

## **Part 5**

# Comparative Assessment of the Chosen System and the Paper System



## **5.1 Introduction** (*Part 5*)

In this part, the chosen electronic voting system is compared with the current paper system of voting in Ireland.

In June 2004 the Houses of the Oireachtas approved an order of the Government requesting that the Commission include in its further reports on the chosen system a comparative assessment of the secrecy and accuracy of the current system (i.e. the paper system) for voting at elections and referenda. This order is set out together with the Commission's terms of reference earlier in this report.

In accordance with this order, the Commission has assessed both systems in respect of their secrecy and accuracy. This assessment has been carried out in the following ways:

Firstly, the secrecy and accuracy attributes of both systems were identified and compared as set out in *section 5.2* of this part. For completeness, other relevant attributes of both systems were also identified and compared but these were not included in the overall comparative assessment as they did not relate to secrecy and accuracy. These are set out separately in *Appendix 5A*.

Secondly, the potential risks to secrecy and accuracy in both systems were identified, assessed and compared as set out in *section 5.3* of this part. In addition to providing independent validation and corroboration of the secrecy and accuracy criteria already considered in *section 5.2*, this assessment of risk also provided a method by which to rank their significance.

The comparative assessment has been informed by knowledge derived from the Commission's first report<sup>62</sup> on the chosen system and from its further work for the purposes of this report, namely, in assessing technical aspects of the chosen system as described in *Part 3* and physical and operational security aspects as described in *Part 4*. The comparative assessment has also been informed by the expert opinion and work of persons engaged by the Commission and having specialist knowledge and experience of the Irish electoral system.

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<sup>62</sup> First Report of the Commission on Electronic Voting, December, 2004.

## **5.2 Comparative Assessment**

This section describes the Commission's work in identifying and comparing secrecy and accuracy criteria as between the chosen system of voting and the paper system. For completeness, additional criteria other than those relating to secrecy and accuracy have also been considered by the Commission. However, while these criteria are discussed separately in *Appendix 5A*, they have not been included in the Commission's comparative assessment for reasons that are set out below.

### **5.2.1 CRITERIA FOR COMPARISON**

There are undoubtedly many performance-related and other criteria on which the chosen electronic system and the existing paper system might be compared. However, the Commission is required by its terms of reference to have regard to only those criteria which relate to secrecy and accuracy.

Although this may at first appear to narrow down considerably the range of possible useful points of comparison between the two systems, it can be seen from what follows in this part that the most significant evaluation criteria for any voting system fall clearly within this remit.

While criteria relating to secrecy and accuracy are thus very important criteria on which to compare both systems, it is appropriate to note at this point that they may not have been the only criteria that informed the original decision to adopt the chosen system. For example, speed of counting is an important and obvious characteristic of the chosen system in this context but, because it is not a determinant of its secrecy or accuracy in accordance with the Commission's terms of reference, it thus falls strictly outside the scope of the Commission's comparative assessment.

In its previous reports, the Commission has been confined by its terms of reference to considering only the chosen system and no other system of voting. The inclusion of the paper system within the Commission's terms of reference for the purposes of comparative assessment in this report has thus provided an additional point of reference for the Commission's work. This has enabled consideration of a number of additional secrecy and accuracy attributes that, although present in the paper system, are absent from the chosen system and that were thus unavailable for consideration by the Commission heretofore. Included among these is the facilitation of audit.

The inclusion of the paper system within the Commission's terms of reference has also brought more clearly into focus a number of secrecy and accuracy attributes of either system - some of them absent in the other system - which were previously considered only peripherally in the Commission's earlier reports. These attributes include the facilitation of tallying and recounts.

Additionally, and as indicated above in the context of criteria that may have informed the decision to adopt the chosen system, the Commission has identified other important attributes without which any comparative assessment of both systems would be incomplete. These attributes have also been assessed and compared but, as they do not relate to the secrecy and accuracy of either system, they have not been included in the Commission's overall assessment and conclusion on the comparative assessment. These attributes (which include the facilitation of deliberately spoiled, blank or null votes, ease of use, general vulnerability to malpractice, speed of counting, scalability, reliability, cost and flexibility, transparency and voter trust) are considered and discussed separately in *Appendix 5A*.

## 5.2.2 ACCURACY CRITERIA

### **Accuracy: Recording of Votes**

The following criteria relate to issues of accuracy that may arise during, or as a result of, the vote recording process under either system.

#### *C.1: Accidentally Spoiled Votes*

The chosen system eliminates the casting of invalid ballots, which comprise 1.6%<sup>63</sup> of all ballots cast at elections and referenda in Ireland since 1985. As approximately half of such ballots are believed to be accidentally invalid (i.e. through inadvertent voter error in the marking of preferences or for want of the official mark), and as such accidents are eliminated under the chosen system, the chosen system is superior in this respect.

Issues relating to the deliberate spoiling of votes and the consistency of behaviour of either system in facilitating this practice are discussed separately in *Appendix 5A* as they do not relate to the secrecy and accuracy of the handling by either system of votes actually cast.

#### *C.2: Unintentional and Precipitate Votes*

A related issue concerns the electronic user interface of the voting machine. The procedure for indicating preferences and casting ballots on the voting machine, particularly at multiple elections, may cause voters to indicate preferences and/or cast ballots which, although valid, are not the ballots that they had intended.

For example, the user interface may give rise to “precipitate” voting, whereby voters may press the “cast vote” button prematurely, and confirm this action, in the mistaken belief that it is necessary to record each ballot, or each preference within a ballot, separately. These “usability” issues concerning the voting machine are discussed in greater detail in *section 3.2.1* of *Part 3* of this report.

