



SECOND REPORT

of the

Commission on Electronic Voting

on the

**Secrecy, Accuracy and Testing of the
Chosen Electronic Voting System**

AN DARA TUARASCÁIL

ón

gCoimisiún um Vótáil Leictreonach

maidir le

**Rúndacht, Cruinneas agus Tástáil an Chórais
Vótála Leictreonaí atá Roghnaithe**

Second Report of the Commission on Electronic Voting

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Foreword

I am pleased to present to the Ceann Comhairle this second report of the Commission on Electronic Voting concerning the secrecy and accuracy of the Nedap-Powervote electronic voting system chosen for use in Ireland. The Commission's first report was presented in December 2004, an interim report having been presented in April 2004.

The Commission's work has taken place at a time of considerable change with regard to electronic voting. In many jurisdictions the introduction of electronic voting, accepted in use elsewhere for some years, has been subject to increasingly close scrutiny by voters, politicians, political scientists, computer experts and the media. As a result, electoral administrators and the manufacturers of electronic voting systems have been required to review and adapt their policies and systems to meet the challenges of new expectations and requirements of electronic voting and to answer questions that rarely arose for paper voting systems, as well as new questions about electronic voting.

Ireland is no exception to change in this regard and, when viewed in the light of these developments, the decision in 1999 to adopt the chosen electronic voting system for use at elections in Ireland, based partly on its successful track record in Holland and elsewhere, must have appeared a much more straightforward matter than it has since transpired to be. Indeed, the breadth and complexity of the issues that have arisen in the Commission's work suggest that no electoral administration anywhere has so far really come to terms with all of the issues raised by the introduction of electronic systems in place of paper voting systems. Not least among these is the issue of public confidence and the ability of voters to trust electronic systems in the same way as they have previously trusted election officials and manual systems.

For these reasons, and because of the in-depth nature of its examination of the chosen system, the Commission felt it would be remiss of it not to make observations and recommendations, where appropriate, on certain matters arising from its work that were not strictly within its remit but that would undoubtedly be of value in the consideration of electronic voting generally. These matters are accordingly considered separately in an appendix to this report but the Commission has not relied on them in reaching its findings and conclusions on the secrecy and accuracy of the chosen system.

Within the particular scope of its terms of reference in relation to secrecy and accuracy, the Commission has taken a broad view of the chosen system. In this respect, the Commission's consideration of the system has also been broadened further by the addition to its terms of reference of the requirement to carry out a comparative assessment with the paper system. Additional characteristics of the paper system, including the possibility of verifiable audit, that are absent in the chosen system (and thus lay outside the Commission's previous remit in relation to the chosen system alone) have now been included and considered in this basis.

I am most grateful to the other members of the Commission, Mr. Kieran Coughlan, Clerk of the Dáil, Ms. Deirdre Lane, Clerk of the Seanad, Dr. Danny O'Hare, former Chairman of the Information Society Commission and former President of Dublin City University and Mr. Brian Sweeney, Chairman of Siemens Ireland and former Chairman of Science Foundation Ireland for their commitment of time, energy and enthusiasm and for the valuable knowledge and experience they brought to the work of the Commission, including in the important and relevant areas of elections and computer systems.

Second Report of the Commission on Electronic Voting

We are very much indebted to the Commission's technical advisers Professor Pádraig Cunningham, Mr. Renaat Verbruggen and Dr. Paul Gibson and to its project manager Dr. John Carney who rendered valuable advice and support to the Commission in its deliberations. Our thanks are also due to QinetiQ Ltd., Certification Europe Ltd. and the Policy Institute at Trinity College Dublin and to those in the School of Computer Science and Informatics at University College Dublin who also assisted the Commission in its work.

I must also thank the Commission Secretary Mr. Alan Murphy for his commitment and dedication to the work of the Commission. His grasp, knowledge and understanding of the subject matter has greatly impressed the members of the Commission and has made our work that much easier. In this he was supported by Ms. Anne Quinlan and Ms. Roisin Greene who provided the essential support for all aspects of the Commission's work that made everything run smoothly.

It was a great honour for me to have been invited by the Government to chair this Commission. We believe that our work has added to the public knowledge and understanding of the chosen system and we hope that it will also contribute positively to decisions concerning the future of electronic voting in Ireland.



Mr. Justice Matthew P. Smith
Chairman

4 July, 2006

Summary Conclusion

The Commission concludes that it can recommend the voting and counting equipment of the chosen system for use at elections in Ireland, subject to further work it has also recommended, but that it is unable to recommend the election management software for such use.

