Observations of the Scottish elections 2007

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INTRODUCTION

During the course of the 2003-2007 session of the Scottish Parliament, legislation was passed which adopted the Weighted Inclusive Gregory Single Transferable Vote (WIG-STV) electoral system for the election of councillors to Scotland's 32 local authorities (LGSA 2004, Farrell & McAllister 2003). STV systems requires voters to rank candidates in order of preference (1,2 etc) and candidates are elected in successive rounds of tallying, elimination and redistribution (for a detailed explanation see Farrell & McAllister 2003).

Previous legislation adopted the additional member system for election of members of the Scottish Parliament (MSP). Additional member systems require voters to cast a single preference vote for a constituency MSP and for a list of candidates covering a larger region. The consequence of the new electoral system for local election was to significantly increase the complexity of both running an election day operation and the subsequent count. Partial automation, through the use of an e-counting system was adopted with the intention of making the election process more manageable.

A number of changes to the Scottish voting system as a whole were also made including: 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; management of postal ballot papers; and the scale of publicity designed to raise awareness of the voting process. In addition, as a result of recent legislative changes (EAA 2006), 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 election day. 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 The introduction of new systems typically results in some disruption during implementation. Elections are 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 rest of this paper is organised as follows. Section 2 outlines the methodology used for the observations. Section 3 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 4 describes the e-counting system itself, and discusses the human factors issues identified with the e-counting system. Section 5 outlines issues noted during the overnight counts across the three locations observed. Section 6 describes wider issues with regard to perceptions of the system operation during the course of the election. Finally, Section 7 draws some conclusions from the experience.

2 METHODOLOGY

The observations themselves were undertaken by observers using the ethno-methodologically informed ethnography approach first developed at Lancaster University (Martin & Sommerville 2006, Viller & Sommerville 2000 and Crabtree, Nichols, O’Brien, Rouncefield & Twidale 2000). Ethnography is the study of people in their own environment, as unobtrusively as possible. The process can be completed quickly, as in the case with this study of the election day polling stations and subsequent evening counts, or it can be undertaken over a more prolonged period of days or weeks. The data gathered for these observations includes conversations with staff, written documentation, photographs of the work environment and observations of the work processes themselves. Ethno-methodologically informed ethnography does not attempt to explain why things occur in a given way (which would require suitable sociological theories and analysis) but instead focuses on recording what actually occurs. In this particular set of observations three count centres, and over 30 polling

¹ See https://www.indeedproject.ac.uk/Iserts/Newspaper_Reports for an archive of news articles.
stations were observed between several researchers, the first time observations on this scale have either been attempted or even allowed independently for elections in the UK.

3 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 use of e-counting. This section discusses changes to the surrounding voting system and their consequent impact on the election process.

3.1 Overview of Voting Process

From the perspective of the voter, some aspects of the voting process remain unchanged. Voting still took place in polling stations distributed throughout a given constituency. Voters registered on the electoral register are placed on an electoral roll, a document used to identify voters for a given election. As in previous elections in the mainland UK, no authentication of identification is required.

Once identified, voter names are crossed from the electoral roll (to prevent double voting); a ballot paper is then removed from each of two packs (parliamentary and local authority). Ballot numbers (unique numbers printed on the ballots themselves) are recorded with the associated electoral roll number of the voter and the ballots handed to the voter. 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. The voter completes the ballot papers and places them face down into a hopper on the ballot box. Voters who spoil either of their ballot papers were entitled to a replacement.

3.2 Ballot Paper Design

Figure 1 shows the two different types of ballot papers used: one for the Parliamentary (AMS) election and the other for the local authority (STV) elections. The STV based election required the voter to number their preferences for candidates. They could use as many numbers as they wished, as long as these were consecutive from 1 upwards. The parliamentary ballot paper was split into two for the two
separate votes for AMS, which were colour coded. The voter places an X against a candidate on each side. The right hand column of the Parliamentary ballot paper lists candidates to be elected in a particular constituency. The left hand column listed party names or independents to be elected from across a larger region as ‘Additional Members’.

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

Figure 1: Ballot paper design

A variety of information sources were used to explain the new processes including distribution of voting information booklets by post, the “VoteScotand” website along with posters in polling stations and the introduction of information officers in larger polling stations.

