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Independent Review of RTGS Outage on 20 October 2014

23 March 2015

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1 Executive summary

1.1 Background and scope of the review

1. The Real-Time Gross Settlement (RTGS) system is operated by the Bank of England (the Bank) and provides a real-time settlement accounting environment to support the UK financial services sector. It is important to the safe functioning of the UK financial system and in fulfilling the Bank's two core purposes — to maintain monetary and financial stability.

2. The RTGS system is designed for making real-time high-value sterling payments. In operating RTGS, the Bank is the settlement agent for a number of payment schemes, including the Clearing House Automated Payment System (CHAPS). CHAPS is operated by CHAPS Clearing Company Limited (CHAPS Co.), whose responsibilities include setting system rules, monitoring compliance and admitting new members. CHAPS Co. is owned by its direct participants, with each settlement bank having a representative on the CHAPS Co. Board.

3. Payments settled through RTGS include wholesale market transactions by financial institutions, including important global cross-currency sterling payments settled by Continuous Linked Settlement (CLS). As well as being an important system for interbank funds transfers, RTGS also settles 'real economy' high value, time-critical payments, including house purchases and corporate business to business transactions. In 2014, £133.9 trillion of payments were settled through RTGS.

4. On 20 October 2014, RTGS suffered an unprecedented outage of approximately 9 hours' duration, which was resolved intra-day. This followed what the Bank had considered to be a routine configuration change to the CHAPS members held within the system.

5. Following the incident Court commissioned an independent review. The Terms of Reference for the review, below, form the scope of our work and this report.

   1) **Causes of the incident**
      a) Conduct a root cause analysis
      b) Evaluate the robustness of the system
      c) Review the governance of the system

   2) **Effectiveness of the Bank's response**
      d) Assess the Bank's response on the day
      e) Evaluate the effectiveness of incident management and back-up

   3) **Lessons to be learned**

6. The Bank supplemented these Terms of Reference with additional guidance (see Appendix J). Whilst helpful, these did not constrain our review.

7. We would like to thank all those who have provided valuable time and evidence in support of our review, within the Bank and externally. In particular, all staff at the Bank contributed openly and transparently in answering our questions and requests for information.

1.2 Impact of the outage

8. This section summarises the main impacts of the outage, including the impact upon operational users of RTGS and the 'real economy'.

1.2.1 Intra-day settlement of CHAPS payments

9. As a result of the outage, the settlement day was extended from the usual 16:20 until 20:00 to maximise the opportunity for settlement.

10. The normal closing time for CHAPS is 16:20. Once CHAPS settlement resumed, RTGS settled approximately 99% of submitted CHAPS payments by value and volume by 18:00 and all submitted CHAPS payments by 20:00. In total 142,759 CHAPS payments were settled with a total value of £289.3 billion. The total volume and value of payments settled was in line with a normal Monday average and close to the Bank's forecast for the day of 145,000 transactions and £276 billion value. Figure 1 below shows how payments were cleared on the day, by volume and value, in comparison to a typical Monday.

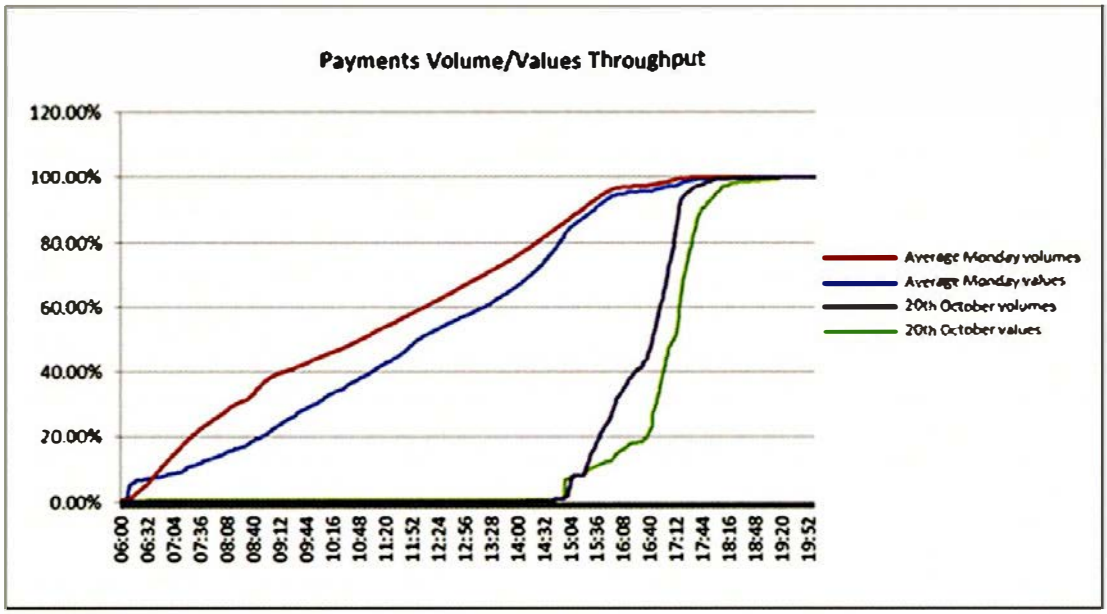


***Figure1**: Payments Volume/Values Throughput (including October 20 incident)*

1.2.2 Housing market

11. On 20 October, the number of CHAPS payments which fell into the typical house purchase value bracket (£50k-£500k) was only slightly below average and CHAPS Co. member banks reported relatively low housing market activity.

12. During the week immediately following the incident, the Law Society of England and Wales undertook an on-line survey asking its members whose residential conveyancing transactions were affected by the outage to complete the survey. The survey had 157 responses and, whilst the results should not be taken as representative, they do provide an indicative view of the impact on the legal profession and their clients. The survey responses suggested that:

- 18 per cent completed within the usual times
- 27 per cent completed with a delay of up to three hours
- 24 per cent completed with a delay of three or more hours

- 30 per cent didn't complete until the next day or after

13. Based on data obtained from the Land Registry, it is estimated that approximately 2,340 residential property sales were settled on a typical Monday in 2014.[1] Using the survey results this would mean that approximately 700 transactions may not have completed until the next day or after.[2] There is some indication that these transactions are more likely to relate to payments through banks or building societies who are not direct CHAPS members. It is possible that not all direct CHAPS members passed on the benefit of the general extension by extending their own customer submission deadlines, but we have been unable to verify this.

14. The survey results also highlighted a general concern over the lack of timely and informative communications to the legal community on the day. The overall view from survey responders was that whilst the incident caused stress to staff and clients alike, the pragmatism exercised by individual firms and solicitors helped to minimise the inconvenience to clients.

15. The Bank recognised that the outage of RTGS caused inconvenience to customers of both CHAPS members and indirect CHAPS participants. A compensation scheme was publicised through CHAPS member banks and through the Law Society of England and Wales, who notified their members in their regular Professional Update on 30 October 2014.

16. As of 20 March 2015, 36 individuals had contacted the Bank directly enquiring about redress and were directed to their banks for further information. The Bank had paid 9 claims totalling £4,056.89 and was not expecting any substantial further claims at the time of publication.

1.2.3 CLS

17. At the point of the RTGS failure, many payments to the CLS cross-currency clearing system had not settled. Pre-agreed manual contingency arrangements were used, resulting in CLS Sterling payments-in being completed satisfactorily. Service levels with two early closing (Asian) markets were, however, breached by approximately 1.5 hours, though no financial penalties were incurred as a result.

1.2.4 Deferred changes

18. Based on our preliminary findings and recommendations from this review the Bank has decided to defer some planned changes to RTGS while business assurance activities are undertaken.[3] The most significant of these is the functionality change to support pre-funding. This is designed to eliminate settlement risk through participants pre-funding their payments with cash held at the Bank. An additional benefit of this change is to facilitate easier access for 'challenger banks' to the Bankers Automated Clearing Service (Bacs) and Faster Payments schemes. The Bank has also delayed two banks joining CHAPS from their planned dates in February and March 2015.

[1] Data obtained from the Land Registry highlights that in 2014 112,374, or 13 per cent of, residential property sales settled on a Monday, out of a total of 864,415 property sale settlements across the whole year. This equates to approximately 2,340 sale settlements per Monday (excluding Bank Holidays).
[2] The same data from the Land Registry shows that 1,589 residential sales settled on Monday 20 October, approximately 70% of the Monday average.
[3] At the time of publication the Bank was undertaking business assurance activities, focused on a code and design review, and a broader regression test of the system. See Section 3.2.3.3 for further information.

We conclude that:

19. All submitted payments were settled within the day and substantive risks to financial stability, financial loss or long-term damage to the economy were avoided.

20. The outage caused considerable inconvenience to those affected. An indicative 51% of housing transactions due on the day were delayed by several hours and up to 30% may not have completed on the day according to the results of a Law Society survey after the event.[4] Nevertheless, claims and compensation payments recorded by the Bank have been very low.

21. As a result of our preliminary findings and recommendations from this review, the Bank has deferred changes to RTGS while business assurance activities are undertaken. This may have some impact on policy initiatives to further reduce risk within the payments system and improve competitiveness within the banking industry.

1.3 Causes of the incident

22. This section summarises the root cause of the incident and our findings regarding the robustness of the system and the Bank's governance over it. A more detailed analysis of these areas is set out in Sections 3.2 and 3.3.

1.3.1 Root cause analysis

23. The failure of RTGS on Monday 20 October 2014 arose from configuration changes made over the weekend of 18-19 October to effect the transfer of a CHAPS membership from Bank A to Bank B. To achieve this, a member was added (not uncommon) and a member deleted (uncommon). This was considered by the Bank to be a routine configuration change, but was in reality non-routine.

24. The change triggered a previously undetected design defect in Process A within RTGS, which then triggered a further two latent functional defects within Process B in RTGS.[5]

25. These consequent functional defects meant the system failed, but not cleanly as it should have done. This led to initial uncertainty as to the cause of the problem and resulted in concern over a loss of integrity within the system. In particular, one of the functional defects caused an unexpected restart of the settlement process, resulting in uncertainty as to why and how many payments were being settled. Full details of how the failures manifested themselves and impacted the system are set out in Section 3.3.1.

26. Detailed reconciliation activities were therefore necessary before direct amendments to the underlying configuration data could be performed to correct the situation. There was no pre-defined approach, scripts or templates to support this activity and this contributed to the duration of the outage. The three defects were introduced during the Liquidity Savings Mechanism (LSM) changes in April 2013 and May 2014 and the Market Infrastructure Resiliency Service (MIRS) functionality changes in February 2014.[6]

[4] The percentages are based on 157 responses to an online survey undertaken by the Law Society of England and Wales during the week immediately following the incident (see paragraph 12).
[5] Latent functional defects are errors introduced into the programme code which had not been identified before the incident.
[6] LSM was introduced to increase the overall liquidity efficiency of CHAPS payments. MIRS was introduced to provide additional resilience in the event of a catastrophic loss of, or access to, RTGS.

27. The defects were not identified by testing, either at the time of the original functionality changes being made, or through the weekend testing of the change to CHAPS members on 18-19 October, or in the final tests during the 'Controlled Start' prior to start of day on 20 October. The reasons why these defects were not identified through the testing cycles are detailed in Section 3.2.3.3.

1.3.2 Robustness of the system

28. The RTGS System has been operational for 18 years and has been highly reliable through most of this period. Figure 2 shows the availability levels achieved over the past 10 years. It also shows that in the 5 years prior to the incident on 20 October, the system had an availability level of 100%. This reflects the considerable investment that has been made in the resilience of its infrastructure, which is regularly maintained.

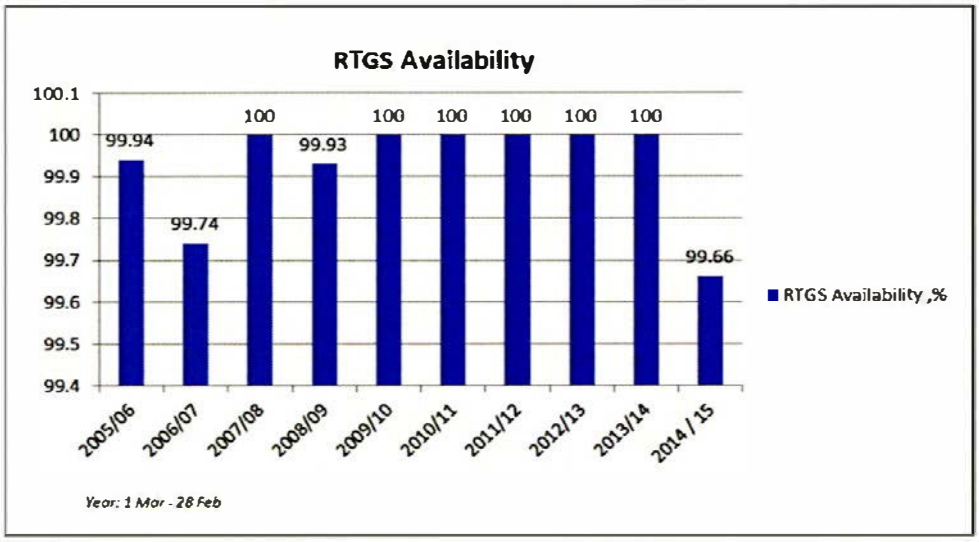


***Figure 2**: Yearly availability of RTGS*

29. During its lifespan, the system has evolved to meet demands for new and changed requirements. As a result, the complexity of RTGS has increased, and we found that this is particularly noticeable following the introduction of LSM and MIRS. Analysis of the incident logs from the inception of RTGS shows that the system has been highly resilient to infrastructure faults. It also shows a step change in the number and frequency of functional errors since 2013 coinciding with the introduction of LSM.

30. Although the complexity of the system has increased over time, the extent and nature of testing has not evolved to match this – see Section 3.2.3.3.

31. This increased complexity, combined with weaknesses in the testing process, results in an increased risk of error when functional or non-routine configuration changes are applied. The complexity is also likely to make fault finding, either through testing or in live incidents, more difficult today and in the future.

1.3.3 Governance of the system

32. There are multiple committees and working parties which contribute to the overall governance of the system. The overarching, or primary, governance committee is the RTGS Board. The RTGS Board is made up of the same staff responsible for the day to day operation of RTGS,

chaired by the Head of Division, Market Services (HoDMS) – in effect it is self-governing. This arrangement, set out in the "RTGS Governance Structure" document (dated January 2014), exists most probably because historically there have been very few failures of the system.

33. Historically the Bank's Information Service & Technology Division (ISTD) appears to have had a subsidiary role in the governance over the system's architecture and testing. The Bank had already taken steps to enhance the status and effectiveness of the ISTD function with the appointment of a new Chief Information Officer (CIO), who joined the Bank in September 2013.