Voting and Counting Equipment

The Commission can recommend the voting and counting equipment as follows:

- The voting machine and related hardware components are of good quality and their design, which is based on voting systems that have been reliable in use elsewhere for some years, has also remained stable since their adaptation for use in Ireland. Subject to some minor security and usability enhancements, followed by extended and rigorous testing once they have been so modified, the voting machine and related components can be confidently recommended for use.
- The embedded software of the voting machine is also of adequate quality, requiring only minor modifications followed by further analysis to confirm its reliability.
- The security of the hardened PC that is proposed for use in preparing elections and in aggregating and counting the votes afterwards is inadequate and needs to be improved.
- Improvements are also required to the security of the methods by which sensitive election data, including votes, are stored, transported and accessed on ballot modules and CDs.

The Commission's work has indicated improvements that would be necessary in order to address these issues, many of which involve only relatively minor modifications or additions to the system.

Election Management Software

The Commission is unable to recommend the election management software used to prepare elections and to aggregate and count the votes on the following basis:

- The software remains under continuous development and is not of sufficient quality to enable its use to be confidently recommended.
- Even if it can be demonstrated to work in most situations, the processes and documentation that underpin the design and development of this software are insufficient to enable its reliability to be assured with the necessary levels of confidence by analysis or inspection of the source code.
- Functional testing has revealed programming errors and suggests the possible existence of others, thus further reducing confidence in the software.

It is likely, however, that alternative election management software compatible with the existing voting machine and other hardware and software components of the system could be developed at a reasonable relative cost.

Security Management

The Commission has also recommended improved physical and operational security measures that do not require modification of the chosen system but that can significantly enhance its overall security.

Testing and Independent Verification

As the Commission has not been advised of any further official or independent testing of the chosen system that has been carried out since the time of its previous reports, the Commission's views in relation to such testing remain at this time as they were presented in those reports:

- The testing of the system as a whole carried out to date, as well as the investigation, analysis and independent testing and certification of its individual components, is insufficient to provide a secure basis for the use of the system at elections in Ireland.
- There is a need for comprehensive, independent and rigorous end-to-end testing, verification and certification by a single accredited body of the entire system as proposed for use in Ireland.

While the Commission's work has laid the foundations for this process, more work will be required in this area.

Comparison with Paper Voting

Following the comparative assessment against the paper system of voting that it was requested to carry out, the Commission has concluded that, in terms of secrecy and accuracy, the paper system is moderately superior overall to the chosen electronic system as currently proposed (and in some respects only marginally so) and that, subject to the Commission's recommendations being implemented, the chosen system has the potential to deliver greater accuracy than the paper system and can provide similarly high levels of secrecy.

Executive Summary

Introduction and Background

This is the second report of the Commission on Electronic Voting established by the Government of Ireland in March 2004 to report on the secrecy, accuracy and testing of the Nedap-Powervote electronic voting system chosen for use at elections and referenda in Ireland – “the chosen system”.

In its interim report¹ presented in April 2004, the Commission concluded that it was unable to recommend use of the chosen system at the June 2004 elections. This conclusion was based not on any finding that the chosen system would not work, but on the finding that it was not proven at that time to the satisfaction of the Commission that it would work. Details of the work that underpinned this conclusion were presented subsequently in the Commission’s first report² in December 2004.

About this Report

In May 2004, the Commission was placed on a statutory footing by the Electoral (Amendment) Act 2004 and, in June 2004, the Houses of the Oireachtas approved an order of the Government under section 22 of that Act requesting the Commission -

- to report further on the work envisaged by the recommendations of its interim report on the secrecy, accuracy and testing of the chosen system, and
- to include in such report a comparative assessment of the chosen system and the current paper system of voting.

The work of the Commission on these matters is accordingly presented in this report.

Role of the Commission

The Commission’s terms of reference require it to consider the secrecy and accuracy of the chosen system, to review the testing already carried out and to carry out a comparative assessment of the chosen system and the paper system of voting. The Commission has not been specifically asked to test, prove or conclusively verify the chosen system, but rather, in the context of reporting on its secrecy and accuracy, it may review the tests already carried out and carry out its own further tests.

These requirements have informed the scope and direction of the Commission’s work while responsibility for policy and administration of electronic voting, including the carrying out of testing necessary to prove or verify the chosen system, remains a matter for the Government, the Department of the Environment, Heritage and Local Government and returning officers.

¹ Interim Report of the Commission on Electronic Voting on the Secrecy, Accuracy and Testing of the Chosen Electronic Voting System ISBN 0-7557-1927-1 (available from Government Publications or on line at www.cev.ie).

² First Report of the Commission on Electronic Voting on the Secrecy, Accuracy and Testing of the Chosen Electronic Voting System ISBN 0-7557-7028-5 (available from Government Publications or on line at www.cev.ie).