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 (Gould 2007). The most common mistake encountered was over-voting on the Parliamentary ballot paper. Despite the colour coding of the ballot paper and the flowchart-like instructions, voters misread the instruction “you have two votes” to mean that they could place two X’s anywhere on 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 Figure 2). The similar issues occurred with the Local Authority ballot papers. Voters placed X’s next to each name instead of numbers, spoiling their ballot in their enthusiasm to elect a given party (as no clear first preference was indicated).

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:
Initially, observers noted that ballot papers completed in this manner were rejected as void under rule 43(1)(b), no first preference (SLGEO 2007). 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 behind this misinterpretation were not discovered during observations. Observers were unable to ascertain whether votes that had already been rejected were re-examined.

3.3 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 to place them in the ballot boxes flat for scanning purposes. 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 in order to maintain the pretence of voting privacy.
3.4 Ballot Paper Production

Two issues were observed with respect to the production of ballot papers. In one constituency there were a number of ballot books with the front and back reversed. This meant that staff were faced with the serial number rather than the ballot on opening, an error which was actually very useful as staff only needed to make a note of the serial number. As such, this may well prove to be a possible improved design for future elections. The discontinuation of the "official mark" also simplified the process for staff considerably and reduced the risk of unintentionally invalid ballot papers.

Some ballot books were also printed on paper which was too long. As a result, the scanning devices were unable to read the paper’s barcodes, which were expected in a particular location on the reverse of the ballot. In this case count officials had to remove the strips by hand (without scissors – they didn’t have any) by repeatedly folding and then tearing the ballots along the fold line. A number of ballots ended up in manual entry due to damage during this process.

3.5 Ballot Box Design

The design of ballot boxes was different for the May 2007 elections from 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. The new ballot boxes were designed with wide apertures (so that folding was unnecessary) and a chute 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, as modelled by a plethora of cryptographic/digital voting schemes (Fujioka et al 1992, Benaloh 1996, Chaum et al 2005, Chaum

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Footnote:
1 The task of linking ballot papers to voters is said to be hard rather than impossible because, in the UK, ballot paper numbers are recorded against voter’s electoral roll numbers as a means of correcting electoral fraud (Blackburn 1995, RPA 1983).
2005). For the e-counting system, the new design of the ballot box reduced the purpose of the box merely 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 a polling place was attacked, ballot boxes breached and ballot papers damaged. The security of the box sticker seals was also questioned by polling clerks. There was a general belief that the boxes could be opened easily, and that this undermined the voter’s confidence in the system. There were instances of security tags coming loose and anecdotal 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 need to be damaged in order to be removed.

4 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 workstations equipped with twin mirrored monitors, keyboard, mouse and barcode scanner; and several shelf areas used to store ballot papers at different stages of the counting process. The server was responsible for the management of the count, including storage of processed ballot images. Users were identified and authenticated to the system using bar-coded identification cards. 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 PlateFigure 14). Workstations are operated by pairs of local authority staff and scanning machines by the vendor’s staff. Count ‘marshals’ were responsible for moving ballot papers between stages of the count.
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.
The scanning machine is illustrated in Figure 2. 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 labelled “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).
The key correction (STV only, see Plate Figure 36a) 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 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. Alternatively for difficult cases the ballots can be placed into a Returning officer adjudication queue.

Plate Figure 36.

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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.

5 COUNT ISSUES

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

5.1 Postal ballots

Postal ballots accounted for a sizeable proportion of votes cast in the election. Folding of postal ballots (necessary to fit into the provided envelopes) introduced imperfections capable of jamming counting machines, requiring the papers to be extricated and re-scanned. The scanners also recorded the fold lines as annotations to the ballot, causing an adjudication to occur (see Plate Figure 36b for an example, one third the way down the ballot paper). One potential remedy would be to use larger envelopes for posting ballot papers (although this may incur extra costs).

5.2 Ballot Paper Adjudication

A number of usability issues were observed with the adjudication process. In particular, the adjudication queue selection window (selection of un-adjudicated batches for processing- Plate Figure 42) caused frustration and wasted effort. There was no separation of Parliamentary and Local Authority ballots in the adjudication queues; nor did operators possess documentation for this purpose. 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 memorised the names for the different areas.
In addition, the adjudication interface presented three options for rejection of a ballot paper:

- **Over voting**: placing two X’s on a single race, for example.