Under paper voting, both the method of expressing preferences and the point at which the ballot is cast are more easily understood and implemented; these features of the paper system are thus likely to deliver a more accurate expression of voter preferences, considering the full range of voter abilities. The paper system is superior in this respect.

#### *C.3: Incorporation of Postal Votes in the Count*

Under paper voting, ordinary ballot papers are issued by post to registered postal voters, who then complete their ballots and return these by post. Once accounted for and authenticated from the accompanying documentation, these ballot papers are mixed with the ordinary ballot papers and included in the count.

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<sup>63</sup> Source: Official election results supplied by the Department of the Environment, Heritage and Local Government.

Under the chosen system, postal voters will continue to vote by the method described above. Before these ballots can be included in the electronic count however, they will have to be entered into the electronic system by election officials using a voting machine. It is proposed that one official will enter the preferences recorded on each ballot and another will check its accuracy before the vote is cast.

Tests carried out previously by the Commission for the purpose of its first report<sup>64</sup> suggest that the error rate in respect of the manual entry of pre-determined votes into the chosen system is 0.1% under “laboratory” conditions and 0.34% in the field. Significant also in this respect is that the Commission’s tests involved a three-way check on each ballot before it was cast. Although the number of postal votes is small<sup>65</sup> relative to the total electorate, it is nonetheless likely that a small proportion of these votes would be entered incorrectly under the chosen system. The paper system is superior in this respect.

### **Accuracy: Counting of Votes**

The following criteria relate to issues of accuracy that may arise during, or as a result of, the counting process under either system.

#### ***C.4: Major Counting Errors***

Given the transparent conditions under which Irish elections are currently conducted in open public view using the paper method, the likely occurrence of major counting errors is extremely low, while the likelihood of a widespread occurrence of such errors in such a way as to affect the overall outcome of an election is virtually nil. The chosen system does not offer the same levels of transparency in the gathering, translocation, sorting and counting of votes since these processes are carried out by electronic means largely out of sight.

Having regard to the fact that relatively minor programming and other errors in the design of electronic systems can have disproportionately large impacts on the tasks those systems have been designed to carry out, it is clear that the potential for an inaccuracy in the counting of votes to go unnoticed is greater under an electronic system than under the paper system.

The likelihood and significance of widespread counting errors is magnified further by another characteristic of electronic systems that are made up of identical distributed devices running identical software, namely, that if a programming error is present in one device then, by definition, it is more than likely to be present in all of them.

A further well-known characteristic of electronic systems which makes it difficult to exclude the possibility of major computer error arises from the fact that a threat to any particular software function may emanate from a part of the system other than the software in question unless appropriate precautions are taken in the design of the system to limit the interdependence, interaction and unnecessary integration of discrete functions. In the case of the chosen system, the integration of counting functions with other election management functions of the system software

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<sup>64</sup> First Report of the Commission on Electronic Voting, December, 2004: Appendix 2C p.170-179. 97 votes were recorded incorrectly, 22 were absent and 6 were additional giving a total of 125 errors out of 36,950 “target” votes.

<sup>65</sup> The Department has indicated that the total number of postal votes is 20,000.

makes this a relevant issue.

Although these weaknesses of electronic systems generally can be largely overcome by rigorous design, testing and assurance stages, combined with the implementation of appropriate audit measures within such systems, the Commission's work in relation to technical aspects of the chosen system suggests that these conditions are not met in respect of the chosen system at this time. The paper system is superior in this respect.

#### *C.5: Minor Counting Errors and Recounts*

From observation of the results of recounts at Irish elections, there is strong evidence to suggest that minor counting errors are widespread and indeed almost inevitable in the paper system. These can be attributed to human error in the assignment and counting of ballots, and to reinterpretation of the validity of individual ballots by returning officers, as often occurs in close elections or during recounts.

A recount is triggered at the request of some candidate, typically in a very close election, where the candidate has reason to believe, given the inevitable minor counting errors that arise with hand counted paper votes, that a recount would yield a different result. Recounts are never used as routine audits of election results that are not in contention. In this sense provision for a recount is a direct response to the many minor errors that arise with a paper ballot and that may materially affect the outcome in very close elections.

While the impact of such minor errors in the paper system is reduced by the fact that they are often "self-cancelling", and while their salience in the paper system is further reduced by the possibility for candidates to demand recounts until they are satisfied with the level of counting accuracy, both types of error are effectively and verifiably eliminated by the chosen system.

Furthermore, under the chosen system, the correctness of any particular election result can be easily and quickly verified by recounting the same set of electronic votes using an alternative counting program. By eliminating inaccuracies due to minor counting and interpretation errors, and by reducing the consequent requirement for recounts, the chosen system is thus superior in this respect.

#### *C.6: Random Sampling*

Under the existing paper system, random sampling is used to determine the proportional distribution of the surplus ballot papers of an elected candidate among the remaining candidates. Of its very nature, this is an imperfect method of counting which can, in theory, give rise to different results when recounts are carried out on the same set of ballot papers, particularly when the numbers of votes involved are relatively small such as at local elections.

In practice however, recounts at Irish elections are conducted on the basis of re-examination of the ballot papers arranged in the same bundles as they emerged from the previous count or, in the case of a full re-count, on the basis of the first preferences as originally assigned to each candidate. Thus the ballots are never randomised again in the same way as when they are first removed from the ballot boxes and in most cases a recount simply involves confirming the correct placement of each ballot within its assigned bundle. Any differences in recounts that arise under the paper system as a result are thus less likely to be caused by random sampling than by human error in the counting and

assignment of ballots and reinterpretation of the validity of individual ballots by returning officers.

As a similar approach to random sampling has also been implemented in the chosen system, there is little to separate both systems in this respect.