Standards of Secrecy and Accuracy

Secrecy of the ballot as required by the Irish Constitution has been held by the Courts³ to mean that the ballot is secret to the voter - “complete and inviolable secrecy” and includes the particular requirement that it must not be possible for the voter to be able to prove how they have voted. Acknowledged subsequently in sections 137 and 162 of the Electoral Act 1992, this standard of secrecy has been adopted by the Commission in its work.

Electronic processing systems can, when functioning correctly, achieve standards of accuracy that are considerably higher than the equivalent manual systems. In a critical process such as voting at national elections, it is to be expected that the highest possible standards of accuracy (i.e. closely approaching 100%) should be achieved in the electronic recording, handling and counting of votes and this is the standard of accuracy that has been adopted by the Commission in its work.

Approach to the Work

While analysis and testing of the chosen system were clearly carried out by the Manufacturers, the Department and others during the development and adaptation of the chosen system for use in Ireland prior to the appointment of the Commission, different parts of the system were reviewed by different independent bodies, both within Ireland and internationally. None of these bodies was asked to take a view of the chosen system as a whole, incorporating all relevant aspects of its hardware and software components, its physical environment and the operational arrangements for its use.

This led the Commission to take a broad view of the system within the particular scope of its terms of reference. In taking this broad view, the Commission has had regard to the key principles that any system is “more than the sum of its component parts” and is “only as strong as its weakest link”.

Software Assurance

As the chosen system relies substantially on the correct functioning of its software to achieve its purpose, a particular focus of the Commission’s work has been to investigate the quality of this software in order to determine that it can be relied upon to achieve that purpose with the requisite levels of secrecy and accuracy. Translated into software engineering terms, this requirement is expressed as assuring the “trustworthiness” or “reliability” of the software by confirming, with reference to its prescribed requirements, specifications and other indicators, that it behaves as it is intended to and that it displays no unintended behaviour.

The Commission has determined, having regard to the democratic, social and economic consequences of failure in a system that would be deployed in the critical tasks of recording and counting votes at public elections, that the standards of software engineering necessary to ensure that the overall goals of secrecy and accuracy are met by such a system are those applicable to a “mission critical” system, that is, a system in which failure can impact on the wellbeing of people who rely on it but who are not necessarily responsible for its failure.

³ *McMahon v Attorney General* [1972] IR 69, (1972) 106 ILTR 89.

The steps that can provide preliminary indicators regarding the reliability of the software of the chosen system have now been taken by the Commission as described in *Part 2*.

Overview of the Work

The Commission's work programme for the purposes of this report has included work in the following areas:

- Software Assurance (*Part 3*): Investigation of the quality and reliability of the software, having regard to its defined requirements and specifications, the design and development process, the system documentation and the source code.
- Hardware Security (*Part 3*): Usability analysis and assessment of the security of the hardware components by inspection, modelling and structured analysis methods and in the context of their use at elections in Ireland.
- Testing (*Part 3*): Extension of the Commission's previous testing of the vote counting software from 10,000 to 100,000 sample election test cases; testing of the hardware for susceptibility to hacking, electromagnetic eavesdropping or interference and power supply disruptions.
- Physical Security (*Part 4*): A "life-cycle" review of the physical and operational security arrangements for the design, development, manufacture, transport, storage, deployment and use of the chosen system.
- Comparative Assessment (*Part 5*): Identification and comparative assessment of secrecy and accuracy criteria as between the chosen system and the paper system of voting in Ireland.
- e-Voting Best Practice (*Part 6*): Evaluation of the overall implementation of electronic voting in Ireland with reference to the legal, operational and technical measures contained in the 2004 Council of Europe recommendation on electronic voting.

The full details of this work, together with the Commission's findings, conclusions and observations arising from the work are set out in the relevant parts of this report as indicated in each case above.

Key Findings

The Commission's key findings in relation to the secrecy and accuracy of the chosen system are as follows (the components of the chosen system referred to below are illustrated for reference in *Appendix 1*):

Hardware

- The main hardware components of the system, namely the voting machine, the programming/reading unit and the ballot module are of good quality and design. They are robust against failure and are well suited to their purpose.

- The measures implemented to secure the hardened PC on which the election management (Delphi code) software would be installed and used to configure elections and to count the votes are inadequate and would need to be reviewed and strengthened in light of the Commission's conclusion regarding that software.
- The widespread use of CDs, in the manner currently proposed, to transfer sensitive election data, including votes, between centres is not sufficiently secure and should be rigorously reviewed and strengthened.