34. In December 2013, the new CIO requested that RTGS should be put on the Bank's risk register to consider the future risk of the system in view of its ageing nature. This was confirmed by the Bank's Audit and Risk Committee (ARCo) in February 2014 and preliminary work to define the work streams and to confirm the terms of reference and membership of each had commenced prior to the incident.

We conclude that the causes of the incident were:

35. The introduction of design and functional defects as part of the functionality changes to enable the Liquidity Savings Mechanism (LSM) and contingency solution (MIRS).

36. Weaknesses in the testing regime, resulting in these defects not being detected.

37. Contributory factors to the above were the increased complexity of the system, following the introduction of LSM and MIRS, and weaknesses in the governance of the system.

1.4 Effectiveness of the Bank's response

38. In this section we provide a summary of the:

- Operational and technical resolution
- Co-ordination and communication of the Bank's response at an operational level
- Involvement of the Bank's Governors and media communications

39. A summary of the key events, communications and decisions on the day of the outage are shown in the timeline opposite in figure 3. A more complete record of the details and timings are set out in Section 3.3.2.

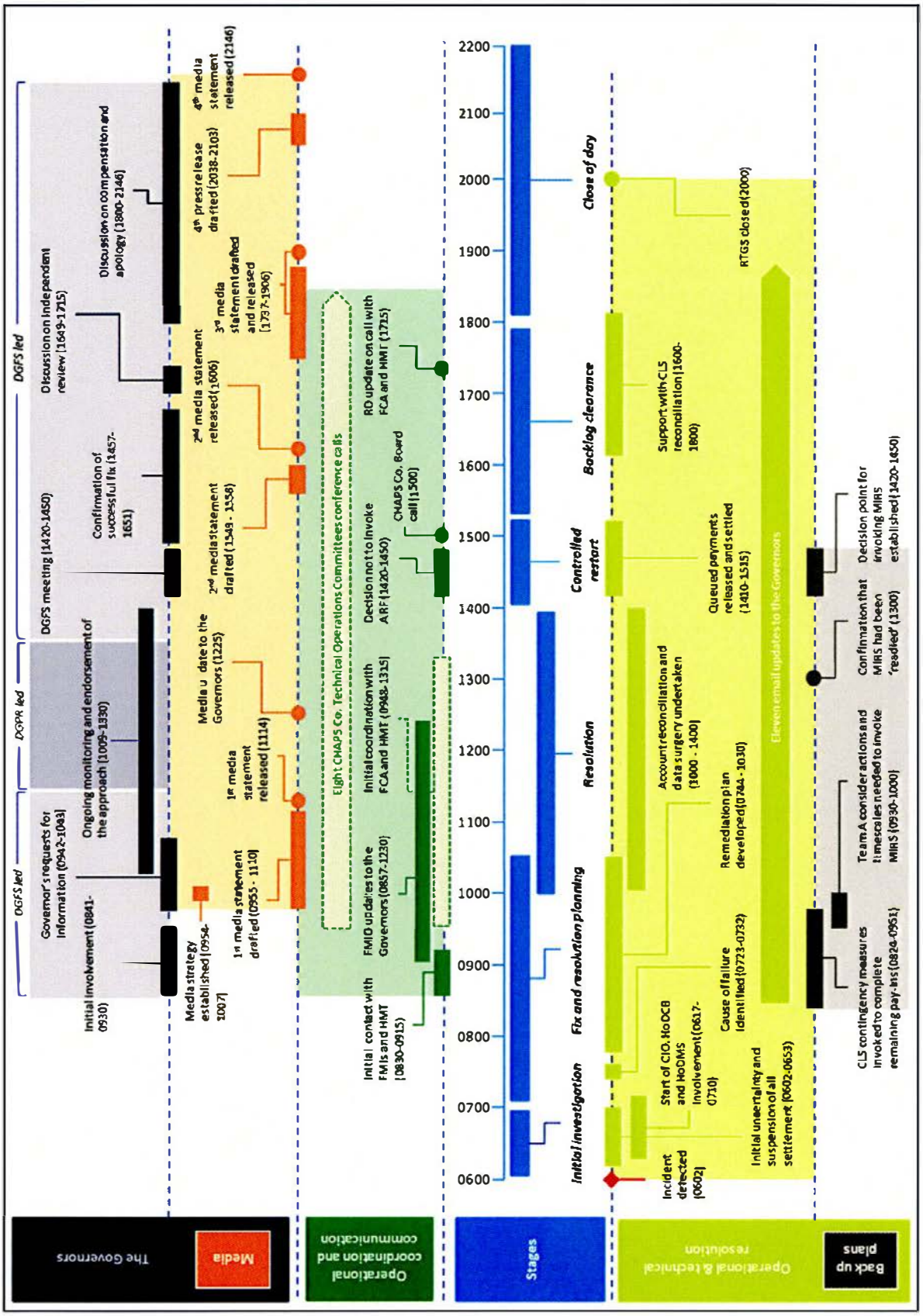


Figure 3: *Timeline of the Bank's response on the day*

Note: Throughout the day there were frequent email communications and phone calls between the Governors and the Press Office. Details of these are provided in Section 3.3.2.

1.4.1 Operational and technical resolution

40. The Bank's monitoring and control processes over start of day processing for RTGS resulted in a system error being detected at 06:02, just after RTGS opened at 06:00. Shortly after this, at 06:17, the CIO was alerted and took immediate management responsibility for the fix and resolution, supported by Head of Division, Customer Banking (HoDCB), and later, HoDMS.

41. The way RTGS had failed and then restarted caused concern over a potential loss of integrity within the system. The operational and ISTD teams working on the issue therefore took a cautious approach, deeming that a detailed reconciliation of account positions within the system was required to ensure integrity.

42. A remediation plan was prepared and finalised by 10:30; work on resolving the issue was already underway by this time. Based on the plan, it was anticipated that there would be a phased restart at approximately 12:30.

43. However, the necessary reconciliation activity took longer than initially anticipated and was hindered by the lack of a pre-defined approach, scripts and templates to support the process. It was not until 14:00 that the reconciliations and necessary data surgery were completed and a phased processing commenced at approximately 14:15 – 14:30.

44. By 15:15 settlement had resumed and all CHAPS banks were able to submit new payments which settled as expected within the day.

45. By 18:00 approximately 99% of submitted CHAPS payments by value and volume had settled, and by 20:00 all submitted CHAPS payments had settled.

We conclude that:

46. The knowledge and experience of the teams working on the identification, fix and resolution and their execution of the remediation plan in a controlled and cautious manner were key factors which contributed to the safe resolution of the issues with RTGS within the day.

47. Appropriate senior leadership was provided to the operational and technical resolution, led by the CIO and supported by HoDMS and HoDCB.

48. There was a clear preference within the operational and technical teams to fix and resolve the issues within RTGS rather than to switch to the contingency system, MIRS.

1.4.2 Operational co-ordination and communication

49. The Bank's Financial Market Infrastructure Directorate (FMID) was proactive in co-ordinating with Payments Schemes, Central Counterparties and overseas regulators during the day, including the European System of Central Banks (ESCB) Payment and Settlement Systems Committee and the Federal Reserve Bank of New York as lead overseer of CLS.

50. Co-ordination and communications with CHAPS Co. and CLS was handled by the teams responsible for the operational and technical resolution. These resources were endeavouring to fix the issue whilst co-ordinating with external operational stakeholders.

51. The current Memorandum of Understanding (MOU) with CHAPS Co. defines responsibilities for the Bank and CHAPS Co. in the event of a disruption; however these are focused predominantly on contingency solutions for operational and technical processes and systems.

The MOU does not currently set out how a joint response between CHAPS Co. and the Bank should work in terms in terms of communication and coordination with operational stakeholders, including CHAPS members and the legal community. Joint structures to undertake this and manage the wider member impact are therefore not in place.

52. The communications channels set out in the Authorities Response Framework (ARF) to co-ordinate the response between Her Majesty's Treasury (HMT), the Financial Conduct Authority (FCA), the Prudential Regulation Authority (PRA) and the Bank to major operational disruptions affecting the financial sector, were not invoked by the Bank. The ARF was discussed at a meeting at 14:20 (see paragraph 64) and it was decided not to invoke it at this time as the system was on the point of being brought back up and that this might confuse matters at this advanced stage.

53. The Payment Systems Regulator (PSR) was not informed until mid-morning of the incident. They are also not currently part of the ARF arrangements.

We conclude that:

54. In the absence of a joint plan for response and co-ordination with CHAPS Co. and a lack of robust crisis management arrangements within the Bank, there were insufficient resources in place to co-ordinate and communicate response activities with the many operational stakeholders internally and externally. This resulted in less timely '*situational awareness*' within the Bank, with the exception of FMID's regular communication and co-ordination with FMIs.[6]

55. The above issue also meant that the extent of communications to CHAPS Co. and others was limited and therefore stakeholders became frustrated with the Bank's response as slippage in the timescales to resolve the issues continued with little information available to them.

1.4.3 Involvement of the Bank's Governors and media communications

1.4.3.1 Involvement of the Bank's Governors[7]

56. An escalation email was sent at 07:23 to Charlotte Hogg (Chief Operating Officer, DGCOO), Minouche Shafik (Deputy Governor Markets and Banking, DGMB) and Chris Salmon (Executive Director Markets, EDM, with cover responsibilities for the vacant Director Banking position) by the CIO. All three people it was sent to were out of the country on official business and in different time zones, so it was not immediately picked up.

57. The Deputy Governor for Financial Stability (DGFS), Sir Jon Cunliffe, was informed by his Private Secretary who had received an email from FMID noting that CLS was not settling due to the outage. He was the first of the Bank's Governors to become aware of the incident, shortly after 08:30. DGFS asked that the Governor was informed. The Governor decided that DGFS should take charge of the Bank's response, supported by the Deputy Governor for Prudential Regulation, Andrew Bailey (DGPR).

[6] The British Standard for Crisis Management (BS 11200) published in 2014 describes situational awareness as a best appreciation of: what is going on and what the impacts might be; the degree of uncertainty; the degree of containment; exacerbating issues; and what might happen in the future. Together, this information, understanding and foresight can inform crisis decision-making.

[7] Throughout this report the term "the Bank's Governors" refers to: The Governor, DGFS, DGMB, DGPR and DGCOO, all of whom were either directly or indirectly involved in the Bank's response.

58. There were frequent communications between DGFS, DGPR, the CIO and HoDCB, as well as between the Governor and Deputy Governors throughout the day. The Governor was out of the country but remained actively engaged and informed throughout the course of the incident. The communications considered and prioritised key issues such as the use of the contingency solutions, the content of press statements and the potential impact on 'real economy' transactions.

59. Because there was no pre-defined structure for crisis response or clear roles and responsibilities between the Governors' level and the teams working on resolving the issue, there were limited resources and a lack of process to gather, analyse and distil information to support decision making.

60. The absence of this structure and process made the Governors reliant on the Bank's operational and technical teams for an understanding of how the day was developing. This resulted in decisions around the endorsement of the plan to fix and restart RTGS rather than switching to MIRS (the 'fix forward' plan), and the content and timing of the first media statement, being made without a full understanding of potential impacts, including those on the 'real economy'. In particular, despite the Governor's request early in the day to identify potential 'pinch points', the specific issue regarding the timing of housing market transactions was not identified early enough and therefore not escalated to Governors. The approach to remediation, and the decision not to activate MIRS, was endorsed on the judgement of the operational team that switching would take as long as fixing, that MIRS lacked full functionality, and that there was sufficient time to bring the system back up and clear all payments within the day. The priority for the Governors, given the operational team's view on the time needed to transfer to MIRS and the lack of MIRS functionality, was to accept the team's preferred remediation strategy to continue until a point where activating MIRS and clearing the payments within the day through it, would no longer be possible. The Governors' priority remained clearing payments within the day, which they were informed could be extended to 20:00.

61. Between approximately 11:30 and 13:30 there was a handover of leadership to DGPR while DGFS was offsite. During this time DGPR, concerned at the absence of a clear timetable for remediation, communicated to the Governors and the operational and technical teams, the need to confirm a time by which RTGS had to be operational to clear the day's payments within an acceptable timeframe. During this period the CIO provided an update to the Governors explaining that the system was still not operational as reconciliation activities were taking longer than originally anticipated.

62. At approximately 14:00, following a series of progress reports, the fact it was getting close to the point at which the option of switching to MIRS to clear the day's payments would no longer be possible, and as a result of continued slippage, DGFS intervened and summoned a meeting at 14:20 with relevant staff within the Bank to discuss progress to date and to agree a decision point for invoking MIRS.

63. At the meeting, the advice from the operational and technical resolution team was that progress with the fix forward plan was now well advanced and that RTGS should be up and running by 15:00 – 15:15. The decision was therefore made that there was enough time to reinstate RTGS and complete the day's transactions. It was agreed that this should remain the primary plan, rather than invoke MIRS. It was also agreed to ask CHAPS members to prioritise house conveyancing payments at the restart and that the meeting should reconvene by 15:15 if RTGS was not up by then to decide whether to move to MIRS.

64. The meeting also considered whether the ARF should be invoked. It was decided not to as the system was now at the point of being brought back up and that this might confuse matters at this stage.

65. Once the system was restored, the Governors discussed the need for a post-event review, an apology and possible compensation. An apology from the Governor, and the commitment to launching an independent post incident review, were communicated in press statements on the day. Because the Bank had no mechanism for collecting and validating such claims, as the issue had never arisen before, no external announcement on compensation was made at this stage. The compensation scheme was agreed on October 22 and launched on October 24.

1.4.3.2 Media communications

66. A press statement was issued by the Bank during the incident and a further three following its resolution (see Appendix E: Press releases). The external media communication line and strategy was established by the Bank's Press Office and agreed with DGFS in consultation with DGPR and the Governor.

67. The initial media statement was prepared at 10:07 on the basis of the operational team's view that the situation should be resolved shortly, but in the knowledge there was no certainty over this. It was intended to provide reassurance and was deliberately constrained to avoid undue alarm. Given the expectation of an imminent fix without an adverse impact on customers, it was decided to hold the release on a reactive basis. When the statement was issued, at 11:14 following the first signs of media activity, its reference to "*The most important payments are being made manually.....*" was open to misinterpretation (it related to CLS not housing payments) and several external stakeholders perceived this as a lack of recognition of the consumer inconvenience which was on-going.[8]

68. In addition to the formal media statements, there was significant interaction between the Bank's Press Office and the media during the day. The Press Office recorded 73 press calls on the day and through these calls gave additional background information and reassurance to the major publications and broadcasters.