### *C.7: Alternative Counting Methods*

Given that random sampling is a prescribed characteristic of the existing method of Irish electoral counting rules which, although imperfect in terms of its accuracy, is implemented on near-equal terms by both the chosen system and the paper system, a further point of comparison lies in the potential ease of migration to a better method of counting. One such method would be the “Gregory method” (of which there are also different versions) under which every ballot paper of an elected candidate is examined to determine the proportional distribution of the surplus votes to the remaining candidates.

To date, no version of the Gregory method has been implemented for Dáil, European or local government elections in Ireland, probably on the basis that it is more complex to administer and would add considerably to the time and effort required to complete large election counts manually. The feasibility of migration to a more perfect and accurate method of counting is thus a point of difference between both systems, since it would be a relatively simple matter to program the chosen system to implement the Gregory method. The chosen system is superior in this respect.

### *C.8: Randomisation of Ballot Papers*

Additionally under the paper system, the effectiveness of this random sampling method in generating an accurately representative sample is somewhat reliant on the thorough mixing or “randomisation” of the ballot papers when they are initially removed from the ballot boxes. The automation of this process within the chosen system, by way of an electronic shuffling of the electronic vote data file, can potentially deliver a more effective initial mixing of the ballot papers than any manual method. The chosen system is superior in this respect.

### **Accuracy: External Influences**

In addition to the inherent properties of either system, already described, that may have a bearing on the accuracy of election results, it is also necessary to have regard to those properties that may leave either system open to deliberate disruption or accidental loss of service from external influences resulting in possible consequences for accuracy.

### *C.9: Denial or Loss of Service*

A significant point of comparison in this respect derives from the fact that votes are recorded, gathered and counted in full public view under the paper system, while the visibility and verifiability of these activities is considerably diminished under the chosen system of electronic voting. Ballots that are recorded in an electronic format – and that are subsequently moved, aggregated, counted and generally handled at all stages of the election process by electronic means – are perceived to be inherently more vulnerable to both deliberate attack and/or inadvertent error



than paper ballots. It is also the case that the various hardware devices implemented as part of any electronic voting system are perceived to be more vulnerable to malicious interference and/or inadvertent error than the tried, tested and trusted “human” hardware of paper voting in Ireland.

While these vulnerabilities can be mitigated by the incorporation of appropriate security features in the design of electronic systems and by administrative procedures, evidence from the Commission’s work in *Parts 3 and 4* suggests that these conditions are not met in respect of the chosen system at this time and that, in some cases, the same security protections and administrative procedures that apply to the paper system have merely been carried over into the electronic system. The paper system is superior in this respect.

### **Accuracy: Facilitation of Audit**

A central concern in relation to the “accuracy” of any voting system is not only its fundamental accuracy (in the sense that election results perfectly reflect the expressed intentions of voters) but its demonstrable accuracy (in the sense that an independent observer can ascertain that all the votes cast have been recorded and aggregated into a final election result). This implies that all aspects of the voting administration processes around the recording and counting of the votes can be audited. Without the possibility of audit, an independent observer cannot know that any voting system is accurate; if a system cannot be demonstrated to be accurate, it possibly may not be accurate.

In the particular context of audit at Irish elections, there has existed statutory provision for the courts to order that paper votes cast at an election be counted afresh on the same basis as they were originally counted. Further provision has also been made, including by section 47 of the Electoral Act 2001 and section 16 of the Electoral (Amendment) Act 2004, to ensure that votes cast electronically using the chosen system can also be counted afresh on this basis.

#### ***C.10: Audit: Vote Recording***

The vote recording process is audited under the paper voting system in the sense that the voter can physically inspect the ballot paper that will actually be counted by election officials before depositing it in the ballot box. Election observers at the count station then physically observe the emptying of ballot boxes; these are opened by election officials facing towards the observers, to show they are fully empty so that all recorded votes cast are seen to be counted.

Under the chosen system, the voter sees a display on the voting machine showing the preferences that have been registered, and can check that these preferences correspond to the buttons pressed. However, the voter has no way of verifying that what appears on the display is what is actually recorded electronically on the ballot module within the voting machine, transmitted to the count centre, loaded onto the count computers, and actually counted in the correct manner. This is because what is counted, the electronic vote, cannot physically be observed.

Although it is possible to audit the vote counting process of the chosen system by re-counting the same set of votes that were included in the original count (see below), this provides no assurances with regard to the vote recording process that has gone before. In response to this problem, laws have been enacted in the United States, where electronic voting is becoming increasingly widespread, requiring some form of paper audit trail to be implemented by electoral authorities who use electronic voting systems. This involves using voting machines that generate a printed version

of the ballot. Where a voter verifiable paper audit trail is required, this paper ballot is typically kept behind a screen so that the voter cannot touch it. The voter must review the paper version and approve it as part of the act of casting a vote before it is deposited by the voting machine in a traditional ballot box at the same time as it records the vote electronically. Similarly, in other countries that have adopted electronic voting, the vote is recorded on paper by the voter themselves in the first instance but in a format that is “machine-readable” and can subsequently be scanned or otherwise read in by a machine, recorded electronically and thus incorporated in an electronic count.

In either case, the paper ballots are retained by election officials, with the consequence that an election can be fully audited with reference to manual vote records if required, using printed ballots that voters have seen and approved as reflecting their intentions. While the paper ballots may not necessarily require to be referred to in this way in every case, such a requirement may arise from a contested result, or it may be a sample count that is audited as part of routine checks to ensure the system is working accurately.

