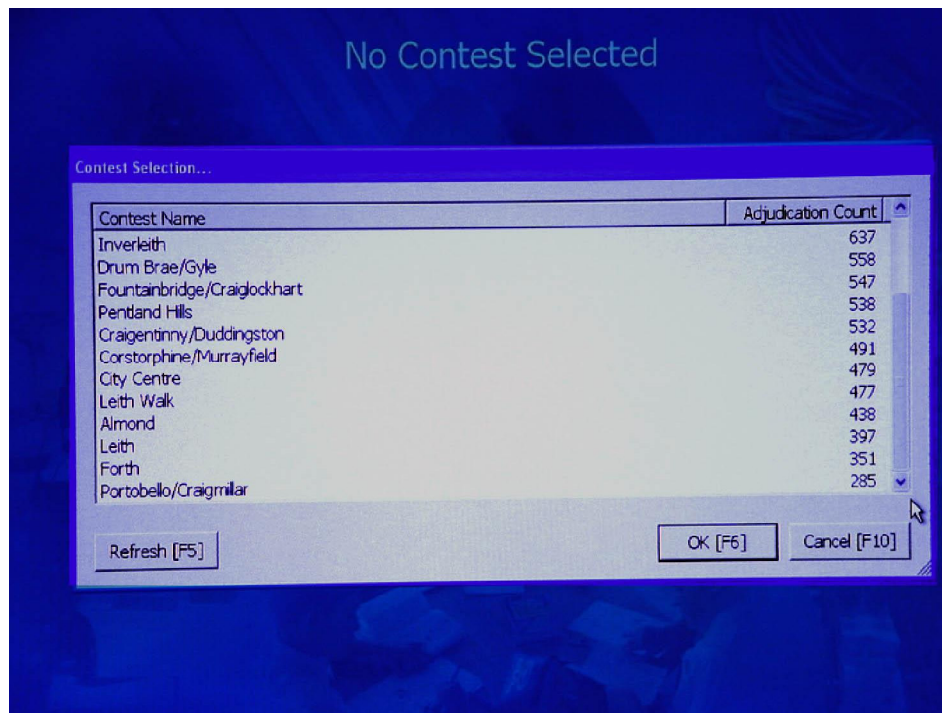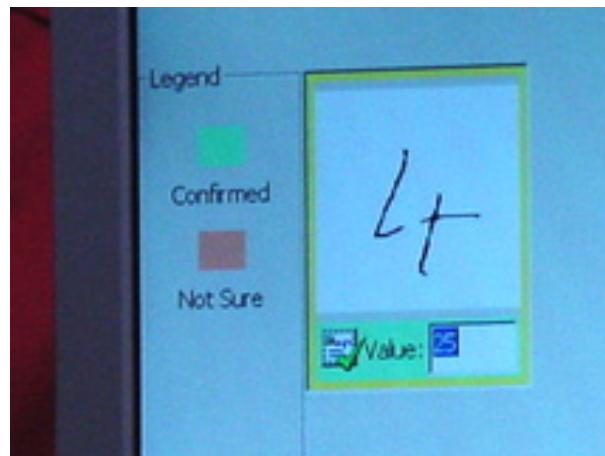
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Figure 7 Adjudication queue screen

The adjudication system interface presented three options for rejection of a ballot paper:

- **Over voting:** the most common example of which would be placing two X's on a single race.

- **Void for uncertainty:** a miscellaneous category for any situation where the voters preference is not clear; an X across two lines for example

- **ID discernable:** The UK uses secret ballots, as such a vote can be spoiled by writing an identifiable mark on the ballot paper, (e.g. writing your name / address across it)

Electoral rules [4] separate "over voting" and "void for uncertainty", however as time passed these categories tended to be used interchangeably depending on which operators were working, and in some cases the ROs deputes were observed not separating the two categories consistently themselves. This can in part be attributed to the far larger volume of adjudications to be made than in previous elections, such that consideration may need to be given to employing a larger number of depute ROs to manage the election process.

The software employed for character recognition (OCR) also presented usability problems. The confidence threshold of the OCR software was configurable. The level of confidence is the defining factor in whether a vote is accepted, or is passed to a human for adjudication. The confidence levels were defined prior to the election by DRS in consultation with the Returning Officers. These were then locked in place, they could not be changed on the night of the count to adapt to changing circumstance. This decision was reasonable given the need to re-evaluate those ballots going to adjudication when confidence levels are altered. For the election the confidence threshold was set low in order to ensure sufficient system scrutiny. However, the system would always guess a number, no matter how low its probability of correctness, if that was deemed the most likely number (see Figure 8 for an example). This proved a troublesome feature, as it was observed that as the count progressed, staff paid less consideration to the systems prompted guesses, effectively as staff lost confidence in the systems ability to aide the operator with suggestions.