69. The Bank's Public Information and Enquiries Group recorded 60 calls providing the same background and reassurance. CHAPS Co. also reported in excess of 100 calls from the CHAPS hotline and a similar number of emails.

70. The Bank's Press Office also spoke to the Payments Council, CHAPS Co., HMT and the FCA press offices during the day.

71. Subsequent press statements were released following the resolution of the issue, to confirm the extension of the settlement day to 20:00 and the Governor's decision to launch an independent review into the outage. The Governor's apology for the problems caused by the incident was given in the final press statement at 21:46.

[8] In the early stages of the outage the Bank had prioritised CLS payments for financial stability reasons, and in view of Asian markets closing times.

We conclude that:

72. Involvement of the Bank's Governors resulted in key issues such as the use of the contingency solutions, the content of press statements and the potential impact on 'real economy' transactions being considered and prioritised through the day.

73. The absence of a defined structure and process to improve situational awareness in support of the Governors meant that the specific issue regarding the timing of housing market transactions was not identified or escalated early enough. Combined with an expectation that the incident would be resolved quickly, these factors influenced the decisions regarding the first media statement, and the decision not to invoke MIRS at an early stage.

74. Whilst the Bank's press releases were limited and the initial press release may have been open to misinterpretation, overall the Bank's engagement with the media was considerable and this avoided uninformed or alarmist reporting.

1.5 Contingency plans and back-ups

75. This section summarises the decisions taken relating to contingency and back up alternatives.

76. A defined and regularly tested manual contingency arrangement for time-critical CLS sterling payments-in was invoked at 08:24. This resulted in CLS sterling payments-in being completed satisfactorily, though with some delay in two early closing (Asian) markets and a necessary reconciliation by CLS later in the day to account for duplicate payments and instructions.

77. The RTGS contingency solution, MIRS, was considered through the day, most notably at the 14:20 meeting convened by DGFS, by which time the actions in the plan to fix and resolve RTGS were nearly complete. Throughout, the operational and technical resolution teams felt the 'fix forward' plan was the best option, although it was agreed at the 14:20 meeting that that if RTGS was not up and running by 15:15 a further meeting would be convened to decide whether to move to MIRS.

78. There were concerns that a switch to MIRS could not then be switched back to RTGS until the weekend (see paragraph 105 for further details). This would have meant running with a system which had reduced functionality (e.g. no LSM) and less resilience (there is full local resilience within the data centre in which MIRS is hosted, but not across two data centres as is the case for RTGS) for the remainder of the week. This was considered by the Bank's operational and technical teams to be a higher risk option than continuing with a prolonged intra-day outage in RTGS when a plan to resolve the issue was in place.

79. It is apparent that the limitations to switching to MIRS were not widely understood before the incident either by the Bank's Governors, or across the industry. In addition, there were no clear criteria to support decision making for MIRS in the context of mitigating impacts to the housing market and 'real economy' transactions. According to CHAPS Co, no consultation took place between the Bank and CHAPS members on the decision not to invoke MIRS in the early stages. CHAPS Co. noted some misunderstanding amongst members on the scenarios in which MIRS would be invoked.

80. The MIRS contingency option was originally conceived to provide additional resilience in the event of a catastrophic loss of, or access to, RTGS. At the time of the incident, it had not been considered as a possible solution for a potential loss of integrity scenario.

We conclude that:

81. The preference to fix and resolve the issues with RTGS on the day was the right decision, despite on-going slippage in the resolution time, given that the process to switch back to RTGS intra-week has not been tested and MIRS lacks the full resilience and functionality of RTGS. However, early invocation of MIRS on the day could have helped mitigate the immediate impact on the 'real economy'.

1.6 Lessons to be learned

82. The outage has provided a valuable opportunity to enhance the overall resilience of RTGS and future response arrangements should another incident occur. Our key recommendations in this regard are set out below. These are described in more detail in Section 4.

1.6.1 Robustness of the system

83. **Improve the governance, change and testing arrangements over RTGS.**

Governance

a. The RTGS Board should be reconstituted, with one of the Bank's Deputy Governors as Chair and the CIO and Director of Banking attending

Change

b. Unless there is a compelling policy or market reason, further functional or non-routine configuration changes to RTGS should be deferred while business assurance activities are undertaken

c. Where a functional or non-routine configuration change is deemed essential, appropriate leadership approval should be given and a risk mitigation plan put in place, including ensuring the availability of an appropriate senior person and operational / ISTD staff on site on the day of the change going live

Testing

d. The Bank should improve the testing regime for RTGS. The Bank should consider: increased independence of testing responsibilities between ISTD and Banking, more thorough regression testing for future changes and more comprehensive test scenarios and scripts

e. Strong consideration should be given to separate test and pre-production environments

Technical strategy

f. The Bank should define the future technical strategy for the delivery of RTGS (taking account of the outcomes of the internal review of the underlying risks of RTGS).[9] The strategy should be reviewed and approved by the reconstituted RTGS Board

[9] Following the meeting of the Bank's Audit Risk Committee (ARCo) in July 2014, where it was agreed to establish a programme to address infrastructure obsolescence, the Bank has established a number of work streams to identify and assess the underlying risks to RTGS. See Section 3.2.3.5 for further details.

1.6.2 Effectiveness of the Bank's response

84. **Accelerate the improvements being made to the Bank's crisis management capabilities.**

Bank-wide crisis management

a. The on-going work to improve and then test the Bank's internal crisis management and communications capabilities should be accelerated to ensure the Bank is better prepared to deal with an operational event, or a situation affecting the Bank's reputation, in a controlled, transparent and co-ordinated manner. This should include:

   i. Incorporating defined escalation protocols and accepted best practice structures, roles and responsibilities for managing a crisis

   ii. Acknowledging within the ARF that in certain circumstances the Bank itself may be the cause of a wider financial services sector 'crisis' and that an RTGS outage is one such scenario and that in such situations the Bank should co-ordinate proactively with the PRA, FCA and HMT and that the ARF provides the mechanism for this

85. **Establish a co-ordinated operational response capability with CHAPS Co. to an RTGS failure, which considers the impacts and needs of all stakeholders.**

RTGS operational response

a. The Bank should recognise more clearly in its contingency planning that RTGS provides high value payments services to the public, corporations and Government and co-ordination and communications in the event of an outage should fully reflect this

b. The roles and responsibilities in the MOU with CHAPS Co. relating to handling an RTGS outage should be re-examined and once completed, both parties should develop a joint response plan enabling them to fulfil the agreed roles and responsibilities, co-ordinate their involvement and support each other

c. The Bank or CHAPS Co. should consider setting-up an access point (on-line) where affected parties can go for information and updates on an RTGS outage. One possibility is the CHAPS Co. website given this is a location that end-users (e.g. CHAPS members and solicitors) would naturally turn to. The role of the website already established for major operational disruptions under the ARF should also be considered in this context

d. The Bank should conduct a scenario based rehearsal of a prolonged RTGS outage as soon as the work above is completed, involving all necessary parties (including external stakeholders). The rehearsal should test escalation protocols, information flows, lines of communication (internally and externally) and key decisions over contingency options and recovery procedures

1.6.3 Contingency plans and back-ups

86. **Prepare for a loss of integrity scenario for RTGS and reduce the barriers to switching to MIRS other than as a decision of last resort.**

MIRS contingency solution

a. Work should be undertaken to remove or reduce the barriers to invocation of MIRS so that the Bank can "switch and fix" in parallel and in confidence. This should focus on testing the process to fail-back to RTGS intraweek (which is the primary barrier to invocation). If it is not possible to reduce this barrier, consideration should be given to enhancing the resilience and functionality within MIRS. In addition the Bank may wish to consider other back-up options for RTGS

b. The understanding and awareness of key internal and external stakeholders of the MIRS contingency option (what it provides, when it would be used and the implications of using it) should be enhanced (this in part can be achieved through the recommended scenario based rehearsal)

RTGS Managers' Contingency Manual

c. The Manual should address a 'loss of integrity' scenario. This should include development of the necessary scripts and templates to facilitate faster reconciliation

d. The Manual should set out the decision criteria for invocation of MIRS, including the impacts and implications for various market segments against a range of decision times for invocation of MIRS

e. The Bank should consider reviewing media communication strategies and the approach to redress and compensation in the event of an RTGS outage, and include these in the Manual

CLS contingency

f. The Bank should also reconsider adoption of the CLS Central Bank Automated Contingency solution which would reduce the manual effort required and make reconciliation of the CLS sterling payments-in faster (it has been adopted by Switzerland, New Zealand and Canada; the Bank does not have a date scheduled for adoption)

2 Description of RTGS

2.1 An overview of RTGS

87. The Real-Time Gross Settlement (RTGS) system is operated by the Bank of England (the Bank) and provides a real-time settlement accounting environment to support the UK financial services sector.

88. The RTGS system forms an important part of two interbank funds transfer mechanisms: the CHAPS high-value payment system and the funds transfer mechanism supporting the CREST securities settlement system in real-time (referred to as 'Delivery versus Payment' or DvP). One particularly important category of CHAPS payments settled in RTGS are CLS (Continuous Linked Settlement) payments. CLS is the foreign exchange settlement system that was introduced in 2002 to eliminate foreign exchange settlement risk in participating currencies. RTGS also enables settlement for lower value clearing schemes including Bacs, Cheque & Credit Clearing, Faster Payments Service, LINK, VISA and settlement of the Note Circulation Scheme.

89. There are currently 21 CHAPS sterling members and 16 CREST sterling settlement banks holding accounts in RTGS. RTGS supports on average £252 billion worth of CHAPS sterling payments, with an average of 144,000 payment volumes daily, and £274 billion of CREST cash movement per day. Also, as part of the Bank's Sterling Monetary Framework, 131 participants hold and manage balances in their RTGS reserve accounts.

90. In addition to its important role in supporting monetary and financial stability policy and the safe functioning of the financial system, RTGS also processes a number of 'real economy' transactions, primarily those related to house purchase transactions, legal probate and large business to business payments including business acquisitions and high value payments to suppliers. Appendix A provides a timeline of milestones in the development of RTGS since its introduction in 1996.

2.1.1 Technical features of RTGS

91. The RTGS Processor is host to all the accounts held in RTGS and carries out all the postings made to those accounts. To ensure the smooth and uninterrupted operation of RTGS, the RTGS Processor runs on fault tolerant computer hardware which is replicated on a second site; with the business operation also conducted on a split site basis.

92. Within the RTGS Processor is a Central Scheduler (CS) through which all CHAPS settlement instructions have to pass and allows CHAPS banks to distinguish between urgent and non-urgent CHAPS payments. Individual CHAPS payment instructions are routed via the SWIFT network to the RTGS system and settled across CHAPS banks' settlement accounts.

2.1.2 A typical day

93. RTGS is open for service between 06:00 and 16:20 from Monday to Friday with clearings settling at set points in the day. On opening, RTGS settles CHAPS Sterling payments; CREST DvP settles at 2 minute intervals through the day; CLS consists of five calculated Pay-in and

Pay-out deadlines each hour from 07:00 – 11:00; all other payment schemes settle at various points in the day. Figure 4 below shows how payments are cleared on a typical Monday, by volume and value.

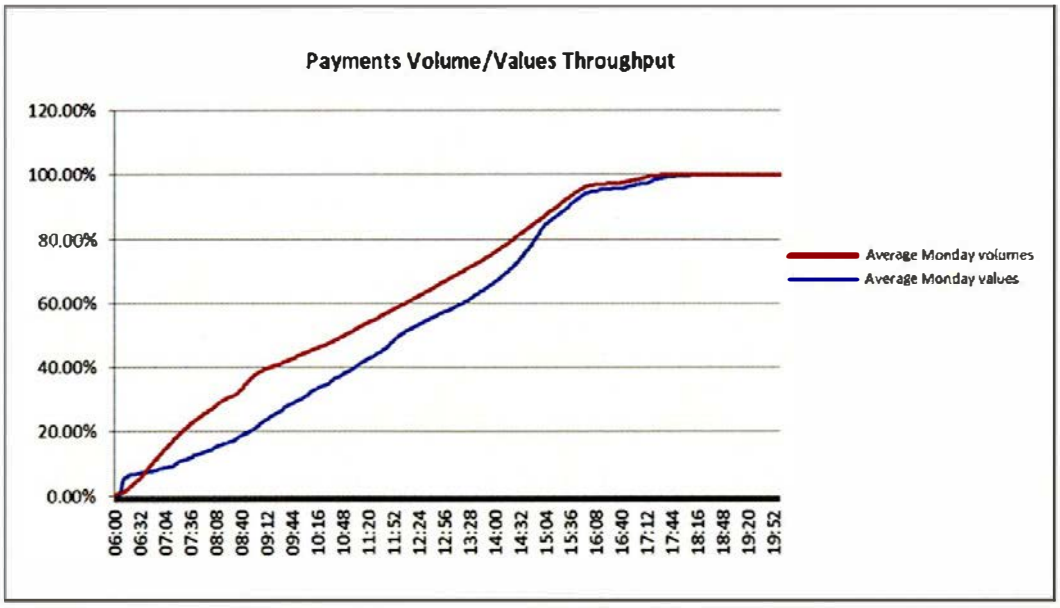


Figure 4: Typical Payments Volume/Values Throughput on an average Monday

3 Description of the incident

3.1 Introduction

94. In this section of the report we describe the relevant facts, the system's reliability to date and relevant issues in the lead up to the incident, during the incident itself and as a result of the incident. The section is set out as follows:

- **Pre-incident** – covering from when RTGS first went live in April 1996 and providing important context leading up to the incident on 20 October
- **The RTGS incident on 20 October 2014 -** examining the incident itself and describing the key events, timings and decisions through the period of the incident; it addresses the technical investigation, the Bank's response and the use of contingency plans
- **Post-incident -** covering activities undertaken since the 20 October including the post incident response, compensation and the impact on planned future changes to RTGS

3.2 Pre-incident

95. Figure 5 provides a timeline of relevant governance, functional and configuration events related to RTGS since it went live in April 1996. Each of these events is described in further detail through this section of the report.