Since the chosen electronic system does not have this facility, and while it does provide features to facilitate a degree of independent audit in its vote counting function, together with features that facilitate audit at the administrative level and confirmation of statutory compliance, it is not subject to any meaningful independent audit of its vote recording function. Thus the paper system is superior in this respect.

### *C.11: Audit: Vote Counting*

In addition to the requirement for recounts and the possibility of demanding them during the counting of votes at an election as already discussed, the primary context in which it is necessary to be able to audit an election count following the declaration of the overall result derives from the possibility of an election petition to the courts as provided for under Irish electoral law. For this purpose, a court may order that all of the votes be counted afresh or that the votes within a particular parcel be counted.

Under the chosen system, the vote counting process can be audited for this purpose since all the electronic votes can be printed out in paper format, together with details of which votes were randomly selected for transfer at each count, and how they were transferred. In order to compensate for the loss of counting transparency and the consequent elimination of the possibility of independent “tallying” under the chosen system, it also proposed to publish the electronic vote file to any interested parties after the election. This allows anyone who wishes to do so to recount the same votes under the same rules, using an alternative electronic counting system of their own choice that implements Irish electoral law. This is why the publication of “anonymous”<sup>66</sup> electronic votes is an important feature of the chosen system.

The existing paper system also allows votes to be officially recounted under public scrutiny on demand during the election and, afterwards, for the purposes of an election petition to the High Court. In either case however, as noted previously, the accuracy of the recount under the paper system may be susceptible to minor errors in manual counting and reinterpretation by election officials of “ambiguous” ballots on which the preferences have not been clearly indicated.

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<sup>66</sup> Publication of “anonymous” electronic votes is described in paragraph *AC.8* of *Appendix 5A*.

Provided that all anonymous electronic ballots are published after the election, therefore, the chosen system is superior in this respect.

### 5.2.3 SECRECY CRITERIA

#### **Secrecy: Recording of Votes**

The following criteria relate to issues of secrecy that may arise during, or as a result of, the vote recording process under either system.

#### *C.12: Breach of Secrecy – Ordinary Voting*

The Constitutional provisions for elections in Ireland require that voting be conducted by secret ballot and the Courts have ruled that this secrecy must be complete and inviolable. In this context, there is little to separate the two systems as regards the surveillance actions or other attacks that might be undertaken by a determined third party during voting in order to identify how an individual voter has voted.

Secrecy issues concerning the voting machine and ballot module used to record votes within the chosen system have been discussed in *Part 3* of this report. The significance of these issues as potential vulnerabilities in the context of the technical review carried out in *Part 3* lies not in the likelihood of their occurrence but in the importance of ensuring that there are adequate safeguards within the system to protect against and detect any theoretical attempt by third parties to exploit them – this has implications for both the actual security of the chosen system and also for its public credibility. For the purposes of the present assessment however, their likelihood is considered to be low, given the degree of difficulty in effecting widespread interference with voting equipment or surveillance of voters across a significant number of polling centres.

As the Courts have further ruled that it must not be possible for the voter to prove to any third party how they have voted, the Commission has also considered ways in which the secrecy of the ballot may be breached under either system in circumstances of collusion or duress. However, and notwithstanding the distinction that under the chosen system, any breach of secrecy arising at the vote recording stage that allows the voter to prove how they have voted must take place at the point of voting (i.e. at the voting machine within the polling centre) while it is possible under the paper system to remove the ballot paper from the polling centre and to mark it under supervision before it is placed in the ballot box, the Commission concludes that the differences between the two systems in this particular respect are negligible.

Therefore, and notwithstanding that there are minor theoretical differences between the systems as regards the somewhat remote feasibility of breaching secrecy by direct means during voting, it is concluded that there is little in practice to separate the two systems in this respect.

#### *C.13: Breach of Secrecy – Postal Voters*

As indicated above in relation to accuracy criteria regarding postal voting, the ballots returned by postal voters under paper voting are accounted for and authenticated from the accompanying documentation before they are mixed with the ordinary ballot papers and included in the count. Before these ballots can be included in the electronic count under the chosen system, they will have to be entered into electronic format by election officials using a voting machine to key in the

preferences recorded on each paper ballot.

This additional process necessitates that the votes cast by post in a particular constituency must inevitably be subjected to additional handling and review by election officials and election observers alike who could, in theory, observe the distribution of preferences across all postal ballots or the actual preferences cast in individual cases.

While it is extremely unlikely that this additional review will give rise to the disclosure of the actual preferences cast by individual postal voters, even in constituencies where the postal voting electorate is very small, it nonetheless represents a diminution of the overall secrecy of the ballot as regards those votes which are cast by post. The paper system is superior in this respect.

### **Secrecy: Counting of Votes**

The following criteria relate to issues of secrecy that may arise during, or as a result of, the vote counting process under either system.

#### ***C.14: Secrecy: Tallying***

When paper ballots are first inspected by election officials for the purpose of verifying which ballots are valid and which are not, each ballot paper is reviewed by officials face up under the scrutiny of observers. Some of these observers are “tallymen” who are agents for particular candidates or parties and who count, ballot box by ballot box, the number of first preferences and, in the case of experienced tallymen, lower preferences for each candidate. This gives the tallymen and those they represent a lot of detailed information about voting patterns at the level of individual ballot boxes - information that is very useful in planning future election campaigns.

There is a long tradition in Ireland of the “tallying” of paper ballots which can also provide a useful informal method of audit as an indicator of accuracy. However, there are many who argue that it infringes the secrecy of the ballot since it is generally known which ballot boxes relate to which streets and townlands, typically comprising only a few hundred voters and, in many cases, fewer than a hundred votes. As there is no corresponding feature of the chosen system by which it would be possible for observers at the count to associate the preferences recorded on individual ballot papers with voters from particular districts, the chosen system is superior in this respect.