The Commission has indicated specific areas for improvement in order to address these issues, many of them involving only relatively minor enhancements or additions to the existing components of the chosen system.

Software

- The embedded C code software within the voting machine and programming/reading unit is of an adequate standard and, while it is not of mission critical standard, there is evidence to suggest that it has been developed according to a recognisable structured design process which is broadly in accordance with industry best practice.
- The election management (Delphi code) software installed on the hardened PC and used to prepare elections and to aggregate and count the votes has not been developed in accordance with any recognisable standard process and is thus unlikely to be capable of meeting the high standards of software engineering that would be required in a mission critical system.

While modification and further investigation of the behaviour of the embedded C code software would be necessary before its reliability could be confirmed for use at elections in Ireland, it is unlikely that the election management (Delphi code) software could feasibly be amended to enable its reliability to be confirmed. It is likely however that alternative election management software, compatible with the hardware and embedded C code software of the system, could be developed at a reasonable relative cost.

System and Data Security

- The measures provided within the system as a whole to restrict access to its services, and to enable operators and observers to check that the software and hardware versions are correct, are less rigorous than would be appropriate in a mission critical system and should be improved.
- The measures to protect against unauthorised access and/or alteration of data contained on ballot modules and CDs could also be improved by the implementation of measures such as encryption and cryptographic signing to give greater confidence in the integrity of the system.

These issues can also be addressed by relatively minor enhancements or additions to the existing components of the chosen system.

Testing and Independent Verification

- The testing of the system as a whole carried out to date, as well as the investigation, analysis and independent testing and certification of its individual components, is insufficient to provide a secure basis for the use of the system at elections in Ireland.
- There is a need for comprehensive, independent and rigorous end-to-end testing, verification and certification by a single accredited body of the entire system as proposed for use in Ireland.

While the Commission's work has laid the foundations for this process, more work will be required in this area.

Physical Security

- There is a wide variation across constituencies in the proposed or actual physical and operational security measures for the management of the chosen system as a distributed system.
- There is a consequent need for clear policy guidance on the minimum security requirements for the storage, transport, set-up, use and disposal of electronic voting equipment and data in order to bring enhanced clarity and consistency in the measures implemented across constituencies.
- There is a particular need for the security of voting machines to be completely assured at all times once they have been programmed for use.
- The methods for supplying and distributing the election management (Delphi code) software are not sufficiently secure and there are inadequate controls on the installation, access and use of that software exclusively on the hardened PC.
- Enhanced physical and data security measures should be developed and implemented in the transport of votes and other election data on ballot modules and CDs.
- Comprehensive electronic asset registers should be established to record the identity, location and movement of all items of electronic voting equipment and appropriate documentary controls should be implemented on the movement of equipment and data, both at and between elections.

Attention to most of these physical security issues would not require any modification to the chosen system, but would nonetheless contribute very significantly to its overall security.

Comparative Assessment against Paper Voting

- 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.

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.

Overall Conclusion

Based on the results of its work to date in relation to technical, procedural and comparative aspects of the chosen system, and recognising that the chosen system can potentially enhance and deliver real efficiencies in the administration of elections in Ireland (as demonstrated by systems based on the same design and used elsewhere for some years), the Commission concludes that it can recommend the voting and counting equipment for use at elections in Ireland, subject to further work it has also recommended, but that it is unable to recommend the election management software for such use.

Further work is also required in relation to the security and operational arrangements for the use of the system as a whole. The enhancement of these administrative arrangements can contribute significantly to the overall security of the chosen system without requiring any modification to the system itself.

Further development, testing and analysis of the system, followed by independent certification of its suitability are thus necessary before it can confidently be used at elections in Ireland. Desirable also in this context would be the development of Irish standards for e-voting in keeping with emerging international best practice and the assignment of responsibility to a single body within Ireland for ensuring that these standards are met.

Areas for improvement in the technical and operational aspects of the system have accordingly been highlighted by the Commission and it has made recommendations concerning the work that is necessary to address these. Approaches to further development, testing and analysis of the system have also been recommended with a view to providing the necessary assurances that the system is reliable.

Subject to this work being carried out in accordance with the recommendations of the Commission, it is likely that the chosen system can be deployed and used with confidence in the future.

In presenting its report at this time, the Commission believes that the technical and other knowledge and information about the chosen system obtained during the preparation of this report can contribute to any decisions that may be taken regarding the future development and use of electronic voting in general, and the chosen system in particular, at elections in Ireland.