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Figure 8: Software OCR during key correction

The amount of training received and/or knowledge retained on the system's features appeared to vary considerably across local authority staff. Some used keyboard shortcuts for example, whilst others were seemingly not aware of them. The software provided a zoom function for inspecting ballot papers during adjudication, but this was badly publicised. The function was accessed via the keyboard "Ctrl+Shift" key sequence. At one count two depute ROs worked independently for a number of hours on opposite sides of a room, with one using the zoom functionality, the other not. An on-screen button would have advertised the feature; indeed this was the only substantive feature of the system not accessible via the on-screen user interface.

Initially, the rate at which adjudication per ballot paper was undertaken was relatively slow. However, as operators familiarised themselves with the system, the process speeded up, particularly as staff learned to use keyboard shortcuts for functions. Although the operators were able to improve the efficiency of the e-counting system in this manner, one consequence was that the operators working partner, political representatives and observers were less able to scrutinise the adjudication decisions that were made. The time required to formulate an objection meant that the operator may have adjudicated several further ballot papers before an observer could express their concern. Although the user interface was equipped with a "back" button, this only permitted an operator to step back one ballot paper from the current adjudication – which was less useful as the operators increased their speed of operation. For example, if one ballot is adjudicated every two seconds, observing parties had a maximum of four seconds to raise an objection. In many cases by the time the observing party had turned to their associates to highlight the point, this time had passed. This limitation of the system had to be advertised to observers during the night (see Figure 9).

4.3   Environmental Factors

There is evidence that the design of the system did not take into account the environment in which it would operate. Although counting machine operators were given seats, they were too low for the operators to reach the counting machine hoppers. The counting machines rarely operated correctly for more than a few seconds at a time, with the consequence that the operators stood constantly whilst operating scanners. Operators were frequently required to collect ballot papers that were ejected from the output hoppers of the scanning machine, suggesting that the scanners had been calibrated for ballot papers of a different weight.

 There were also frequent complaints from the adjudication operators, since although they sat in a normal office style environment the system was very mouse intensive. The system forced users to

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move the mouse from one corner of the screen to another each time a vote was adjudicated. Key correction was worse for the staff, as they were not fully aware of the keyboard shortcuts available, forcing rapid repetitious movements. Consequently staff swapped roles every few minutes due to hand and arm pains. A better user interface layout, staff training and the provision of wrist supports could have greatly improved the working environment for staff. The layout of the user interface suggested that the designers of the system were not aware of common user interface design principles – Fitt's law, for example.

Figure 9: Reminder of the system's limitations

4.4   Data Entry

Having two operators to each adjudication machine worked well in reducing the number of errors; however in many cases the main advantage was to reduce the fatigue problems relating to mouse movement rather than loss of concentration.

There were also issues relating to the manual ballot entry systems; due to the fact that ballots papers for the two different votes were mixed into a single batch box for each constituency. In order to manually enter a ballot the operator first scanned the barcode on the control sheet then on the ballot paper. If the user accidentally scanned an incorrect control sheet, (there were two for each box, one parliamentary, one local) the message displayed by the system was unclear. As staff became more tired this became more frequent, in some cases leading to the RO having to deal with the problem, which was invariably caused by the staff member scanning the wrong sheet.

4.5   Usability and Security

Operator-Workstation authentication was achieved through the allocation of barcoded identification cards to all personnel, which were typically worn on a lanyard around the neck or as a clip on tag. All workstations were issued with a barcode scanner, which doubled up as the barcode scanner for manually counted ballots and batch control sheets. Workstations locked after a period inactivity for security purposes. The length of time before the screen locked however was quite long; this was most perceptible at the Returning officers adjudications, as the Returning officer deputes frequently discussed cases or left their station to perform other tasks. The use of lanyards engendered good security practice as the operators did not have to remove the lanyard to scan the barcode. However at counts where clip on tags were used staff had to remove the tag before scanning, in some counting centres staff degraded the security provided by leaving their barcode identifiers on their desk next to

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the scanner to save time, though in nearly all cases the staff member remembered to collect the badge before they left their stations.