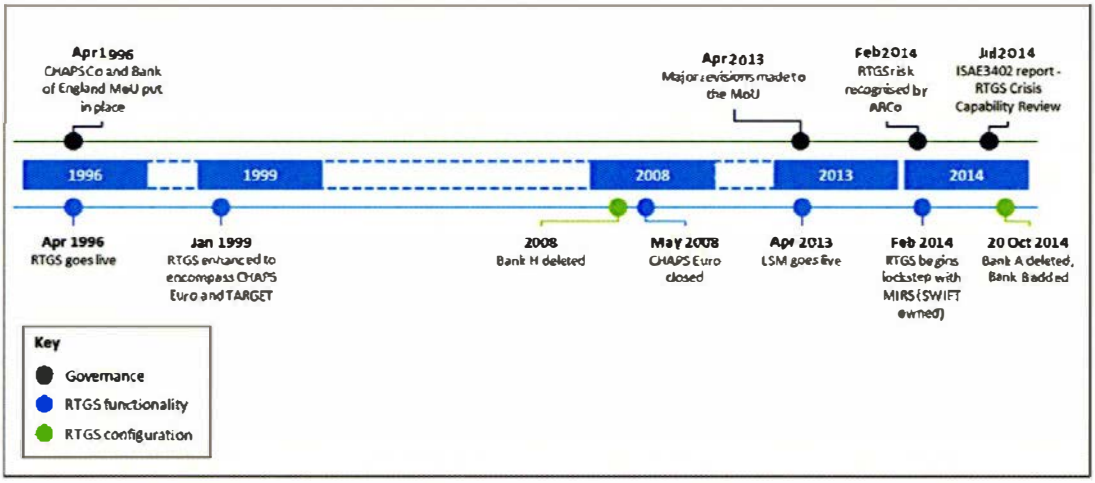


Figure 5: Pre-incident timeline

3.2.1 Reliability of RTGS up to 20 October

96. The RTGS System has been operational for 18 years and has evolved to meet demands for new and changed functionality. The Service Level set out in the MOU between the Bank and CHAPS Co. is 99.95% over any month, which equates to an average monthly downtime of 7 minutes (assuming a 20 day month). Figure 6 illustrates the achieved availability levels over the past 10 years. In each of the previous 5 years, prior to the incident on 20 October, the system had attained an availability level of 100%.

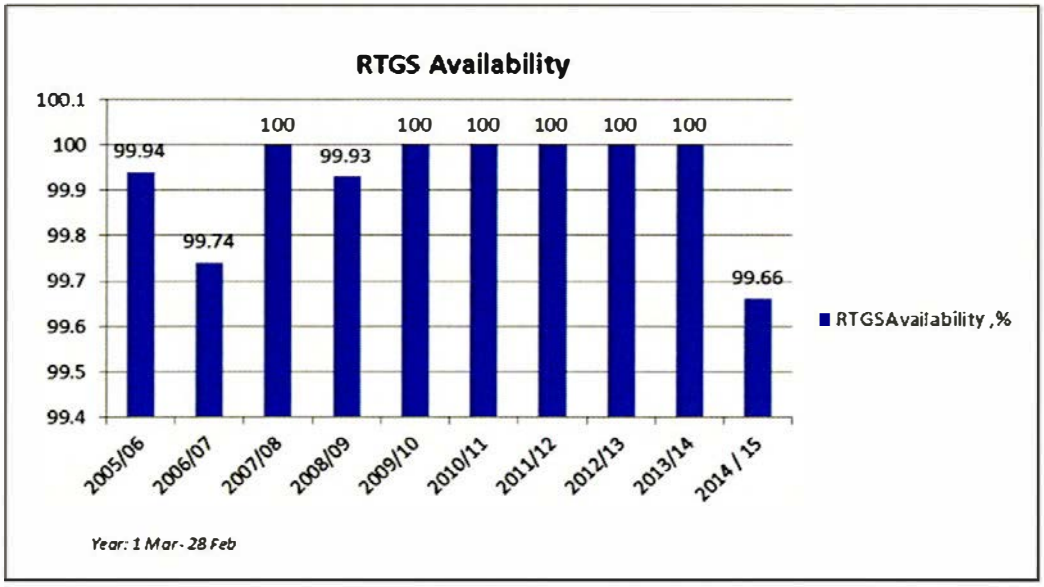


Figure 6: Yearly availability of RTGS

97. By comparison, TARGET2 (the RTGS system for the processing of cross-border transfers throughout the European Union) has maintained an availability average above 99.90% since 2011.

3.2.2 Key changes and conditions relevant to the incident

98. The last CHAPS member removal prior to 20 October was the removal of Bank H, in 2008. This was prior to the major functional changes introduced with LSM and MIRS. In order to facilitate the 20 October removal, some preparatory changes to the system were necessary; these were completed in April 2014 and tested in May 2014.

99. These changes are explained in more detail below, followed by events over the weekend leading to 20 October.

3.2.2.1 Introduction of the LSM

100. The LSM launched **in April 2013**, in part as a result of tighter liquidity regulation following the financial crisis, with the aim to increase the overall liquidity efficiency of CHAPS payments.[10] The liquidity efficiency of CHAPS was improved, without a significant detriment to the timing of payments, by using a two-stream approach to processing payments. Individual urgent payments continue to settle immediately, while non-urgent payments are temporarily queued.

101. The queuing of payments prior to their settlement allows them to be 'matched' by an algorithm that looks for combinations of payments that, if settled simultaneously, use less overall liquidity to do so than would be used if those payments settled sequentially. This process is known as 'payment offsetting', and is the basic principle by which the LSM works, providing on average 21% daily liquidity savings.

102. **In April 2014**, a change was made to enhance the process for adding and deleting CHAPS members' profiles in preparation for 20 October. This change introduced a design defect in Process A, which ensures multilateral/bilateral profiles are present for each CHAPS Sterling

[10] Liquidity Saving Mechanisms are a common feature of most modern RTGS systems.

member. This defect, which was not picked up in the testing in May 2014 prior to its introduction into the live system, is described in Section 3.3.1.3.

3.2.2.2 Introduction of MIRS

103. The MIRS contingency option was originally conceived to provide additional resilience in the event of a catastrophic loss of, or access to, RTGS. The objective of MIRS is to maintain an essential CHAPS service in the case of the failure of the Bank's RTGS system. There are two types of RTGS failures that could result in activating MIRS:

    1. A functional or operational issue with RTGS, whereby the hardware and infrastructure remain available
    2. A complete loss of the RTGS service with no backup or development system available (for example, a possible complete loss of both RTGS sites)

104. In the event of its invocation MIRS would, after a switchover period, enable CHAPS inter-bank payments to continue to be made during the day with finality and immediate settlement. The switch over period can take up to two and a half hours; this is defined in the SLA with SWIFT and has been subject to regular testing. Once MIRS is fully active it has been determined through testing that it is capable of processing peak daily payment volumes in two and a half hours.

105. Following an invocation of MIRS, there is no technical impediment preventing a switch back to RTGS at the end of the day as the process for an intraweek switch back is the same as a weekend, which is documented and tested regularly. However there is a concern within the Bank that as a manual process there would be an increased risk of error if attempted overnight. There is work planned in 2015 to look at reducing the risk of manual error through increased automation of the switch back process.

106. Functional defects to RTGS were introduced with the implementation of MIRS and are discussed in Section 3.3.1.6.

3.2.2.3 Weekend prior to the incident on 20 October

107. On the evening of Friday **17 October**, work was performed on the RTGS system to transfer the CHAPS membership of Bank A to its subsidiary Bank B by removing the CHAPS member table entries for Bank A and adding the required entries for Bank B.

108. This configuration change was tested on Saturday **18 October** in line with standard procedure (see Section 3.3.1.1). On Monday, **20 October** a planned "controlled start" (where members exchange offsetting payments of £1) was undertaken before the formal opening of RTGS. In both the weekend and controlled start tests, no errors were detected.

109. Although not complex in itself, no members had been removed from CHAPS since 2008, making this the first such instance since the LSM and MIRS projects went live. On Monday 20 October, despite the testing, it was this configuration change that triggered the failure of the RTGS system. This is further discussed in section 3.3.1.

3.2.3 Internal governance

3.2.3.1 RTGS Governance Structure

110. The Market Services Division is responsible for providing and operating the RTGS system and the HoDMS is the Business Owner for RTGS accountable to the EDM for the provision of the RTGS service.

111. Governance of the RTGS system centres around the co-ordination of RTGS related issues between seven core groups; the RTGS Board, Financial Operations (FO) Operations Business Change Group; FO Operations Portfolio Progress Group; RT Change Review; RT Live Issues Group and Crisis Command Group. Internal and external issues relating to RTGS are input into this core structure, allocated to the appropriate areas, discussed in the relevant group and then moved up the governance structure or output to external working groups. Of these groups, the RTGS Board has most direct oversight for RTGS being responsible for long-term strategy, development, the programme of change, key supplier relationships and performance reviews with a specific remit to identify areas of fragility or risk.

112. The RTGS board meets quarterly and its membership mainly comprises representatives in Market Services Division, Payment System & Communications, and Banking Services at Senior Manager level and below, and technical members from ISTD. The system is therefore governed by those responsible for its day to day operation.

3.2.3.2 Changes to the ISTD function

113. Historically, the role of ISTD in the governance of RTGS has been subsidiary to that of Banking Services. This may have contributed to an incomplete view of complexity and risks associated with enhancements to RTGS.

114. In the past 12 months, the ISTD function of the Bank has undergone important changes. There has been a change in leadership with the appointment of a new CIO from industry in September 2013 and thus an overall change to the governance of the function which now reports in to the Chief Operating Officer.

115. The Bank has recognised the need to further review roles and responsibilities for the management and governance of the RTGS system. Work is also being undertaken on the key risks relating to RTGS (see Section 3.2.3.5), and considerations about its architectural direction and the way in which responsibilities for the RTGS service are set out.

3.2.3.3 Testing

116. During the operational life of RTGS, the structure of testing activity has also evolved with a reduction in dedicated testing resources within ISTD. We noted a number of limitations in the approach to and execution of testing which allowed the design and functional defects that led to the incident to remain unidentified until they surfaced during live running. These are detailed in the paragraphs below.

117. ISTD is responsible for the technical design assessment and the unit and system testing of change. It has a defined process and toolset for conducting these tests. These activities are conducted by the small pool of staff who are also responsible for developing RTGS. Whilst there is a degree of independence between the design, development and testing activities, it is not fully in line with good industry practice which would involve an independent dedicated testing function. Furthermore, in practice for larger changes, most members of the design and development team are likely to have been involved in the change, which effectively means team members may be required to test their own changes limiting the independence of the testing and making it difficult to identify design or coding issues due to self-review.

118. Unit and system testing are conducted in ISTD's development environment for RTGS, which can inhibit the effectiveness of testing due to limitations with the environment and introduces complexity in managing the testing process if the environment cannot be 'locked down' to development whilst the testing is undertaken.

119. There is no pre-production environment available to migrate the changed code to prior to release. Such an environment would typically replicate the production environment and be used to enable testing through the full production life cycle to confirm the changes can be released into the live environment effectively. Critical systems would commonly be expected to have a pre-production environment.

120. As a result, one of the limitations in the testing of RTGS is the inability to undertake a full 'Day 1' test to mirror the conditions of a release into production. The issues relating to the removal of Bank A and the subsequent RTGS problems which were triggered may have been highlighted before they went live if such an environment had been available and full life cycle testing had been completed.

121. Regression testing describes the process used to check that the changes being introduced have not negatively impacted existing system functionality. Regression testing is conducted by Team D as part of each change. Given the manual nature of the testing, a full regression test of RTGS can take up to 8 man-weeks.

122. As a result of the extended time to complete regression testing, test packs are run selectively as part of each change based on the experience of the testing and development team and the functions being changed. Selective regression testing does not provide assurance that all existing functions have not been amended or negatively impacted by the change. Good practice would be to run a full regression test as part of the testing of every change and regression testing may sometimes be required to be run a number of times if there are multiple cycles of changes. However, the lack of automated tools to support testing inhibits the Bank's ability to run a comprehensive suite of tests to confirm the results of existing functionality have not been altered and that the system performs as expected in all scenarios.

123. Furthermore, testing is generally focused on confirming that added or changed functionality works as intended. As such, the test scripts are not designed to test the system responses to 'bad data' or to test negative scenarios (in which the system would be expected to fail). As a result, the opportunity may be missed to understand fully how the system will behave or to develop an appropriate response if those scenarios occur in the live environment.

124. Once testing has been completed, sign-off is required by various parties involved in the testing to approve the change prior to implementation into the live environment.

125. The performance of live testing, which involves participation of CHAPS members, was limited to confirming successful payment to and from the added CHAPS Member. To do this, all CHAPS members were required to make a £1 payment to Bank B and Bank B was required to make a £1 to all CHAPS members. This did not confirm that payments between all existing CHAPS members had been unaffected.

126. As a result of the outage, the Bank commenced business assurance activities in November 2014. This is focused on a code and design review, and a broader regression test of the system.

3.2.3.4 Risk assessment of RTGS changes

127. A process is in place for identifying when changes to RTGS are deemed as significant, with size and cost of the change being key factors used to determine its significance. The change that resulted in the incident on 20 October, however, had not been flagged as significant because it was deemed to be a configuration rather than functional change and therefore neither sizeable nor costly.

128. Whilst adding and deleting CHAPS members would not be considered a significant change in a modern system which handles reference data robustly, a greater focus on risk factors such as those below should have led to the conclusion that the change warranted particular attention:

- Deletion of a CHAPS member involved a more complex process to amend reference data and had not occurred for a long time
- Major functionality changes had been made to RTGS since the previous CHAPS member deletion

3.2.3.5 RTGS raised on the risk register

129. The CIO, who joined the Bank in September 2013, requested in **December 2013** that RTGS should be put on the Bank's risk register to consider medium term risks to RTGS in view of its ageing nature.

130. On **25 February 2014** RTGS was formally registered as a risk with the Bank's Risk Oversight Unit. It was identified that "The underlying technology of the critical RTGS platform has become increasingly difficult to support and maintain with the right set of skills and experience becoming more difficult to recruit and retain."

131. An initial terms of reference was prepared to examine the risks associated with RTGS in advance of a meeting of the Bank's Audit Risk Committee (ARCo) in **July 2014**. At this meeting it was agreed that the work to establish a programme for addressing infrastructure obsolescence, including investment in RTGS, would commence. Five work streams were established to identify and assess the underlying risks. These were:

1. Programme and Change
2. Application
3. Infrastructure
4. Data
5. Security and Privacy

132. We reviewed the available Terms of Reference for the relevant working groups (Infrastructure; Application; Programme and Change; and Data) tasked with identifying the detailed risks to RTGS. At the time of our review, each working group had held at least one meeting and was in the process of refining their respective terms of reference with a view to consolidating the risk identification process and providing an assessment of options for risk mitigation.

3.2.3.6 Complexity of RTGS

133. During the 18 years since RTGS was first launched, the incremental changes have resulted in an increase in complexity and a system which is now more difficult to understand and

maintain. In particular, the LSM and MIRS changes introduced additional functionality with an associated increase in complexity.