#### ***C.15: Artefacts of Voter Identification Process***

Under the paper system of voting as it was originally implemented in Ireland, the reverse of each ballot paper and the face of its corresponding counterfoil (the “stub” left in the book of ballot papers) were imprinted with a unique identifying number. When assigning a ballot paper to a voter, the number of that voter in the electoral register was also recorded on the counterfoil and retained by the election official. The stated purpose of this practice was to facilitate election administration, in particular election petitions, by making it possible to identify any ballot papers in respect of which it was alleged that personation or other electoral offences had been committed. However this practice was ruled by the Courts<sup>67</sup> to constitute a breach of the constitutional requirement of secrecy

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<sup>67</sup> *McMahon v Attorney General* [1972] IR 69, (1972) 106 ILTR 89.

since a voter's identity could be traced from their ballot to their name on the register, and the practice was accordingly discontinued.

Under paper voting, the only remaining physical artefacts of the process whereby voters are identified from the register and issued with ballot papers are (i) the voter's polling card retained by the presiding officer, (ii) the fact that the voter's name has been marked off the register, and (iii) the ballot paper itself which is transferred into the counting process.

Under the chosen system, the corresponding physical artefacts are (i) the voter's polling card retained by the presiding officer, (ii) the fact that the voter's name has been marked off the register, (iii) the voting slip issued to the voter once they have been identified by the presiding officer and which the voter gives to the voting machine operator to indicate which polls they are entitled to vote in. No voter identification information is passed to the voting machine or transferred into the counting process.

There thus exists, within the counting process under paper voting, a physical artefact of the voter identification and voting processes which is absent under electronic voting because the physical link between voter identification, voting and counting is broken at the point of voting. In the event that an election official (or the voter themselves) sought to mark a paper ballot in such a way as to make it identifiable during the count, this represents a secrecy vulnerability of the paper system that is absent in the chosen system. The chosen system is superior in this respect.

One design feature of the chosen system that facilitates its superiority in this respect is the fact that it does not incorporate an electronic voter identification and authentication function. Registration of voters in Ireland is currently a manual process and, while the concept of electronic registration may have advantages in other respects, it is clear that the incorporation of such a function as an integrated part of any electronic voting system could raise additional issues regarding the secrecy of that voting system.

#### 5.2.4 SUMMARY OF COMPARATIVE ASSESSMENT

Following the identification, assessment and comparison of secrecy and accuracy criteria as between the chosen electronic system and the existing paper system of voting in *sections 5.2.2 and 5.2.3*, the results of the comparative assessment are summarised and discussed below. Within each category, the criteria have been listed in order of their importance in the opinion of the Commission. A unique reference to the relevant paragraph within the preceding sections of this part in which the discussion of each criterion can be found is indicated in each case (*C1*, *C2*, etc.).

##### **Summary of Accuracy Criteria**

The accuracy of the chosen system is superior in the following respects:

- prevention of accidentally spoiled votes (*C.1*);
- avoidance of minor counting errors and recounts (*C.5*);
- ease of implementation of alternative counting methods (*C.7*);
- facilitation of independent audit in vote counting process (*C.11*);
- randomisation of ballot papers (*C.8*).

The accuracy of the paper system is superior in the following respects:

- avoidance of major counting errors (*C.4*);
- avoidance of denial/loss of service attacks (*C.9*);
- avoidance of unintentional and precipitate votes (*C.2*);
- facilitation of independent audit in vote recording process (*C.10*);
- incorporation of postal votes in the count (*C.3*).

Additionally, there is little to separate both systems in terms of their implementation of random sampling to determine the distribution among remaining candidates of the surplus votes of an elected candidate (*C.6*).

##### **Summary of Secrecy Criteria**

The chosen system is superior in terms of its ability to limit or preclude breaches of the secrecy of the ballot in the following respects:

- elimination of unofficial “tallying” (*C.14*);
- non-transfer of voter identification artefacts into count process (*C.15*).

The paper system is superior in terms of its ability to limit or preclude breaches of the secrecy of the ballot in the following respect:

- for postal voters as a whole (*C.13*).

Additionally, there is little to separate both systems in terms of their ability to protect the secrecy of the ballot for all voters against covert third-party surveillance, and in circumstances of collusion or

duress, during voting (*C.12*).

### **Analysis of Secrecy and Accuracy Criteria**

No conclusion can be drawn simply on the basis of the number of attributes in respect of which each system is recorded above as differing from the other; different attributes can carry significantly different weights. The Commission has not attempted to quantify precisely the relative weightings of these attributes, although the analysis and comparison of risks in *section 5.3* goes some way towards prioritising them.

One reason the Commission has refrained from quantifying the weight that should be assigned to any particular attribute lies in the fact that the Commission's consideration of the chosen system is confined to its secrecy and accuracy. Although it has been possible for the Commission to reach a conclusion on this basis and without assigning such weights, there are also other valid points of comparison as between both systems which are of significance but which lie outside the Commission's scope – some of these are considered in *Appendix 5A*.

Since it is unlikely that it will be sought to change any aspect of the paper system at this stage, any change in the balance of superiority between the two systems can only come about through proof and/or enhancement of the chosen system.

It is clear from the comparative assessment that the issues of principal concern as between both systems relate more to accuracy than to secrecy. It is also clear from the Commission's work reported in *Parts 3* and *4* that most of the secrecy issues regarding the chosen system, together with some of the accuracy issues, can be easily addressed through minor modifications to the hardware or software of the chosen system or through revision of the electoral law or the administrative procedures for deployment of the system.

