DIRECTORATE OF AUDIT, RISK, AND ASSURANCE
Internal Audit Service Provider to the GLA

REVIEW OF LONDON MAYOR’S ELECTION COUNT
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1. Background

1.1 This review was carried out following a request from the GLA to examine the process followed to deal with issues that arose during the count at 6th of May in the London Mayoral elections held in May of this year. In this report, we set out our findings and comments on our evaluation of the process followed by IntElect regarding the follow-up to the discrepancies found in the 1st and 2nd preference totals for the Mayoral candidates.

1.2 The GLA (Greater London Authority) outsourced the e-counting process for the London Mayoral Election to IntElect. IntElect comprises DRS Data Services Ltd and Electoral Reform Services (ERS) who are working in partnership to deliver the GLA 2016 project (as they did in 2012).

1.3 Our evaluation took place in May and included a site visit to IntElect’s office in Milton Keynes where we held interviews with key individuals. The attendees were Steve Gowers (DRS CEO), Tracey Talar (DRS Senior Project Manager), Eric Keith (DRS Software Manager) and Firnaz Nagoorthamby (DRS e-Counting Lead Software Developer).

1.4 E-counting involves scanning ballot papers through machines that capture and store the votes on a secure database. As with the London Mayoral Election, IntElect provided their scanners and their software, and printed the ballots.

1.5 During the production of the Mayoral Results on the 6th of May, there were discrepancies identified in the 1st and 2nd preference totals for the Mayoral candidates in the preliminary reports, in the final reports at constituency level and in the final reports at the central consolidated level.

1.6 We reviewed the process that was followed and the actions taken by IntElect to produce the correct Mayoral results on the evening of the 6th of May. We also reviewed the validity of the causes of the discrepancies as determined by IntElect in their investigation report of 18th of May, the reasons the causes of the discrepancies were not identified during tests that were carried out on the e-counting system, and what testing would have needed to be done to identify the cause in advance of the election.

2. Review Objectives

2.1 Our overall objective was to evaluate the process followed by IntElect regarding the follow-up to the discrepancies found in the 1st and 2nd preference totals for the Mayoral candidates.

2.2 In particular, we reviewed:

- The actions taken by IntElect on the evening of Friday the 6th of May to resolve the discrepancies in their systems in terms of 1st and 2nd preference votes for the London Mayor election.

- The process that IntElect followed to produce the Mayoral results.
The results to confirm they are in accordance with the scanned and recorded data.

The validity of the cause of the discrepancies as set out in the investigation report and covering letter from IntElect.

The reasons that the causes of the discrepancies were not identified during the tests that were carried out on the e-counting system and what testing would have needed to be done to identify the cause in advance of the election.

3. Scope of Review

3.1 We evaluated the process followed by IntElect regarding the follow-up to the discrepancies found in the 1st and 2nd preference totals for the Mayoral candidates. Specifically, we:

- Interviewed key individuals including Steve Gowers (DRS CEO), Eric Keith (DRS Software Manager) and Firmaz Nagoorthamby (DRS e-Counting Lead Software Developer). All these individuals were directly involved in the preparation and review of IntElect’s investigation report of 18th of May 2016, as well in the process to solve the discrepancies.

- We reviewed the application- & database code responsible for the generation of the reports. In particular, we tested the validity of the cause of the discrepancies by means of a simulation of the error that was described in the investigation report of IntElect.

- The scope also included review of the manual process that IntElect followed to generate the final reports both at constituency and consolidated level.

- Finally we reviewed the User Acceptance Testing that was carried out prior to the election.

4. Audit Opinion

4.1 We have concluded the following for each of the above areas reviewed:

- Following an assessment of the related control environment and actions taken to resolve the discrepancy once identified the overall process carried out to produce an accurate final count was reasonable and appropriate.

- Our review of the (partly manual) process that IntElect followed to produce the Mayoral results did not identify any irregularities.

- We determined, based on a sample of 5 constituencies that the final results were in accordance with the scanned and recorded data.

- Our review identified that the cause of the discrepancies as set out in the investigation report and covering letter from IntElect of 18th of May are valid.
Based on the results of this review, the reason that the causes of the discrepancies were not identified during tests was in the main due to the fact that the test databases did not have sufficient capacity. The phenomenon of parallelism which led to discrepancies in the results only occurs from an unusually high amount of records. During UAT, a database of 60,000 records per contest was used. Based on interview and walk-through, we would recommend a database that will reflect the expected amount of records during the election is maintained in future.
5. General Overview of Structure

5.1 We determined that the e-Counting system has 5 core modules: Registration, Scanning, Verification, Adjudication and the Centre Manager & Dashboard. The Dashboard module is particularly relevant to the audit as it is used to generate the reports at constituency level.

5.2 The London Count Centre Structure consists of a Central Site (City Hall) and three Supersites (Alexandra Palace, Olympia and Excel). Each supersite was managing the e-counting process for several constituencies, 14 in total. IntElect provided the supersites with a Centre Manager (1 for each constituency), a Deputy Centre Manager (1 for each constituency), a Co-Coordinator (1 per supersite) as well with several systems, support and software engineers.

5.3 We reviewed the design of the e-counting process and the ballot paper workflow method. The design shows a diversity of physical, technical and administrative controls and no related issues were noted.

6. IT Environment

6.1 We determined that the IT Architecture follows the London Count Centre Structure. There are four main physical IT environments (City Hall, Alexandra Palace, Olympia and Excel). Each physical IT environment consists of a vSphere cluster, workstations, displays, scanners, firewalls and switches. Each supersite manages the e-counting process of several constituencies. For each constituency a separate virtual environment exists with several virtual machines, such as: application server, SQL server, staging server, image server and a communication server. For an overview of the IT Architecture, see Appendix 1. Based on our review of the design of the infrastructure, we did not identify any specific issues that directly correlate with the initial data discrepancies in the mayoral results.