134. In combination with the ageing development language used to program RTGS, the result is a system which is more complex to support, heavily reliant on the skills and experience of the team to support it, and more susceptible to errors which take longer to diagnose. Therefore there is an increased risk of functional or configuration changes causing errors and if or when the system does fail it may take longer to resolve the issue.

135. Information about RTGS complexity is included in Appendix C and Appendix D sets out the volume and nature of incidents relating to RTGS since 2005. This highlights a spike in functional errors following the introduction of LSM and MIRS functionality. Figure 7 below illustrates this.

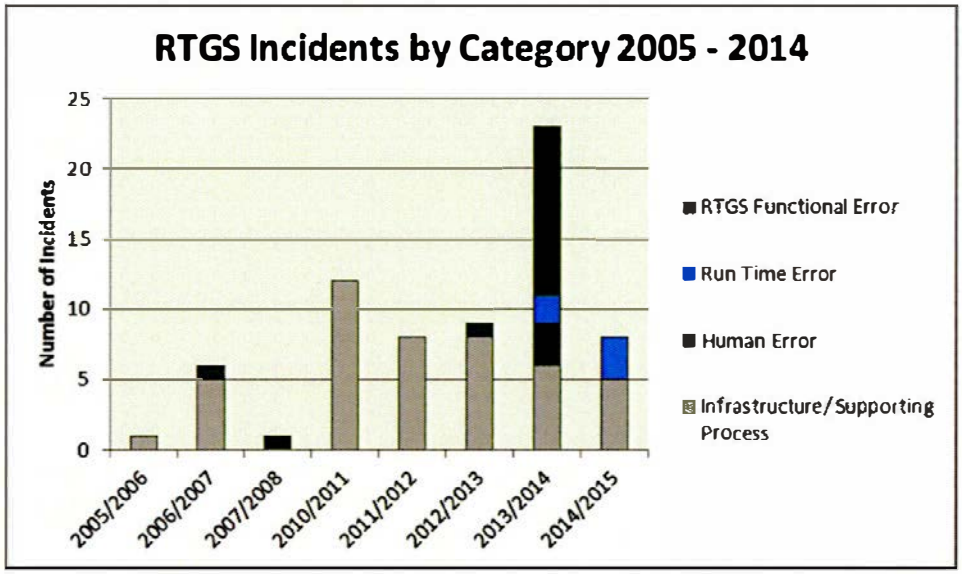


Figure 7: RTGS Incidents by Category since 2005 (excluding the RTGS outage on 20 October 2014)

3.2.4 External governance

3.2.4.1 The relationship with CHAPS Co.

136. The Bank is the settlement agent for CHAPS (Clearing House Automated Payment System), the system designed for making real-time high-value sterling payments. The CHAPS system is operated by CHAPS Clearing Company Limited (CHAPS Co.), whose responsibilities include setting system rules, monitoring compliance and admitting new members. CHAPS Co. is owned by its direct participants, with each settlement bank having a representative on the CHAPS Co. Board.

137. The MoU between the Bank and CHAPS Co. has been in place since RTGS went live (1996) and is revised regularly. It defines management responsibilities between the two parties which include providing a forum for discussion of CHAPS issues, liaison with other payment scheme and regulatory bodies and devising and managing the testing of suitable contingency arrangements. The last major revisions made to the MoU were following the LSM project which went live in April 2013.

138. Notably, whilst the MOU does cover responsibilities for the Bank and CHAPS in the event of a disruption, these are focused on operational and technical contingencies. The MOU does not

define how the Bank and CHAPS Co. should coordinate to manage the impact of an incident on a wide range of operational stakeholders, including CHAPS members.

3.2.4.2 External

139. In **August 2014**, the twelfth audit report on the operation of the Bank's RTGS service (ISAE 3402 'Independent Auditor's Report on the Provision of the Bank of England Real Time Gross Settlement Services') was issued.

140. The report concluded that the controls tested provided reasonable assurance that the RTGS control objectives were achieved and operated effectively throughout the period 1 March 2013 to 28 February 2014.

141. Overall, RTGS policies and procedures were operating so as to provide assurance that the Bank's control objectives were achieved. The Bank commented that this was a highly satisfactory conclusion that reflected the importance the Bank attaches to RTGS and the resources it deploys in the development and operation of the system.

142. In **March 2014**, on the Bank's recognition that it needed to strengthen its Business Continuity and Crisis Management capabilities, we (Deloitte) reported on the Bank's Business Continuity deployment model, and its application in practice. Work within the Bank to progress this was still underway at the time of writing.

143. In **July 2014**, in support of the ISAE4302 work for RTGS, a high level theme based review of the Market Services Division's (MSD) Crisis Management capability was also undertaken.

3.2.4.3 Internal

144. Since 2007, the Bank's Internal Audit (IA) function has completed five RTGS specific audits and one general audit of IT contingency. Two of these audits were rated as 'Needs improvement' and four as 'Satisfactory'.

145. In **December 2014**, IA assessed their coverage of RTGS in light of the outage on 20 October and noted that, whilst it has always assessed the relative inherent risk of RTGS as very high, as a result of the incident it had now identified further areas of work, including expanding the breadth of and depth of testing of the controls that IA review, as well as reviewing the MIRS alternative contingency service arrangement introduced in February 2014. These have been embedded into the audit plan for 2015/16.

3.3 The RTGS incident on 20 October 2014

3.3.1 The causes of the incident

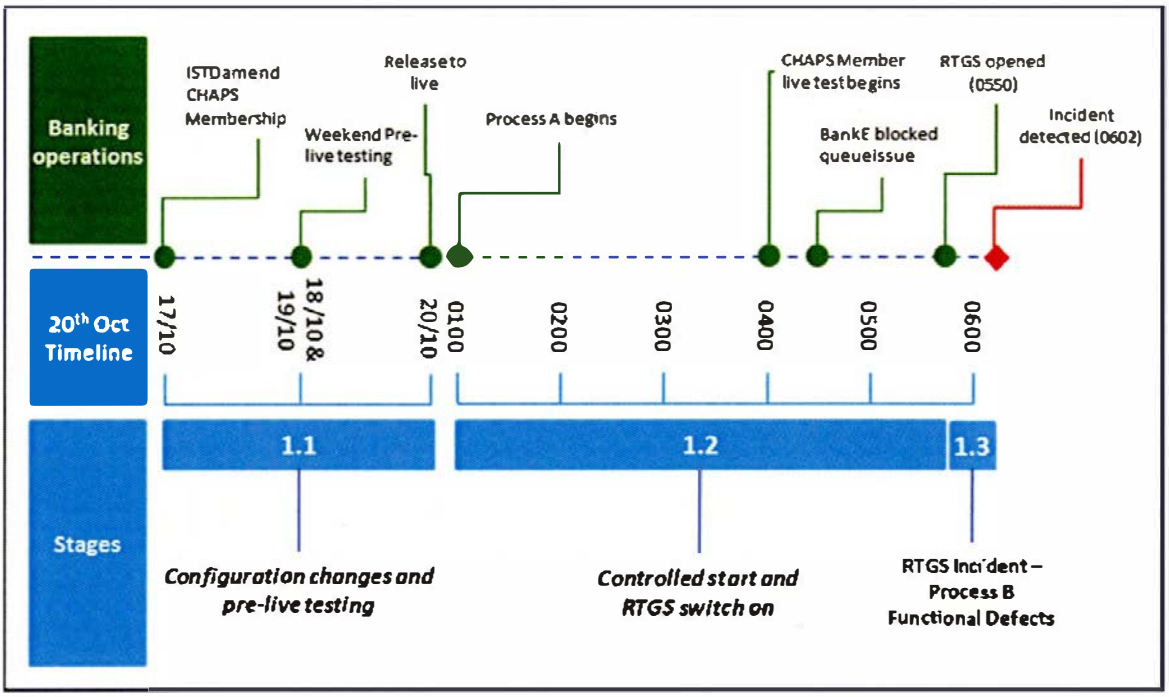


Figure 8: Causes of the incident timeline

146. Sections 3.3.1.1 to 3.3.1.6 describe in detail the technical cause of the incident.

3.3.1.1 Stage 1.1 - Configuration changes and pre-live testing

147. On **17 October**, after end of day processing, the list of valid CHAPS Sterling Members which is maintained by ISTD was amended to add and remove the relevant CHAPS member This is normal procedure for a change in CHAPS members.

148. Following the changes made on 17 October, testing was conducted over the weekend of **18 / 19 October**. As part of this all CHAPS banks successfully sent test payments of £1 to Bank B. Bank B returned these £1 test payments to each bank. No tests of payments to the deleted Bank A were made.

3.3.1.2 Stage 1.2 – Controlled start and RTGS switch on

149.

3.3.1.3 Process A – design defect

150. [redacted]

151. As noted in Section 3.2.2.1, the Process A functionality was changed in April 2014 and tested in May 2014 in preparation for the anticipated transfer of CHAPS members. [redacted] During this change, a design defect was introduced [redacted] 9 below.

[redacted]

152. [redacted]

153. Given that CHAPS member deletion had not occurred since 2008, and the design defect was introduced in May 2014, [redacted] the design defect had not previously impacted the live environment.

154. The design defect had not been identified during testing due to limitations in the testing process (see Section 3.2.3.3), to simulate adequately the behaviour of RTGS [redacted]

3.3.1.4 Erroneous Bank E Payments to an Invalid CHAPS Member

155. [redacted]

156. [redacted]

157. [redacted]

158. This issue was not central to the incident but added uncertainty in the incident issue identification.

3.3.1.5 How the Design Defect caused the incident

159. [redacted]

160. [redacted]

161. The weekend and "controlled start" testing did not identify the error because they did not require existing members to send payments to each other, i.e., all banks to all banks (see Section 4.1.2). Therefore, the primary cause of the incident (see Section 3.3.1.1) was not identified.

162. At **05:50,** the controlled start was deemed effective and therefore Team A opened RTGS, which started matching payments at 05:50 (it is normal for RTGS to open slightly earlier than the official CHAPS opening).

163. At **06:02** Bank C was the first to attempt to settle payments to Bank D. This triggered a system error and a further two functional defects in Process B as set out in Section 3.3.1.6 below.

3.3.1.6 Stage 1.3 – RTGS Incident – Process B functional defects

164. [redacted]

165. [redacted] Process B was enhanced as part of the introduction of MIRS in RTGS [redacted] and implemented to l'ive in December 2013, although not activated until February 2014.

166. [redacted]

167. However, a previously undetected functional defect [redacted] resulted in gross settlement (urgent payments) unexpectedly restarting.

168. [redacted]

3.3.2 The effectiveness of the Bank's response

169. A summary of the key events, communications and decisions on the day of the outage are shown in the timeline opposite (figure 10). These are described in more detail in Sections 3.3.2.1 to 3.3.2.5. These sections are set out as follows:

- *Section 3.3.2.1*: Operational and technical resolution
- *Section 3.3.2.2*: Operational co-ordination and communication
- *Section 3.3.2.3*: Involvement of the Bank's Governors
- *Section 3.3.2.4*: Media communications
- *Section 3.3.2.5*: Contingency plans and back-ups

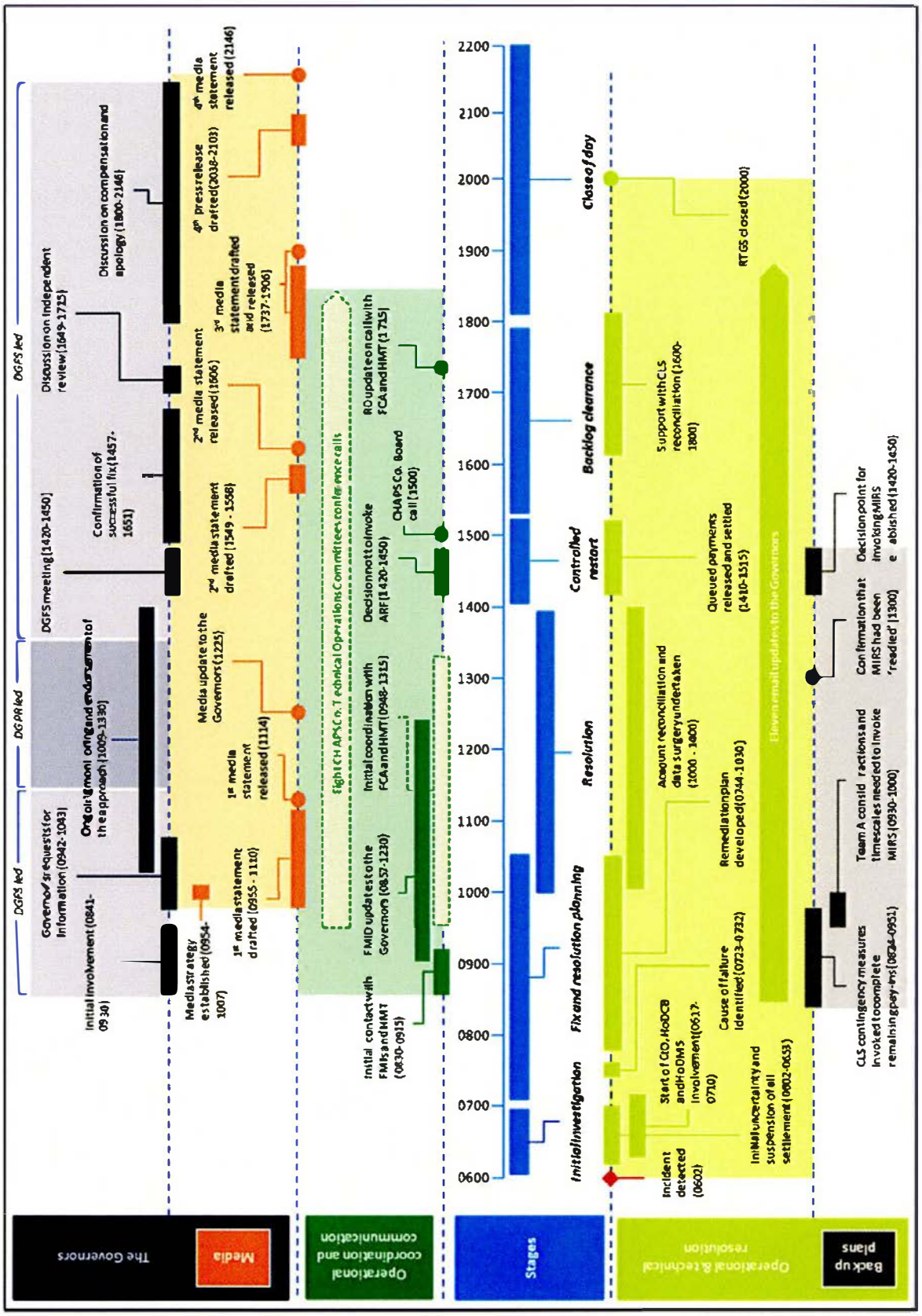


Figure 10 – Timeline of the Bank's response on the day

Note: Throughout the day there were frequent email communications and phone calls between the Governors and the Press Office.