For example, the behaviour of the voting machine could be modified so as to reduce the likelihood of unintentional or precipitate voting, while the risk of interference with its software or hardware could be reduced by enhanced controls on access to its services and procedures to facilitate independent verification that the installed software and hardware versions are the correct ones. The introduction of alternative electronic methods for the recording of preferences by postal voters and disabled persons who require assistance in voting would enhance the secrecy and accuracy of the processes by which these voters' ballots are recorded and incorporated into the count. Greater protection of the anonymity of individual ballots would be achieved if publication of the counted ballots was confined to only those higher preferences within each ballot that were necessary (or were used) to determine the election result.

The significant differences as between the two systems thus relate to accuracy and the weight of evidence on these suggests that the paper system is superior to the chosen system as currently proposed, but that this can be addressed if the reliability of the chosen system can be assured.

The Commission's review of technical aspects of the system in *Part 3* has indicated that the necessary level of assurance in respect of the chosen system can be achieved through modification of the hardware, through further analysis of the embedded software necessary to confirm its reliability and through the development, at feasible cost, of alternative election management and counting software.



### **Areas of Unambiguous Difference Between Systems**

It can thus be said that some differences in terms of secrecy and accuracy between the two systems are marginal, and furthermore that the overall balance of superiority on these criteria in favour of the paper system may change if feasible modifications are made to the chosen system. Other differences will not change without major interventions in the design and deployment of the chosen system, followed by further analysis and verification of the revised system. However, there are also areas where one or other system can be said to be unambiguously superior and, in some cases, that this is likely to remain so.

The chosen system is unambiguously superior in the following areas:

- prevention of accidentally spoiled votes (*C.1*);
- avoidance of minor counting errors and recounts (*C.5*);
- ease of implementation of alternative counting methods (*C.7*);
- facilitation of independent audit in vote counting process (*C.11*).

The paper system is unambiguously superior in the following respects:

- avoidance of major counting errors (*C.4*);
- avoidance of denial/loss of service attacks (*C.9*);
- facilitation of independent audit in vote recording process (*C.10*).

### **Finding as a Result of Comparative Assessment**

If, in addition to addressing the relatively trivial secrecy concerns identified by the Commission, the accuracy concerns regarding the chosen system were also addressed, and if the resulting version of the chosen system can be proven to be reliable, then it is likely that the chosen system would be a superior method to the paper system. Meanwhile, and on the basis of the comparative assessment in terms of secrecy and accuracy reported in this part, the paper system of voting is moderately superior overall, and in some respects only marginally superior, to the chosen system as it is currently proposed.

This is not a new finding but one that represents a revised perspective on the observations and conclusions reached by the Commission in its previous reports and developed in the other parts of this report.

Taken in conjunction with the comparison and analysis of risks in *section 5.3*, this finding contributes to the Commission's conclusion in *section 5.4* regarding the comparative assessment of the chosen system and the paper system.

### 5.3 Comparison of Risks

In addition to the comparative assessment of secrecy and accuracy of the chosen system and the paper system as described in *section 5.2*, a risk assessment was also carried out which considered risks that are common to both systems as well as risks that are unique to either system.

As with the comparative assessment, the risk assessment was confined, in accordance with the Commission's terms of reference, to considering only those risks that related to the secrecy and accuracy of either system.

This risk assessment was carried out independently of the comparative assessment already described in *section 5.2* but it has been taken into account by the Commission in reaching its conclusion on the comparative assessment in *section 5.4*.

#### Identification and Classification of Risks

##### *Identification of Risks*

The risk assessment included consideration of 61 risks as set out in *Appendix 5B*. For ease of reference, each risk is identified in this section by the reference number (**R.1**, **R.2**, etc.) assigned to it in *Appendix 5B*. The 61 risks relate to the chosen system and the paper system as follows:

- 24 risks are common to both systems;
- 12 risks are unique to the paper system;
- 25 risks are unique to the electronic system.

These risks are identified and discussed in detail in the analysis further below.

##### *Classification of Risks*

The risks considered included risks of both widespread and isolated (systemic and non-systemic) occurrence as well as risks occasioned either accidentally or deliberately (by error or malpractice). Within these categories, the detailed classification<sup>68</sup> of risks by type is as follows:

- Risks of non-systemic error: risks **R.1** to **R.21**;
- Risks of non-systemic malpractice: risks **R.22** to **R.36**;
- Risks of systemic error: risks **R.37** to **R.55**;
- Risks of systemic malpractice: risks **R.56** to **R.61**.

It will be noted that, in some cases, there is no systemic risk corresponding to a non-systemic risk

<sup>68</sup> Explanation of risk classifications:

Non-systemic Error (NE) = accidental occurrences on a small scale;  
 Non-systemic Malpractice (NM) = deliberate interference on a small scale;  
 Systemic Error = accidental occurrences on a wide scale;  
 Systemic Malpractice = deliberate interference on a wide scale.

identified in the assessment. Following examination of these cases it was considered that while there was some risk of isolated occurrences (such as in the case of voter intimidation or sabotage), the risk of widespread occurrences of this kind was negligible and could be disregarded.

### *Further Classification of Risks*

For ease of reference and discussion in this section the risks identified have been further classified into the following groups:

- Voter identification: **R.12, R.13, R.14, R.16, R.24, R.43, R.44, R.45** and **R.58**.
- Invalid ballots: **R.18, R.19**, and **R.20**.
- Recording errors: **R.5, R.6, R.7** and **R.39**.
- Counting or interpretation errors: **R.11, R.21, R.42, R.51, R.52, R.53** and **R.55**.
- Machine or process failures: **R.1, R.2, R.3, R.10, R.15, R.37, R.38, R.41, R.46, R.47, R.48, R.49, R.50** and **R.54**.
- Accidental damage: **R.4, R.8, R.9, R.17** and **R.40**.
- Interference with ballots: **R.25** and **R.26**.
- Interference with equipment: **R.27, R.56, R.60** and **R.61**.
- Attempts to influence elections: **R.22, R.23, R.28, R.29, R.30, R.57** and **R.59**.
- Official malpractice: **R.31, R.32, R.33, R.34, R.35** and **R.36**.