- **ID discernable**: The vote is void because it records the identity of the voter.

- **Void for uncertainty**: a miscellaneous category for any situation where the voter’s preference is not clear; an X across two rows for example

Electoral rules (SLGEO 2007) separate “over voting” and “void for uncertainty”, these categories were sometimes used interchangeably and in some cases the RO’s deputes were observed not separating the two categories consistently themselves. This can in part be attributed to the far larger volume of adjudications than in previous elections. Consideration may need to be given to employing a larger number of depute ROs to manage the election process.
The optical character recognition software was also a source of usability problems. When adjudicating STV ballots, the system would always suggest the most likely number, no matter how low the probability was (see Figure Plate 5 for an example). Observers noted that staff progressively paid less consideration to the system’s suggestions, as operators lost confidence in its ability to aid them.

Plate 5|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 staff, for example, did not use the provided zoom function for inspecting ballot papers during adjudication, which was accessed via the keyboard “Ctrl+Shift” key sequence shortcut. At one count two depute ROs worked independently for a number of hours on opposite sides of a room, one using the zoom functionality and the other denying its existence. 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.

As operators familiarised themselves with the system, the rate of adjudication speeded up, particularly as staff learned to use keyboard shortcuts for functions. Although greater speed improved the efficiency of the counts, the operator’s working partner, political representatives and observers were less able to scrutinise the adjudication decisions that were made. The time required to formulate an

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objection meant that the operator may have adjudicated several further ballot papers before a concern could be expressed. 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. By the time a decision had been made to raise an objection the window of opportunity had often passed. This limitation of the system had to be advertised to observers during the night (see Figure Plate 69).

5.3 Environmental Factors

Several concerns regarding operating environment were identified. For example, the seats provided for counting machine operators were too low for the operators to reach the counting machine hoppers. The machines rarely operated correctly for more than a few seconds at a time; effectively this meant that operators had to stand whilst working.

There were also frequent complaints from the adjudication operators, since although they were sitting down, their task made extensive use of the mouse. The system required users to move the mouse from one corner of the screen to another each time a vote was adjudicated. 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 (grouping common functions to avoid lengthy repetitive movements), for example.
5.4 Data Entry

Two operators were used for adjudication to reduce errors, however in most cases the main advantage was to remove mouse related fatigue problems instead, something that could largely have been avoided. Fatigue problems were not helped by the error messages exhibited by the system when encountering incorrect operations. Given the unusual nature of the count, and the time pressures, more careful design of these aspects could have aided the operators greatly.

5.5 Usability and Security

Section 3 described the use of bar-coded credentials for authenticating to a workstation. 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 for the credentials 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 the scanner to save time, though in nearly all cases the staff member remembered to collect the badge before they left their stations.

6 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; isolation of the computer system networks at counts; and mirroring of server databases at counts. However, it is clear that the technical system itself was designed to be completely trusted (as distinct from trustworthy), whilst its operators were not. This may be satisfactory to the election officials who procured the e-count system, however it was not clear that the implications were adequately explained to candidates. For example, prior to the initiation of counting, observers and political representatives were invited to observe the “master clear down”, a process to prove the server database was empty via database queries. 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 presents 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 result” set of ballot papers which have previously been hand counted. 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.

Work stations connected to large displays were used to give real-time results of count progress (see Figure 10Plate 7) from queries of the count system database. However, the common failure of this
feature undermined stakeholder’s confidence in the system. At some counts, the information was merely slow, at others the system failed completely. The displays themselves were not a feature of the system discussed at demonstrations prior to the count, suggesting that it may have been a late addition 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.

![Figure 10: Plasma information display screen](Plate 7)

**Figure 10 Plate 7: Plasma information display screen**

**TAKE IN PLATE NO 7**
This uncertainty lowered perceived confidence and some questioned the system’s 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 of 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.

7 FUTURE WORK & CONCLUSIONS

This paper has outlined some of the human factors and dependability 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.

Despite the problems identified in this paper with the 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; but 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.

It is hoped that future observations of local by-elections will provide a contrasting viewpoint of smaller scale processes. Interviews with election officials and other participants in the Scottish
Elections are planned for the future in order to gain further understanding and perspectives about the deployment of the e-counting technology.

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