3.3.2.1 Operational and technical resolution

3.3.2.1.1 Initial investigation (06:00 – 07:00)

System errors detected (06:02-06:03)

170. At **06:02** alarms were received on the screens used to monitor the operation of the system indicating that the settlement process had been automatically disabled.

171.

172. The strong monitoring and control over Start of Day processing for RTGS resulted in the near immediate detection of the system errors and enabled rapid escalation to ISTD support, which immediately began investigation.

Initial uncertainty and suspension of all settlement (06:05 – 06:53)

173. At **06:10**, on advice from ISTD, Team A sent a request to CHAPS Co. to issue a recorded message to all members to stop submitting payments. However, uncertainty was created when gross settlement (settlement of urgent payments) automatically restarted due to a previously undetected defect (see Section 3.3.1.6). Believing that urgent payments could still settle, Team A sent another request to CHAPS Co. at **06:30** to issue a voicemail to members to submit remaining CLS payments-in. By this stage the CIO had been alerted to the issue (at 06:17) and took immediate management responsibility for the fix and resolution.

174. At **06:45** ISTD started receiving error messages from each CHAPS member's payment stream which became blocked when they attempted to make the CLS payments-in.

175. By this stage an initial communication had been sent from Team B to selected HoDs, managers and operational staff in ISTD, Banking, Markets and FMID informing them of the problem, although no Executive Directors, Deputy Governors or their offices were included in this distribution list.

3.3.2.1.2 Fix and resolution planning (07:00 – 10:30)

Cause of Process B failure identified (07:00 – 07:32)

176. At **07:23** an email was sent by the CIO to the DGCOO, DGMB and EDM informing them that RTGS was not working. The email was not picked up because all three were overseas on official business in different time zones on the day, and this was not identified at the time.

177. [redacted] Having identified the cause of the [redacted] failure the ISTD team started to look at a data surgery plan to remove the extraneous rows.

Developing the remediation plan (07:44 – 10:30)

178. By this stage ISTD's Major Incident Management (MIM) process was invoked. Calls were set up between ISTD and Banking teams to discuss remediation and regular email updates were sent to senior managers and operational staff from ISTD, Banking and Markets, although the distribution lists of these emails did not include DGs' offices.

179. By **07:44** ISTD had outlined an initial plan to undertake reconciliation checks to understand current and future positions, make surgical changes to remove Bank A, start the settlement of Bank C's 157 outstanding payments and start the settlement for the other banks' queued payments. This outline plan was developed, refined and walked through with Banking several times before being finalised at **10:30**. The plan included:

- Reconciliation work to calculate expected positions once Bank C's payments settled
- Back-ups of the RTGS machines across both sites
- A clear down of Bank C messages to Bank D
- Database surgery to remove Bank A (considered at this time as the decision point for turning RTGS back on)
- A controlled restart to release queued payments, one CHAPS member at time
- Consideration to turn LSM off and allow settlement in 'gross mode' only
- Consideration of MIRS as a 'plan B'

180. Throughout this period regular communications were sent by the CIO and HoDMS to the Governors, who by the beginning of this stage were involved and leading the Bank's response, informing them that the remediation plan was being developed and reviewed.

181. The close relationship between Banking and ISTD meant that the teams worked well together to identify the issues; determine the cause; and, despite initial uncertainty, be in a position to start implementing some of the resolution actions from 10:00.

3.3.2.1.3 Resolution (10:00 – 14:00)

Account reconciliation and data surgery (10:00 – 14:00)

182. Although the remediation plan was not finalised until 10:30, by **10:00** work streams had been established to:

a. Commence the RTGS account reconciliation. A detailed reconciliation was considered necessary given the uncertainty and concern over a potential loss of integrity created by the failure of Process B, and the unexpected restart of the settlement process for urgent payments. The purpose of the reconciliation was two-fold. Firstly, to establish accurate current positions and projected future positions

needed prior to the controlled re-start, and to ensure that there would be no overdrafts when all the queued credits and debits in RTGS settled. Secondly, to ensure that the account and account group balances, as at the point where all Process B payments had settled were as expected by Process B. Given that Process B had not completed cleanly and non-Process B payments had settled gross post Process B, this added complexity to the process

b. Make internal preparations to invoke MIRS contingency if required. This included considering how MIRS would be invoked in the event the plan either failed or ran too late in the day, including the calculated time required to bring MIRS online and then process the day's business

183. By **12:43** ISTD had completed the account reconciliation, which showed a match for all projected Account Group positions compared against the adjusted Account Group positions. At this point the reconciliation was deemed successful and communicated to management.

184. ISTD originally estimated that the reconciliation activities would take between 60 – 90 minutes to complete. The longer than anticipated timeframe (165 minutes) was due partly to the uncertainty as to whether integrity had been lost, therefore requiring a very thorough reconciliation, but also due to the lack of a pre-defined approach, tools or templates to support the process. The seven SQL queries required to extract data from the RTGS database to support the above steps did not already exist and had to be designed, reviewed and tested on the day.

185. Between approximately **13:00-14:00**, following the successful completion of the detailed reconciliation ISTD performed further data surgery to remove remaining references to Bank A in the system. By **14:00** the system was ready for a controlled re-start.

186. Throughout this period progress updates were provided by the CIO to the Governors. Earlier communications in this period suggested that the controlled restart would be able to commence at approximately 12:30; however later updates changed this to approximately 14:15 when it became clear that reconciliation activities and data surgery activities were taking longer than originally anticipated.

3.3.2.1.4 Controlled restart (14:00 – 15:15)

Settling of Bank C's outstanding payments and all other queued payments (14:00–15:15)

187. At **14:10**, following the completion of data surgery, Bank C's 157 queued payments were released and settled over a three second period. At **14:12** Banking confirmed settlement of these payments and ISTD performed a successful 2nd stage reconciliation of CHAPS Group Account positions against where they should have been had Process B finished settling at 06:02. The system was then handed back to Banking for a controlled return to gross settlement.

188. The return to gross settlement began at **14:45** when Team A turned off the LSM. This had the effect of auto-promoting all payments to 'Urgent' so that all payments could be settled in gross, therefore bypassing Process B. CHAPS members' group accounts were re-activated in a specific order with Bank of England and CLS accounts re-activated first, followed by Bank F and Bank G who needed to transfer liquidity to support their CREST settlements. All remaining CHAPS member accounts were then re-activated starting with smallest banks by volume

based on payments sent on a normal day. The advantages and disadvantages of this staged process, and the order in which accounts were reactivated, were not discussed or agreed with CHAPS Co. or CHAPS members prior to the decision being made by the Bank. CHAPS Co.'s perspective is that the approach taken by the Bank increased liquidity exposure and counterparty risk, and may have slowed the clearance of payments for some end-users. In reality this staged process took 25 minutes.

189. By **15:15** Banking had completed the controlled restart and RTGS was once again available for members to submit payments as normal. The Bank requested CHAPS members to switch to their contingency profiles; this increases each bank's bilateral limits thereby easing the flow of payments which had built up. Again, this had not been discussed with CHAPS Co. who have expressed a view that the use of contingency profiles introduced "significant counterparty risk for a short period" and also potentially increased operational risk, given that RTGS would not be operating in its normal fashion.[11] In practice the contingency profile is designed to facilitate a scenario such as this and no issues were encountered.

190. At this point some CHAPS members started to experience problems with Enquiry Link, the secure direct link between the RTGS Processor and Account Holders, due to multiple members attempting to access the system at the same time to change their 'Start of Day' profiles to their contingency profiles; however this was not significant in the overall events of the day.

191. By the end of this stage the teams undertaking the operational and technical resolution considered the outage to be over. Although the resolution of the incident took longer than originally anticipated, it should be noted that the knowledge and experience of the teams working on the identification, fix and resolution of the incident were critical and that they executed the plan in a controlled and cautious manner.

3.3.2.1.5 Backlog clearance (15:15 – 18:00)

Assistance with CLS reconciliation (16:00 – 18:00)

192. Shortly after RTGS was operational again the Governors were informed that settlement had resumed, that all payments were settling as normal, and that CHAPS and other FMIs would extend settlement closing times to 20:00 in order to maximise the opportunity for settlement.

193. During this period CLS undertook a detailed reconciliation of its Sterling account position with the Sterling payments-in on the RTGS system. This was because CLS received 22 duplicate payments-in when RTGS restarted, and needed to determine if these were duplicate funds (actual money sent multiple times in error by a CHAPS member) or duplicate instructions (multiple instructions for the same payment sent in error). To do this CLS needed to identify which payments-in had been made manually versus those that had processed successfully before the outage.

194. At approximately **17:00** there was a changeover of Team A staff at the Bank which, according to CLS, added complexity to the reconciliation process because incoming personnel did not appear to understand fully which payments had been made manually and which had processed straight through. CLS felt that this resulted in the reconciliation taking longer than originally anticipated and that this could have been avoided had there been better continuity of

[11] CHAPS Co. Post Incident Review document

Bank staff between those who had been booking CLS payments-in during the morning, and the teams who arrived later in the day.

3.3.2.1.6 Close of day (18:00 – 20:00)

195. By **18:00** Banking confirmed that settlement had now caught up and processed the backlog of payments in the system. Shortly before **19:00** ISTD sent a final update of the day to the Governors and Bank staff involved. Payments teams within banks, FMIs and some solicitors reported having to work through until late that evening to reconcile, clear up and prepare for the next day.

3.3.2.2 Operational coordination and communication

3.3.2.2.1 Fix and resolution planning (07:00 – 10:30)

Initial contact with FMIs and HMT (08:30 – 09:15)

196. FMID first became aware of the incident after picking up email updates provided by Team B sent shortly after the outage. FMID subsequently forwarded an internal email to the Private Secretary of DGFS at 08:31, effectively marking the start of the Governors' involvement.

197. Between **08:30** and **08:45** initial communications were made to HMT's Exchequer Funds team by Team C, who also undertake , to say there was a problem with RTGS, though it should be fixed very shortly.

198. Between **08:40** and **09:15** FMID began contacting Central Counterparties and Payment Schemes to inform them of the incident.

Co-ordination with FMIs: On-going FMID updates to Governors (08:57 – 12:30)

199. Starting at **08:57** FMID provided regular updates to DGFS Office on the implications of the outage for different FMIs. These were based on regular communications FMID had with FMIs throughout the morning of the incident. A consolidated summary of the impact on FMIs was provided to the Governors by Director, Financial Market Infrastructure Division (DFMID) at **12:29** (see paragraph 213).

Coordination with CHAPS Co.: Technical & Operations Committee calls (09:30 – 18:15)

200. At **09:30** CHAPS Co. hosted the first of eight "Technical & Operations Committee" (TOC) calls that would be run throughout the day, the final TOC call being held at 18:15. These calls were the primary mechanism for keeping CHAPS members updated on the situation. The Bank was represented at these calls by Managers and Senior Managers from Team A who provided updates to CHAPS members.

201. Several external stakeholders we interviewed believed that the Bank's representation on these calls was too junior, lacked continuity and that senior Bank representation was not visible early on during the incident. The same stakeholders cited that the representatives from the Bank were only able to provide limited information regarding the progress of the resolution.

202. CHAPS Co. have indicated that the emergency TOC call process is the laid down process by which emergency CHAPS Operational Incidents are handled between stakeholders in order to

ensure a common understanding between members. This process is not set out in the MoU or in RTGS Manager's contingency manual.

3.3.2.2.2 Resolution (10:00 – 14:00)

Initial coordination with HMT and FCA (10:08 – 13:15)

203. At **09:48** the Resolution Directorate provided an update of the situation via email to HMT and the FCA. What followed was a series of communications between the three parties (between **10:08** and **11:48**) as HMT and the FCA wanted an assessment of the severity of the incident, including the consumer impact, timescales for resolution and the press lines the Bank was taking. DGFS Office, the Press Office and the teams undertaking the operational and technical resolution were not included on the distribution lists of any of these communications.

204. Concerned that the information from the Bank was limited, HMT emailed Executive Director Resolution Directorate (EDRD), Andrew Gracie, and EDM at **11:51**, asking for an update to meet an urgent request to brief the Chancellor and stating that better communications channels were needed, resulting in HMT receiving a verbal briefing directly from HoDCB and separately from EDRD. Subsequent email correspondence between HoDCB and HMT during this period confirmed HMT's need to have a further update by 15:00 in order to brief the Chancellor. This request was relayed to the Governors by HoDCB.

205. It is clear that there was little or no co-ordination between those dealing with the incident and the Bank's Resolution Directorate, or vice versa, prior to 14:30.

3.3.2.2.3 Controlled restart (14:00 – 15:15)

CHAPS Co. Board call (15:00)

206. At **15:00** CHAPS Co. hosted a Board call which HoDMS attended. At this call HoDMS requested that, on restart of the system, members prioritise what appear to be 'real economy' payments (e.g. house purchases).

3.3.2.2.4 Backlog clearance (15:15 – 18:00)

RD update to Governors (17:05)

207. At **17:05** Private Secretary to EDRD (EDRD PS) provided an update to the Governors' offices summarising an earlier call EDRD had with members of the ARF to discuss the outage. On this call the FCA and HMT asked if the Bank intended to compensate consumers for potential late payments and what the Bank was doing to field individuals' questions about consumer payment arrangements. No comment was provided at this stage regarding the Bank's intent or otherwise to compensate consumers.

3.3.2.3 Involvement of the Bank's Governors

3.3.2.3.1 Fix and resolution planning (07:00 – 10:30)

Initial involvement (08:31 – 09:30)

208. DGFS, who had not been informed of the situation previously, was the first of the Bank's Governors to become aware of the situation when he was informed by his Private Secretary shortly after **08:31** as she had received an email from FMID who in turn had been informed that CLS was not settling due to the outage. During this period DGFS immediately sought updates from the CIO and HoDCB who were overseeing the technical and operational resolution of the outage. DGFS was informed of the underlying cause of the issue (the design defect) and that a remediation plan was being developed. DGFS enquired about the use of MIRS at this stage but was advised that this would require a 2 – 2.5 hour activation time, by which time it was expected that RTGS would be operational again (c.11:30). DGFS was also advised that RTGS had the spare capacity to clear a full day's payments in three hours and that opening could be extended to 20:00 to ensure payments were cleared intra-day. DGFS therefore endorsed the decision to progress with the fix forward plan at this stage.