## **Analysis of Common Risks**

### *Overview of Common Risks*

Of the 24 risks that are common to both systems, the assessment of risks in *Appendix 5B* indicates that –

- 8 risks are higher in the chosen system;
- 7 risks are higher in the paper system;
- 9 risks are broadly similar in both systems.

These common risks are listed below in order of the magnitude of the *difference* in risk between the two systems, rather than in order of magnitude of the risk itself.

### *Common Risks that are Higher in the Chosen System*

The 8 common risks that are higher in the chosen system are as follows:

- Accidental voter identification (small scale) (**R.12**),
- Alteration of ballots (wide scale) (**R.59**),
- Voter coercion or bribery (**R.28**),
- Substitution of ballot box/ballot module (**R.29**),
- Disabled voter identified (small scale) (**R.14**),
- Postal voter identified (small scale) (**R.13**),

- Postal voter identified (wide scale) (**R.44**),
- Disabled voter identified (wide scale) (**R.45**).

When summarised by risk grouping, these risks relate to voter identification (5 risks) and interference with elections (3 risks). Of these risks, the majority are accidental risks to secrecy while the remainder are deliberate risks to accuracy.

From this it is suggested that, in terms of comparing the risks that are common to both systems, the greater, and the more numerous, risks under the chosen system are the risk of voter identification in certain cases and the risk of interference with elections.

#### *Common Risks that are Higher in the Paper System*

The 7 common risks that are higher in the paper system are as follows:

- Inherent fault in counting process (**R.51**),
- Accidental miscounting of ballots (small scale) (**R.11**),
- Accidental miscounting of ballots (wide scale) (**R.42**),
- Accidental damage to ballots during transportation (small scale) (**R.8**),
- Deliberate damage to ballots during storage or transportation (small scale) (**R.26**),
- Error in translocation/uploading of ballots (small scale) (**R.10**),
- Loss of ballots (small scale) (**R.3**).

When summarised by risk grouping, the majority of these risks relate to counting or interpretation errors (3 risks) and process failure (2 risks). Other risks relate to accidental damage (1 risk) and interference with ballots (1 risk). No risks to secrecy are highlighted by this analysis as being higher in the paper system.

From this it is suggested that, in terms of comparing the risks that are common to both systems, the greater, and the more numerous, risks under the paper system are the risk of counting errors and the risk of irretrievable loss or damage to ballots (there being no backup arrangement under the paper system<sup>69</sup>).

#### *Common Risks that are Similar in Both Systems*

The 9 common risks that are broadly similar in both systems are as follows:

- Votes accidentally lost during counting (**R.48**),
- Impersonation (small scale) (**R.23**),
- Interference with ballots during storage or transportation (small scale) (**R.25**),
- Impersonation (wide scale) (**R.57**),
- Adding votes before opening of poll (**R.31**),
- Power failure at a polling station (**R.2**),

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<sup>69</sup> It was noted in *section 5.2*, paragraph *C.9* above that the paper system is superior in terms of ensuring the integrity of election data. There is a difference in assessment here because, while there may be a greater likelihood of loss under the chosen system the fact that there is a backup ballot module means that the impact of the loss is reduced.

- Deliberate voter identification (small scale) (**R.24**),
- Incorrect outcome resulting from sampling error (**R.54**),
- Deliberate voter identification (wide scale) (**R.58**).

When summarised by risk grouping the majority of these risks relate to machine or process failures (3 risks), attempts to influence elections (2 risks) and voter identification (2 risks). Other risks relate to interference with ballots (1 risk) and official malpractice (1 risk).

From this it is suggested that, in terms of comparing the risks that are common to both systems, they are subject to broadly similar levels of risk to accuracy from accidental process failures (as opposed to inherent or built-in ones) and from deliberate (as opposed to accidental) risks to secrecy.

### **Analysis of Unique Risks**

For the purpose of analysing the larger numbers of risks that are unique to each system, the risks are described by reference to their group classifications as set out above. The groups are listed below in order of the number of risks in each group while the risks within each group are listed in order of risk magnitude on the basis of the assessment of risks in *Appendix 5B*.

#### *Risks Unique to the Chosen System*

The 25 risks identified that are unique to the chosen system may be summarised as follows:

- Machine or process failures (**R.37, R.46, R.15, R.38, R.41, R.49, R.50, R.1** and **R.47**),
- Interference with equipment (**R.61, R.56, R.27** and **R.60**),
- Recording errors (**R.39, R.6, R.5** and **R.7**),
- Accidental damage (**R.17, R.4, R.9** and **R.40**),
- Voter identification (**R.16** and **R.43**),
- Inherent fault in counting hardware (**R.52**),
- Substitution of ballots in CD (**R.30**).

From this it is suggested that in terms of risks that are unique to the chosen system, the greatest, and the most numerous, are those relating to machine or process failures (9 risks), interference with equipment (4 risks), recording errors (4 risks) and accidental damage (4 risks). Unique risks of lesser magnitude in the chosen system relate to voter identification, counting or interpretation errors and attempts to influence elections.