5   PERCEPTIONS OF THE E-COUNT SYSTEM'S DEPENDABILITY

From the demonstrations and observations made of the e-count system in operation it became apparent that some consideration had been made to implement and demonstrate system dependability. The use of bar-coded badges for operator-work station authentication (with multiple levels of privileges) demonstrates some consideration for managing user capabilities on the e-count system. Further, the decision to isolate the e-count system network within the count centre reduced the potential for malicious external attack. In discussions with representatives from the vendor, it is also understood that the system's database server was mirrored across two physically separate machines, in order to provide some redundancy in the event of hardware failure.

However, it became apparent that the design of the e-count system is based on the assumption of a trusted e-count system (including trusted software developers), but non-trusted operators. Whilst the assumption made *may* be satisfactory to the election officials who procured the e-count system, it was not clear that the implications in terms of system transparency and integrity were adequately explained to candidates. For example, prior to the initiation of counting, election officials performed a "master clear down" of the e-count system's server, with the intention of demonstrating that no votes had been counted prior to the close of poll. Candidates were shown the results of system database queries which indicated that the database was empty and awaiting a known number of ballot batches. Whilst this was useful to demonstrate that the election officials had not attempted to subvert the system at the count, it did not demonstrate that the count system had not been already subverted! The assumption that the user interface provides an accurate representation of the internal state of the e-count system was not challenged, since this clearly requires some expertise in information systems.

A second example is provided by the test process used to demonstrate a system has been set up correctly. During setup, the e-count system is tested on a "known election" set of ballot papers which have previously been hand counted. The results produced by the e-count system can thus be compared to the hand-count result previously established. Whilst the test procedure does provide some indication that the system has been set up correctly it does not demonstrate that the system will perform correctly for the "live" election, since the e-count system is tested in a "test configuration" mode, rather than in the configuration for the election.

The perception of political representative's confidence in the e-counting system was initially high, as a number of demonstrations had been made during the procurement process. The system was equipped with large plasma-screen displays to provide real-time updates of the progress of the count (including the allocation of votes to candidates) for political representatives. The information operated as a slide show, indicating voting in each area in turn after 4-5 seconds of each. However, at many counts the information provided by the plasma screen was inaccurate or out of date and was eventually switched off, leaving little information as to the progress of the count. The plasma screen display showing real-time updates of the count progress was not a feature of the system discussed at demonstrations prior to the count, suggesting that it may have been a late feature added to the system. Late feature additions are often high risk procedures, since there may be inadequate time to test the feature or its effect on the larger system.

In comparison, the previous hand count system was considerably more transparent. For hand counts, candidates appoint counting agents who are able to observe the processing of all ballot papers and the votes they record. Consequently, candidates are able to obtain an estimate of the result of an election, typically within a few percent of the final result.
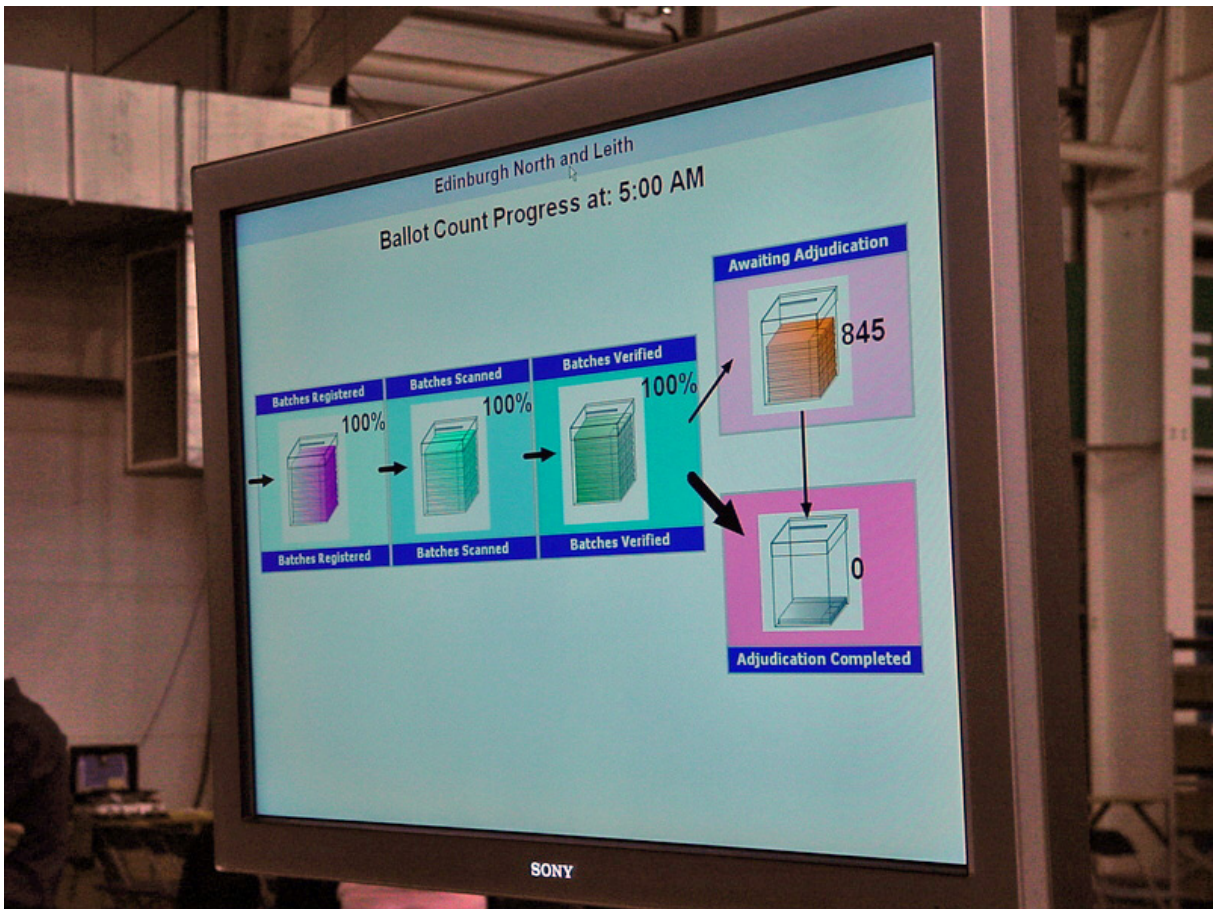
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Figure 9: Example of the information screen system