209. Between approximately **09:20** to **09:30** DGFS spoke separately with Jenny Scott (Executive Director Communications, EDComm), the Governor's Private Secretary (GPS) and DGPR to alert them to the issue for the first time, and to start thinking about press lines the Bank should take.

The Governor's request for information (09:42 – 10:43)

210. DGFS asked that the Governor was informed. The Governor was alerted to the issue by GPS at **09:42**, and shortly after confirmed that DGFS should take charge of the Bank's response with DGPR supporting. GPS emailed the CIO, HoDCB to ensure this was clear to the operational team working on the fix. At this point the Governor also asked for a briefing on potential 'pinch points' (large batches of payments at particular times of the day) and possible contingencies. An update was provided at **10:43** stating that: CLS had completed settlement for the day; remediation was underway and may take approximately 2 hours; that there is a contingency option (MIRS); that CHAPS activity is smoothed through the day; and that there is sufficient capacity and time to complete all payments within the day. The specific 'pinch point' regarding housing transactions, which normally complete by 13:00, was not cited and therefore not escalated to the Governors.

3.3.2.3.2 Resolution (10:00– 14:00)

Ongoing monitoring and endorsement of the approach (10:09 – 13:30)

211. During this period the Governors received updates from the CIO on the status of remediation activities, stating that a controlled restart was likely to commence at approximately 12:30. Between **11:00** and **12:00** DGFS had further conversations with HoDCB and the CIO to understand the financial stability risk posed by the outage and to consider activating MIRS. At this stage DGFS was informed that there was no substantial financial stability risk provided the problem could be resolved by mid-afternoon and that the fix forward plan was on track to achieve this by approximately **12:30**.

212. Between approximately **11:30** and **13:30** there was a handover of leadership to DGPR as DGFS was offsite giving a speech at Chatham House, on the expectation that the issue was likely to be resolved by 13:30. At 12:01, DGPR sought an update on the situation. Due to his growing concern at the absence of a clear timetable for remediation, DGPR communicated to the Governors, and the teams undertaking the operational and technical resolution, the need to confirm a time by which RTGS had to be operational to clear the day's payments within an acceptable time.

213. **At 12:10** FMID had an update from supervised FMIs detailing the impact on them from the incident (this was subsequently provided to the Governors in an email update at 12:29). This update revealed that the impact on payment systems (excluding CHAPS), CREST and Central Counterparties was not substantial. Specific details of the update included:

- Bacs and FPS were operating normally with retail payments processing but interbank settlement was not occurring and that this may require intervention to continue processing if caps were reached
- CLS settlement and all payments were complete
- CREST was processing DvP normally

214. **At 12:17**, in response to DGPR's request for an update at 12:01, HoDMS sent an email to the Governors explaining that:

- There were 157 Bank C payments in the scheduler which would be released progressively as part of the system restart.
- RTGS could settle a full day's worth of CHAPS payments in under three hours
- An extension for payments could be made until 20:00 and that CHAPS had already been put on notice for this
- The remediation plan was progressing
- CREST settlement was progressing as normal

215. HoDMS's view at this stage was that the Bank was not yet at a point where they were unlikely to complete the day's business and that although MIRS was being prepared, the expectation was to resume CHAPS settlement with RTGS (i.e. 'fix forward'). DGPR acknowledged the update at 12:24.

216. At **13:08** the CIO provided an update to the Governors explaining that the system was still not operational as reconciliation activities were taking longer than originally anticipated (see paragraphs 183-184 for further details).

217. At approximately **13:30** DGFS returned from Chatham House and, concerned by the slippage in timescales, summoned a meeting of the relevant staff within the Bank to discuss progress to date and to decide whether to invoke the MIRS back-up. DGFS also spoke to the Chancellor's Office to provide an update on the situation at approximately 13:30.

3.3.2.3.3 Controlled restart (14:00 - 15:15)

DGFS meeting (14:20-14:50)

218. Present at the meeting were DGFS, DGPR, EDRD, EDComm, DFMID, the CIO, HoDCB and HoDMS. The advice from the operational and technical resolution teams was that completion of the forward fix plan was at an advanced stage and RTGS should now be up and running by 15:00 – 15:15. The decision was therefore made that there was enough time to reinstate RTGS and complete the day's transactions. It was agreed that this should remain the primary plan, rather than invoke MIRS. It was also agreed to ask CHAPS members to prioritise house conveyancing payments at the restart and that the meeting should reconvene by 15:15 if RTGS was not up by then to decide whether to move to MIRS.

219. The meeting also considered whether the ARF should be invoked. It was decided not to as the system was now at the point of being brought back up and that this might confuse matters now that the fix forward plan was in an advanced stage. It was agreed that the ARF would only be invoked if there was a subsequent move to MIRS.

Confirmation of successful fix (14:47)

220. At **14:57** HoD Plan ISTD informed the Governors that Bank C's transactions had been processed successfully and that all other banks were being brought on in phases (see paragraph 188). At this point the Governors understood the system to be back online.

3.3.2.3.4 Backlog clearance (15:15 – 18:00)

Confirmation of successful fix (continued) (15:36 – 16:51)

221. At **15:36** an update was sent to the Chancellor's Office confirming that CHAPS members' payments were being restarted on a phased basis and that RTGS would remain open until 20:00 to maximise the opportunity for settlement, although in some cases this may be too late for end recipients to act on the payment (e.g. house purchases).

222. An email update was sent to the Governors from HoDMS at **15:54** stating that settlement had resumed just before 15:00, that all payments were settling as normal and that CHAPS members had been asked to prioritise mortgage and other 'real economy' payments.

223. DGFS updated the Governor at **16:51** stating that RTGS was working again but that it was very likely that some 'real economy' transactions would not happen given the later settlement time.

Discussion on independent review (16:49 – 17:15)

224. The Governor, DGFS and the Chair of Court ("CoC") discussed by telephone whether a post-event review should be undertaken by an internal or external reviewer. The Governor and CoC stated their preference for an external independent review, and this was communicated to the Governors and the Press Office.

3.3.2.3.5 Close of day (18:00 – 22:00)

Discussion on compensation and apology (18:00– 21:46)

225. During this period, discussions were held regarding potential compensation. The CEO of the FCA wrote to DGPR at **18:02** enquiring what the Bank's position would be regarding compensation for customers. The position in relation to compensation and the rules and process for making claims resulting from the outage were not clear since the Bank has no mechanism for collecting and validating such claims. Therefore no external announcement was made at this stage.

226. Between **20:38** and **21:37**, a series of email exchanges between the Governor, EDComm, DGFS and DGPR discussed the necessity and wording of an apology for the delays caused. This was also discussed with the Bank's legal team prior to a fourth and final press release being issued at **21:46** providing an apology.

3.3.2.4 Media communications

3.3.2.4.1 Resolution (10:00 – 14:00)

Media strategy established (09:54 – 10:07)

227. At **09:54** the Press Office drafted a first media statement for DGFS to comment on. By this stage DGFS had already been liaising with EDComm and DGPR to establish an external communications line and strategy. During this period both DGFS and the Governor reviewed and provided input to the first media statement.

First media statement release (09:54 – 11:14)

228. The first media statement was ready at **10:07** on the basis of the operational team's view that the situation should be resolved shortly, but in the knowledge there was no certainty over this. This was intended to provide reassurance and was deliberately constrained to avoid undue alarm. On EDComm's advice, it was decided to hold the first media statement as a reactive response, given the expectation that the situation would be resolved shortly without an adverse impact on customers.

229. At approximately **11:00**, with the outage still unresolved, the Press Office detected the first sign of media activity (a tweet by the BBC regarding the incident) and advised that the media statement should be released immediately. This was done at **11:14** with approval from DGFS and the Governor (see Appendix E for full statement).

230. The first media statement was cited by several stakeholders we interviewed as potentially open to misinterpretation by stating that "*...the most important payments are being made manually and we can reassure the public that all payments made today will be processed*". The reference to the most important payments related to CLS sterling payments-in, not to housing transactions. Given the time this statement was released to the Press, which was close to the normal deadline for completing housing transactions, this created frustration with external stakeholders as they perceived a failure to fully recognise the consumer detriment which was on-going. As previously noted, Press Office had not been made aware of the pinch point in housing transactions.

Media update to the Governors (12:25– 12:30)

231. At **12:25** EDComm provided a media update to the Governors noting that since the outage the Press Office had received 16 press calls, with the main focus being on house purchase funds being blocked, and 26 calls to the public enquiries line. The update also included lines to take which the Press Office had been developing with the operational and technical teams. At this stage DGPR, who had assumed leadership of the response while DGFS was offsite, commented that official lines should not suggest that there is "minimal customer disruption" because this would not portray a sympathetic view for those whose house purchases may have been affected.

3.3.2.4.2 Backlog clearance (15:15 – 18:00)

Second media statement release (15:49 – 16:06)

232. Following the successful restart of RTGS the Press Office drafted a statement to confirm that the Bank was processing payments as normal through RTGS and that opening hours had been extended to 20:00 to maximise the opportunity for settlement. Following approval from

both DGFS and DGPR the media statement was shared with the Chancellor's office before being released at **16:06** (see Appendix E for full statement).

3.3.2.4.3 Close of day (18:00 – 22:00)

Third media statement release (17:37 – 19:06)

233. Following discussion between the Governor, DGFS and CoC, a third media statement was drafted at **17:37** to confirm that the Governor had launched an independent review into the outage which would cover the causes of the incident, the effectiveness of the Bank's response and lessons learned for future contingency plans. This was subsequently released at **19:06** (see Appendix E for full statement).

Fourth media statement release (20:28 – 21:46)

234. Between **20:38** and **21:37**, a series of communications between the Governor, EDComm, DGFS, DGMB and DGPR discussed the necessity and wording of an apology for the delays caused. This was also discussed with the Bank's legal team prior to a fourth and final press release being issued at **21:46** providing an apology (see Appendix E for full statement).

3.3.2.4.4 *Social media*

235. The RTGS failure resulted in a two-day spike in conversation about the Bank, peaking at 3,009 tweets on 20 October, 2014. As part of our review we undertook an analysis of sentiment relating to conversations on social media about the outage. Whilst the conversations were negative in sentiment towards the Bank this was temporary and the sentiment recovered to 'neutral' over the week.

3.3.2.5 Contingency plans and back-ups

3.3.2.5.1 Fix and resolution planning (07:00 – 10:30)

Manual contingency for time critical CLS sterling payments-in invoked (08:24 – 09:51)

236. At **08:24** the Bank instructed CHAPS Co. to ask members to send remaining CLS pay-ins by contingency fax so that all necessary pay-ins could be received to facilitate the completion of settlement and funding in CLS. By **09:51** CLS contingency pay-ins were completed; however this was too late to avoid a breach of service levels with two 'Early Closing' (Asian) markets (South Korea and Australia) by CLS when pay-outs were eventually completed at **10:24**. No financial penalties resulted but this caused an extension to the normal market close times in these two countries.

Preparation of MIRS contingency (09:30 – 13:00)

237. During this period technical and operational teams started to make internal preparations to invoke MIRS if required. This included considering how MIRS would be invoked in the event the fix forward plan either failed or ran too late in the day, including calculated timescales required to bring MIRS online and then process the day's business. At a **13:00** conference call between ISTD and Banking it was confirmed that preparation activities to make MIRS 'ready' for activation were complete.

3.3.2.5.2 Controlled restart (14:00 - 15:15)

Decision not to invoke MIRS (14:20 – 14:50)

238. The contingency solution, MIRS, was considered through the day, though most notably at the **14:20** meeting convened by DGFS, by which time the planned actions to fix and resolve RTGS were nearly completed. However, it was agreed at the 14:20 meeting that if RTGS was not up and running by **15:15** a further meeting would be convened to decide whether to move to MIRS.

3.4 Post-Incident

239. RTGS started at 06:00 on Tuesday 21 October with no reported issues. Since the incident on 20 October, a number of post-incident activities have taken place as illustrated in the post-incident timeline in figure 11. These are discussed further below.

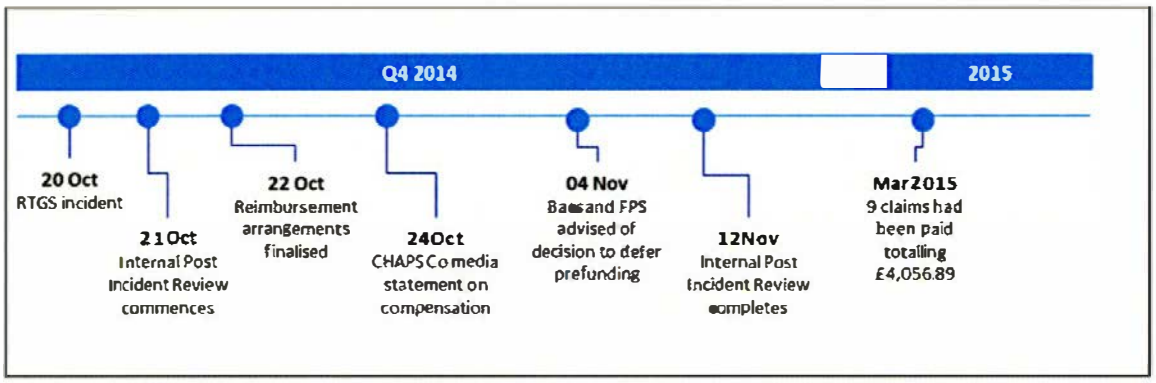


***Figure 11**: Post-incident timeline*

3.4.1 Immediate term

3.4.1.1 Compensation arrangements

240. Discussions between the Bank's Governors towards the end of the day on 20 October recognised the need to deal with the issue of customer redress as soon as possible. However, the position in relation to compensation and the rules and process for making claims resulting from the outage were not clear on the day of the outage, as the issue had never arisen before.

241. By **21 October**, the Bank had developed an initial line on compensation prior to the CHAPS Co. Board call at 13:00. Following the CHAPS Co. Board call, where it was revealed that no CHAPS member had yet received a claim for compensation, the Bank continued to develop its position on compensation and liaised with selected CHAPS members to understand their customer redress processes.

242. By **22 October** the Bank had finalised its line on compensation which confirmed that the Bank would consider "*all reasonable claims for compensation*" from CHAPS members regarding payments they made to customers affected financially by the outage. The line also stated that any individuals who believed that they had suffered any detriment due to the outage should "*contact their banks in the first instance*". The line was used to brief journalists and answer

questions from the public. CHAPS Co. released a media statement on **24 October** urging affected individuals to contact their bank or payment provider as soon as possible.