Electronic Voting Context

The Commission recognises that its work has taken place at a time of significant “climate change” with regard to electronic voting generally. During this time, voting technologies have been required to meet and adapt to new challenges that have arisen as a result of significant alterations in the levels of public and political expectation and acceptance of electronic voting, both in Ireland and abroad. Consideration of these “climate change” issues lies mainly outside the scope of the Commission’s work as currently framed by its terms of reference and the Commission has accordingly refrained from considering them.

Based on these wider developments and on the perceived and reported conclusions of the Commission’s previous reports and the subsequent non-use of the chosen system, the Commission also recognises that the public perception of the current and future status of electronic voting in Ireland may differ from what the Commission was able to consider in its work and in making its reports.

The Commission has endeavoured, within the particular context of its terms of reference in relation to secrecy and accuracy, to shed as much light as possible on the chosen system. In this way, by reporting to the fullest possible extent on the general nature of the chosen system, its specific characteristics and the operational arrangements for its deployment, the Commission believes that its work can contribute to greater public knowledge and understanding of the chosen system.

Consistent with its independent role, the Commission has maintained an open view on electronic voting in general, while acknowledging that its introduction in Ireland can make a positive contribution to inclusive and representative democracy. Within the particular scope of its terms of reference, the Commission also recognises that, when compared with paper voting, electronic voting methods in general can deliver enhanced levels of accuracy and similar levels of secrecy and that this potential also exists in the particular case of the chosen system.

Second Report of the Commission on Electronic Voting

Terms of Reference and Membership of Commission

Terms of Reference⁴ (March 2004)

The Commission was established by a decision of the Government of 1 March, 2004 with the following terms of reference:

- (1) The Commission, which shall be independent in the performance of its functions, shall prepare a number of reports for presentation to the Ceann Comhairle (the Chairman of Dáil Éireann) on the secrecy and accuracy of the chosen electronic voting and counting system i.e. the Powervote/Nedap system.
- (2) The Commission shall make one or more of such reports to the Ceann Comhairle not later than 1 May, 2004 *comprising recommendations on the secrecy and accuracy including the application or non-application as the case may be of the electronic voting and counting of the Powervote/Nedap system for the local and European elections on 11 June, 2004⁵.*
- (3) The Commission's subsequent report or reports will record its views of the operation and experience of electronic voting and counting at elections.
- (4) In carrying out its work, it will be open to the Commission to review the tests already undertaken to validate the electronic voting and counting system and to have further tests undertaken. It may also retain the service of such consultants or other persons that it considers are desirable.
- (5) The Commission shall be entitled to invite and consider submissions on such basis as it thinks appropriate.

Membership

The following persons were invited by the Government to become Members of the Commission:

The Hon. Mr. Justice Matthew P. Smith, *Chairman*

Mr. Kieran Coughlan, *Clerk of Dáil Éireann*

Ms. Deirdre Lane, *Clerk of Seanad Éireann*

Dr. Danny O'Hare, *former Chairman of the Information Society Commission and former President of Dublin City University*

Mr. Brian Sweeney, *Chairman of Siemens Ireland and former Chairman of Science Foundation Ireland*

⁴ These are the original terms of reference of the Commission when appointed by decision of the Government in March 2004. In May 2004 they were confirmed by the Electoral (Amendment) Act 2004 and in June 2004 they were supplemented by an order of the Government made pursuant to that Act and approved by both Houses of the Oireachtas.

⁵ The original terms of reference of 1 March 2004 were amended by decision of the Government on 9 March 2004 as indicated in italics.

Electoral (Amendment) Act 2004 (*May, 2004*)

The Electoral (Amendment) Act 2004, enacted on 18 May, 2004 contained provisions relating to the Commission. These provisions are set out in *Appendix 2*.

Commission on Electronic Voting (Further Reports) Order 2004 (*June 2004*)

The following Order of the Government made under section 22(5) of the Electoral (Amendment) Act 2004 was approved by resolutions of Dáil Éireann and Seanad Éireann on 29 June, 2004.

Whereas the Commission on Electronic Voting (hereinafter referred to as “the Commission”) has presented an interim report to the Chairman of Dáil Éireann on 30 April, 2004, and

Whereas that interim report set out in paragraph 4.5 a number of recommendations for action,

Now therefore the Government by this Order under Section 22 (5) of the Electoral (Amendment) Act, 2004 hereby requests the Commission to make such further report or reports as are necessary concerning the work envisaged by the Commission under the said paragraph 4.5. for the purpose of the Commission assessing the secrecy and accuracy of the Powervote/Nedap System, and to include in such report or reports a comparative assessment of the secrecy and accuracy of the current system for voting at elections and referenda.

GIVEN under the Official Seal of the Government

This 24th day of June, 2004

(Signed) Mary Harney, T.D. Tánaiste