#### *Risks Unique to the Paper System*

The 12 risks identified that are unique to the paper system may be summarised as follows:

- Official malpractice (**R.32, R.33, R.36, R.34** and **R.35**),
- Counting or interpretation errors (**R.53, R.55** and **R.21**),
- Invalid ballots (**R.18, R.19** and **R.20**),
- Alteration of ballots (small scale) (**R.22**).

From this it is suggested that in terms of risks that are unique to the paper system, the greatest are those relating to counting or interpretation errors (3 risks) and invalid ballots (3 risks). Unique risks of lesser magnitude in the paper system relate to official malpractice (although these risks are more numerous) and attempts to influence elections.

### **Analysis of Risks to Accuracy and Secrecy**

The risks to accuracy under either system and the risks to secrecy under either system are considered separately below, including risks that are common to both systems and risks that are unique to either system.

#### *Accuracy*

The risks to accuracy that are highest in the paper system are as follows:

- Counting or interpretation errors (**R.51**, **R.53**, **R.55**, **R.11**, **R.42** and **R.21**),
- Invalid ballots (**R.18** and **R.19**).

The risks to accuracy that are highest in the chosen system are as follows:

- Alteration of ballots (wide scale) (**R.59**),
- Software error in voting machines (small scale) (**R.15**),
- Widespread tampering with count software (**R.61**).

From further examination of the above risks, it is suggested that the risks to accuracy in the chosen system are fewer and of lower magnitude than in the paper system. However, this is based on the assumption that the chosen system can be shown to be reliable and behaves as intended in all other respects. The validity of this assumption is addressed in other parts of this report.

#### *Secrecy*

The risks to secrecy under both systems are low. The risks under the paper system are generally lower than under the paper system with only marginal differences between both systems. In this context, the only areas identified by this analysis in which the risk to secrecy is notably higher (but still very low) in the chosen system are as follows:

- Abstaining voter identification (spoiled, null or blank ballot) (small scale) (**R.16**),
- Accidental voter identification (small scale) (**R.12**).

### **Findings as a Result of Risk Assessment**

The assessment of risks as reported in this section provides a more quantitative basis on which to consider many of the accuracy and secrecy attributes of the chosen system and the paper system already considered qualitatively in *section 5.2*. On this basis, and although some points of comparison are unique to each assessment, there is nonetheless significant correlation between the

findings of the two assessments which were conducted independently of each other.

In particular, the risk assessment corroborates and reinforces the principal findings of the comparative assessment as follows:

- In relation to accuracy, the principal difference between the paper system and the chosen system is that there is a very small risk of widespread systemic error and/or fraud in the chosen system which does not exist in the paper system. If functioning correctly, the chosen system has the potential to eliminate the widespread minor counting errors inherent in the paper system.
- In relation to secrecy, the paper system provides a higher level of secrecy than the chosen system but the chosen system could be modified to improve the level of secrecy it provides.

## **5.4 Conclusion on Comparative Assessment**

This section sets out the Commission's conclusions on the comparative assessment of the chosen system and the paper system based on the criteria identified in *section 5.2* and the risks identified in *section 5.3*. The Commission's conclusions arising from its work in relation to other aspects of the chosen system are set out, in each case, at the end of the other relevant parts of this report. The Commission's overall conclusion on the chosen system is set out in *Part 7*.

It is important to re-state that no conclusion can be drawn simply on the basis of the number of attributes or risks in respect of which each system is recorded above as differing from the other; different attributes or risks can carry significantly different weights. It has not been necessary for the Commission to assign these precise weightings since, when those attributes and risks which appear to the Commission to be of lesser importance are set aside, the balance of superiority is clear in terms of criteria of obviously greater importance.

Furthermore, since this comparative assessment relates only to attributes concerning secrecy or accuracy, in accordance with the Commission's terms of reference, it does not include the wider range of attributes and risks which, if included with appropriate weighting, might yield a different result.

On the basis of the Commission's consideration of these attributes and risks, and having regard also to their relative rankings as suggested by the risk assessment carried out by the Commission, it is concluded that:

- issues of accuracy arise in relation to both systems while issues of secrecy are relatively insignificant under both systems;
- the chosen system has the potential to be superior to the paper system in many significant respects concerning its accuracy;
- both systems are broadly similar in terms of secrecy and, while the chosen system can be improved to match the high standard of secrecy offered by the paper system, it is unlikely to exceed this standard;
- the achievement of the full potential of the chosen system in terms of secrecy and accuracy depends upon a number of software and hardware modifications, both major and minor, and more significantly, is dependent on the reliability of its software being adequately proven.

The Commission accordingly concludes that, when compared in terms of secrecy and accuracy, the existing paper system is moderately superior overall to the chosen electronic system as currently proposed for use in Ireland (and in some respects only marginally so). However, the Commission's work has highlighted modifications to the chosen system and the procedural arrangements for its deployment, together with further software analysis and testing of the system as a whole that could potentially remedy this situation.

The aspects of the chosen system that require modification in this respect have been highlighted specifically in this part in terms of secrecy and accuracy and in *Parts 3* and *4* as regards technical and operational aspects that have a bearing on its secrecy and accuracy. They are also reflected in



the Commission's recommendations in *Part 8*.

Taking account of the ease and relative cost of making some of these modifications, the potential advantages of the chosen system, once modified in accordance with the Commission's recommendations, can make it a viable alternative to the existing paper system in terms of secrecy and accuracy.

These conclusions on the comparative assessment of the chosen system and the paper system of voting have been drawn, and should be interpreted by others, in the context of the Commission's conclusions arising from other aspects of its work set out elsewhere in this report. This includes the Commission's work on technical aspects and testing (*Part 3*) and on physical and operational security aspects of the chosen system (*Part 4*). These conclusions are also incorporated within the Commission's overall conclusion on the chosen system in *Part 7*.