This uncertainty lowered perceived confidence and some questioned the systems transparency. To compensate, a number of political representatives were observed instead undertaking the hand tally estimates of adjudicated electronic ballots. In addition, at some counts, officials provided printouts of information extracted from the database server, effectively bypassing the plasma screens to ameliorate the lack of information provided. A remedy to this lack of information could have been to slow down the rate of scanning ballot papers, such that the votes they record are visible to observers. However, the decision was made to process ballot papers as efficiently as possible in order to obtain a result early on in the night.

6 RECOMMENDATIONS FOR FUTURE ELECTIONS

Despite the problems identified in this paper with Scotland's e-counting system, our perception of the system as a whole is that it performed relatively well for the local STV vote, which could not have been realistically achieved by a hand count; considerably less so for the parliamentary vote, which proved slower than its hand count equivalent on this occasion. Although the timetable for some of the counts was delayed by almost 24hrs, results were released for the entire country by the Friday afternoon. The introduction of new systems into existing processes is commonly fraught with difficulty and the rarity of elections as events mean that implementing incremental change is difficult. Whilst the problems described in this paper contributed to the difficulties in using the e-counting system, wider systemic issues also caused disruption and contributed to delays, which we will discuss in a future paper. Below, we propose some changes to the system for future elections:

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- The user interface for adjudication should list functionality and shortcuts in a clear, consistent fashion

- The training provided to personnel should be improved, too much variation in the application of procedures and rules was observed throughout

- The key correction should be amended to not offer avoid low confidence glyph "guesses"

- The working environment should be made more amenable to those working all night shifts in the counting centres, including the provision of mouse supports

- Provision should be considered for permitting candidates and their representatives to perform personal counts of some ballot papers (e.g. as they are passed through the scanner at an observable rate).

In addition, consideration should be made for the role of political representatives, in for example, providing for sufficient transparency of the counting system to permit independent counts. Whilst the opportunity to observe demonstrations of the system was well intentioned, they did not accurately demonstrate how the system would operate on election night. A closer involvement of political representatives in the training sessions, for example, may have highlighted problems from the perspective of an observer of the system.

7   FUTURE WORK & CONCLUSIONS

It is hoped that future observations of local by-elections will provide a contrasting viewpoint of smaller scale processes. Reports will also be submitted to both the electoral commission and local returning Officers to promote wider understanding of the issues faced in the operation of elections.

This paper has outlined the human factors related issues observed with the use of e-counting systems during the Scottish elections; provided some discussion of the causes of the problems and proposed some remedies. Our intention is not to suggest that the e-counting system failed, that the system is unusable, or should not be used for future elections. Rather, as with all new systems, observers are able to identify and propose remedies to problems not obvious to designers, thus improving the system for future use.

Note: The opinions expressed within this paper are those of the authors as observers. Due to time limitations relating to the paper deadline insufficient time has been available to verify all details with election officials.

8   ACKNOWLEDGMENTS

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