Application Server

6.2 The e-counting application code repository is stored at a Team Foundation Server (TFS) within DRS’s network. We determined that the GLA 2016 project was migrated from the GLA 2012 project on the 3rd of February 2015. We also found that no software changes have been made since the 14th of October 2015 (version 5.1.10.8), which is the version that was used during User Acceptance Testing that took place between 2 and 6 November 2015. Based on inspection of the virtual machines that IntElect restored for the current audit, we determined that the version that was used during the elections was the gold build of version 5.1.10.8, which was produced on the 13th of January 2016.

6.3 We reviewed the security patches on the application server and found that security patches were applied through 5th of April 2016. In general, security patches should be applied monthly, which is in line with Microsoft’s best practices\(^1\). In our opinion and based on our evidence, whether security patches

have been applied or not, this did not trigger the cause of the discrepancies in the production of the mayoral results reports.

Database Server Overview

6.4 We identified that the SQL Server version in use during the elections was 10.50.6220, which is the same version as prior to Kit Readiness testing.

6.5 We found that the configuration of the Max Degree of Parallelism was set to 2, which means that the number of processors employed to run a single statement for each parallel plan execution amounts to a maximum of 2 processors. This is appropriate, since the physical systems only have 2 processors.

6.6 We identified that the configuration of the Cost Threshold for parallelism was set to 5, which is the threshold at which Microsoft SQL Server creates and runs parallel plans for queries. It should be noted, that the value of 5 is the default value that comes with a new installation of SQL server, which is usually appropriate. SQL Server creates and runs a parallel plan for a query only when the estimated cost to run a serial plan for the same query is higher than the value set in cost threshold for parallelism. The cost refers to an estimated elapsed time in seconds required to run the serial plan on a specific hardware configuration.

6.7 Note: We could not determine which configurations were used during the Mayoral Elections of 2012 for comparison purposes, since IntElect have not retained the originally installed systems from that time and these settings are not preserved in backups.

7. Root Cause Analysis and User Acceptance Testing (UAT)

7.1 We performed a code review2 and a walk-through of the production of the Mayoral Results. We determined that the code that is responsible for the construction of the report consists of code written in C# (C-sharp), which relies on the results of a SQL stored procedure called ‘Dashboard_GetBallots’. Our code review confirms that the C# code that constructs the report, expects the dataset that is returned from the stored procedure to be in a specific order.

7.2 Our resulting audit walk-through confirmed that the SQL stored procedure that was used during the elections, in combination with the high volume of records, invokes the SQL Server to use parallelism, which results in another ordering of the data each time the query is executed and hence in the incorrect allocation to the 1st and 2nd preference votes of a given candidate. In summary, due to the large volumes of records, the SQL server had to use two processors (instead of usually 1), which led to an unordered return of the results to the application that was producing the report. Since the application that produced the report was expecting the results in a certain order (and this was not the case anymore),

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2 A code review is a comprehensive analysis of source code in a programming project with the intent of discovering bugs, security breaches or violations of programming conventions. In this case, a code review was performed specifically aimed at discovering and confirming the issue that led to the discrepancies in the 1st and 2nd preference votes.
the application made errors in allocating a vote to either 1st preference of 2nd preference.

7.3 Our walk-through confirmed that adding an ‘ORDER BY’ clause to the SQL stored procedure resolves this issue, since it forces the SQL query to return the results in the order that is expected by the C# code responsible for the construction of the report.

7.4 Based on discussion with IntElect and our own investigation, we confirmed that the effect of parallelism is only triggered when the estimated cost to run a serial plan for the same query is higher than the value set in cost threshold for parallelism. This is usually the case when there are high volumes of records that need to be processed. A separate volume test with at least the (expected) amount of records during the elections would have discovered the issue.

7.5 Based on our review of the User Acceptance Testing (UAT) documentation, we determined that a total of 180,000 ballot papers were used during the UAT (60,000 per contest). We determined that the effect of parallelism does not occur at these relative low volumes of records. A separate volume test with at least the (expected) amount of records during the election would have discovered the issue.

**Recommendation**

Given the facts as described above, we would recommend, for a future e-count, a separate volume test which uses a database with at least the (expected) amount of records during the election. We would specifically emphasise that the test be performed with known results, since a volume test without known results would only address the current issue. A volume test with known results will have a broader scope and be more effective in detecting

8. Production of Final Results 6 May 2016

8.1 On 6 May 2016, it was agreed between the GLA and IntElect to focus on the production of the results rather than to investigate the root cause of the discrepancies at that time. The agreed approach was to generate a specific SQL-query to produce manually data to identify total votes per constituency, per candidate, and by preference (1st or 2nd).

8.2 We found significant evidence that the results in the final reports at constituency level are in accordance with the recorded data in the SQL-database. In line with our Internal Audit guidelines, we performed a sample test on the following five constituencies and determined that 1st and 2nd preference votes for each candidate are in accordance with the results of the SQL-query that was executed on the recorded data:

- Bexley & Bromley
- Lambeth & Southwark
- Greenwich & Lewisham
8.3 Since the discrepancies in the 1st and 2nd preference votes also affected the results at consolidated level, another SQL-query was generated and used on the 6th of May 2016 to generate the raw data for the matrix of count of 2nd preference votes per candidate based on 1st preference candidate vote. We determined based on a sample on the same constituencies as listed under 8.2 that the final results in the consolidated report are in accordance with the recorded data.
Appendix 1

IT Architecture Diagram

Overall

Alexandra Palace

May 2016
Review of London’s Mayor Election Count