243. As of **20 March 2015**, the Bank had paid 9 claims totalling £4,056.89 using the required reimbursement process. Thirty six individuals contacted the Bank through the Public Information and Enquiries Group (PIEG) seeking redress and were asked to contact their own bank or building society directly, as per the process outlined by the Bank's reimbursement arrangements. At the time of publication the Bank was not expecting any substantial further claims.

3.4.1.2 Post-incident Review

244. On **21 October** the Governor formally wrote to the Chairman of the Treasury Select Committee to confirm that an external independent review into the outage would be launched. On the same day DGMB also spoke to the Managing Director of CHAPS Co. who expressed his gratitude to the Bank for reaching a successful resolution and for the public apology issued by the Bank at the end of the day. He also welcomed the decision for an independent review and formally requested that CHAPS Co. be included amongst those parties that the Independent Review seeks input from given the impact that this had on the Scheme. By **23 October** the Governors had agreed the Terms of Reference for the review and submitted these to Court for review.

245. Between **21 October** and **12 November** the Bank carried out an internal Post Incident Review to: recreate a timeline of key events, decisions and communications on the day; identify the root cause of the incident; identify key observations and lessons learnt; and agree actions for remediation. The review was led by Head of Run ISTD and was undertaken collaboratively with the teams responsible for the operational and technical resolution of the outage. At the time of writing remediation actions were still in progress.

3.4.2 Longer-term

3.4.2.1 Deferrals to changes within RTGS

246. As a result of our preliminary findings and recommendations from this review the Bank had decided, at the date of this report, to:

- Defer functionality changes due at the end of 2014 to eliminate settlement risk in Bacs and Faster Payments through participants prefunding their payments with cash held at the Bank of England
- Delay two banks joining CHAPS from their planned dates in February and March 2015

4 Lessons to be learnt

4.1 Robustness of the system

4.1.1 Design and complexity of the code

Findings

247. The RTGS system has been in operation for approximately 18 years and has been developed incrementally during that period. The complexity of the RTGS design and code increased significantly following the introduction of LSM and MIRS and is a contributor to the following undetected (or latent) design defect and functional defects which were at the root cause of the incident on 20 October 2014:

248. RTGS is written in which is generally considered to be a robust, stable and performant language for high volume and highly repetitive activity. However, is an aged coding language

Lessons to be learnt

249. Given the complexity of the system, the increase in functional errors recorded in the incident log since the introduction of LSM and MIRS (see detailed analysis in Appendix D) and the heightened risk of outage resulting from a change, a corresponding focus on system stability and increase in the governance controls over change is required. This includes:

a) Deferring further functional or non-routine configuration changes to RTGS unless there is a compelling Policy or market reason, while business assurance activities are undertaken

b) Where a functional or non-routine configuration change is deemed essential:

   i. The compelling reason should be approved by the reconstituted RTGS Board

   ii. The change should be treated as 'high risk' and an associated risk mitigation plan developed which includes considerations such as the nature and extent of testing to be performed

   iii. The availability of appropriate senior people and operational / ISTD staff on-site on the day of the change going live should be confirmed

   iv. Final approval for the 'go live' should be made by the RTGS Board following review of the risks and mitigations and availability of appropriate staff on-site

c) Defining the future technical strategy for the delivery of RTGS (taking account of the outcomes of the internal review of the underlying risks of RTGS). The strategy should be reviewed and approved by the RTGS Board

4.1.2 Gaps in testing

Findings

250. The process for technical and user testing of changes was not adequate to identify functional defects in the system caused by coding errors or inadequate design. Specifically:

a) The current arrangements for testing do not enable a full 'Day 1' test to mirror live conditions and therefore any issues which would arise in live on Day 1 of a change may not be identified

b) The lack of automation of regression testing and User Acceptance Testing currently inhibits the Bank's ability to run a comprehensive suite of tests to confirm the results of existing functionality has not been altered and the system performs as expected in all scenarios

c) Testing is not designed to test fail states (such as table space overruns) and negative scenarios (unexpected or early exit from a system process), nor to use 'bad data' (incorrectly formatted variables) to assess system responses and focuses in the main on confirming successful settlement conclusion based on 'happy path' data

d) The performance of live testing, which involves participation of CHAPS members, was limited to confirming successful payment to and from the added CHAPS Member, but not to confirm that payments between existing CHAPS members had been unaffected. A £1 payment was made from all banks to the new member and from the new member to all banks; no test was made to the deleted member. As such, it did not confirm that the deletion of Bank A had been successful or test the state of RTGS in the event that a CHAPS Member attempted payment to Bank A. Furthermore, the approach did not 'regression' test the system in the sense that it did not confirm that existing CHAPS Member relationships continued to work effectively

e) Throughout the code, unit and system testing process, there is an aim to use designers and developers who are independent of the code development to perform the testing, but in practice these resources all work for the same small team and it is therefore harder to achieve independence in testing for larger changes. Whilst there are benefits relating to the knowledge and experience of the team, good industry

practice would include the use of independent testing teams both at the technical and user acceptance testing stages

f) Whilst adding and deleting CHAPS Co. members may not be a significant change, a greater focus on risk factors may have led to the conclusion that as deletion of a CHAPS Co. member had not occurred for a long time, the change might have warranted particular attention

Lessons to be learnt

251. The Bank should improve the testing regime for RTGS and should consider:

a) Increased independence between testing responsibilities within ISTD and Banking and clarity on the handover between these roles

b) More thorough regression testing for all future changes

c) More comprehensive test scenarios, replicating day 1 operation more effectively, requiring all participants to exchange payments (not just added or removed banks) and scenarios which test failure of the system to confirm whether the system operates as expected if 'bad' data is present or if a process fails during processing

d) A separate test environment to enable ISTD to conduct full functional testing and a pre-production environment, which replicates the production environment, to enable release process testing

4.2 Governance of RTGS

Findings

252. Whilst the relationship with CHAPS Co. during normal business appears to work effectively, at times of crisis it lacks formality and relationships can quickly deteriorate; the ability of CHAPS Co. to support the Bank in managing the situation appeared to be at 'arm's length' and the Bank and CHAPS Co. have not jointly rehearsed an RTGS failure scenario.

253. Within the Bank the allocation of roles and responsibilities and overall accountability for RTGS between Banking and ISTD do not fully recognise the service provider relationship; equally the lack of a permanent Director in Banking may create a structural deficiency in the relationship. This was compounded on the day because the DG overseeing Markets & Banking and the acting Director Banking Services were away on official business; the CIO therefore took the lead role for managing the RTGS incident in conjunction with HoDCB and HoDMS.

254. The primary governance committee is the RTGS Board, comprising the same staff responsible for the day to day operation of the system. It is therefore effectively self-governing and this is likely to have arisen due to the historic low number of system failures.

Lessons to be learnt

255. The relative roles of the Bank and of CHAPS Co. during an RTGS incident should be defined; if CHAPS Co. are to be the conduit for co-ordination with direct and indirect CHAPS members, the RTGS incident response process should be jointly developed and rehearsed.

256. The RTGS Board should be reconstituted, with a DG Chair and the CIO and Executive Director of Markets attending.

257. Additionally, there is an opportunity to clarify roles and responsibilities in relation to RTGS between Banking and ISTD.

258. RTGS has been identified as a risk on the Bank's risk register and as a consequence of our review we have recommended particular focus on system complexity, testing and data integrity. The Bank should consider including the following areas within the scope of the work being done to address infrastructure obsolescence (see paragraph 131):

- Application Risk Working Group – the Terms of Reference should include a focus on the complexity of the system specifically relating to its design logic and coding; and its interaction with the database and underlying data
- Programme & Change Risk Working Group – the Terms of Reference should explicitly include the risks relating to testing (and this may also feature across other working groups)
- Data Risk Working Group - the Terms of Reference should include risks relating to data integrity in MIRS and the risks relating to management of reference or static data

4.3 Effectiveness of the Bank's response

4.3.1 The Bank's Crisis Management approach

Finding

259. There was a lack of defined crisis management arrangements, including appropriate structures and allocation of roles and responsibilities to: support the wider response on the day; establish the link needed between the Governors, particularly DGFS (who, as GPS's email had made clear was leading the Bank's response (see paragraph 210)) and the operational teams resolving the issue; and provide clarity at an operational level over who was leading the response. This resulted in:

a) Delayed involvement of the Bank's Governors and the Press Office early in the day

   i. The initial escalation from the CIO to DGCOO, DGMB and EDM at 07:23 was not received by them as they were in different time zones

   ii. The distribution lists for the initial Team B notification at 06:20 'and P1' incident email update at 08:32 was confined mainly to technical and operational teams and did not include the Bank's Governors or their offices.

b) A lack of coordination of the operational response, including engagement with key internal and external stakeholders

   i. With the exception of FMID, there was no clear distinction between those responsible for fixing the issues and those who needed to co-ordinate across the Bank and with other external parties in order to manage the wider impacts across the industry. As a result coordination with CHAPS Co. was carried out predominantly by teams responsible for the operational and technical resolution with the result that these resources were stretched on the day trying to fix the issue and co-ordinate with external operational stakeholders. This created the perception amongst stakeholders interviewed that information provided by the Bank was limited and senior Bank representation was not visible

   ii. The communications channels set out in the ARF to co-ordinate the response between HMT, the FCA, the PRA and the Bank to major operational disruptions affecting the financial sector, were not invoked. Other authorities we spoke to felt this constrained communications with the Bank on the day, resulting in them having to 'push' for information

iii. According to CLS, the changeover of Team A staff at the Bank added complexity to the reconciliation process because incoming personnel did not appear to understand fully which payments had been made manually and which had processed straight through. CLS felt that this resulted in the reconciliation taking longer than originally anticipated

Lessons to be learnt

260. The Bank had previously identified that its Bank-wide crisis management capability needed to be improved and work had commenced in the summer of 2014 to revise the structures, processes and protocols as part of this. At the time of the incident, this ongoing work was in the design stage and it had not been implemented, nor had staff been trained or rehearsed. The on-going work to improve and then test the Bank's internal Crisis Management and Communications capabilities should be accelerated to ensure the Bank is better prepared to respond to and manage a situation in a controlled, open and co-ordinated manner. This should include:

a) Incorporating accepted best structures and practices for managing a crisis including defined escalation protocols and crisis roles and responsibilities which provide a clear distinction between:

- Fixing and resolving the issue
- Co-ordinating across the Bank and with other external parties to manage the wider impact
- Providing strategic direction and critical decision making

This is illustrated in figure 12 below, with an overlay of those areas where the Bank's response was less effective

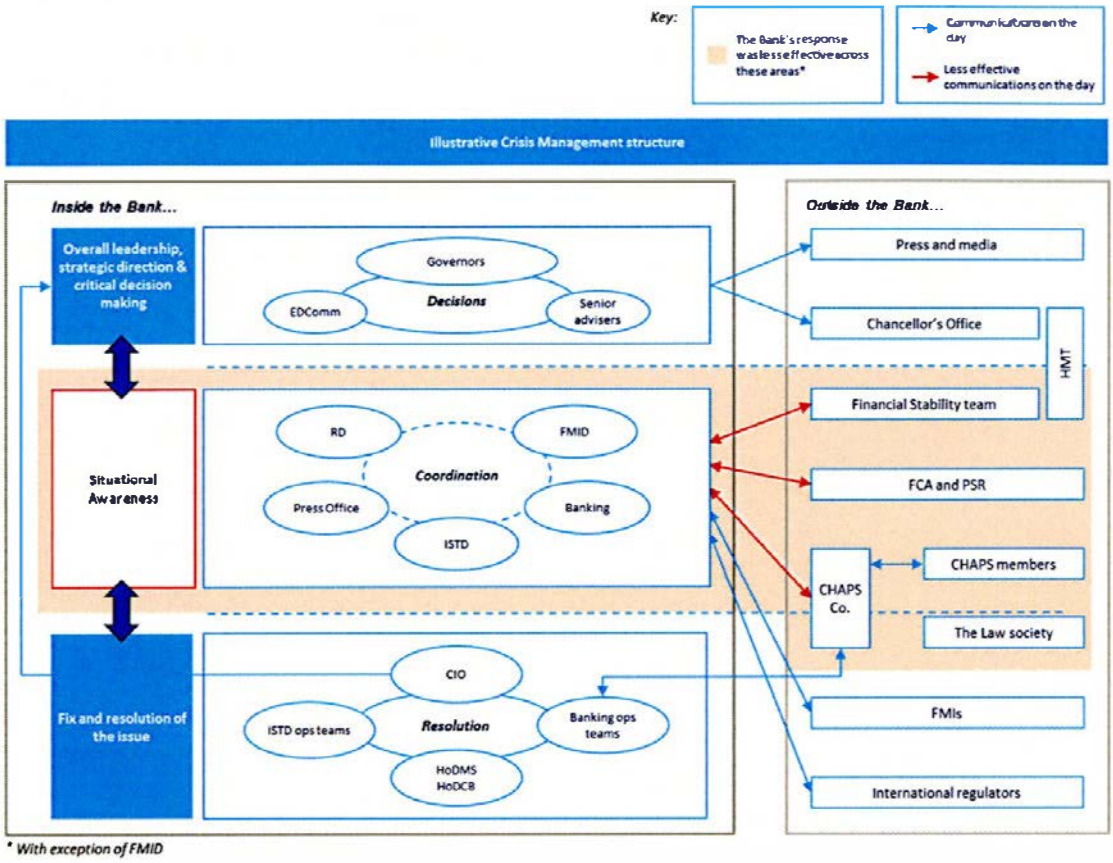


Figure 12: Accepted best practice Crisis Management structures - illustrative only

b) Incorporating the various response processes currently in place across the Bank, including ISTD's Major Incident Management process, under one single Bank-wide Crisis Management framework to facilitate a common approach to a disruptive event across functional and business teams

c) Robust 'stand down' and handover protocols should be defined and documented to facilitate smooth changeovers of staff during an incident and minimise disruption

261. The Bank should consider if any future RTGS failures should result in immediate escalation to pre-defined Governors, their offices, the Bank's Press Office, the RD, the PRA and relevant external stakeholders such as CHAPS Co. and FCA.

262. Recognising that the Bank itself may be the cause of a wider Financial Services sector 'crisis' and that an RTGS outage is one such scenario, the Bank should:

a) Better incorporate its Resolution Directorate to coordinate with the PRA, FCA and HMT In the event of an internal disruption which could have external impacts, and that the ARF provides the mechanism for doing this

b) Consider how using other parties such as the Payment Systems Regulator (PSR) and other channels, such as the Law Society of England & Wales, could help the Bank understand the broader impacts in a similar scenario incident and communicate where to go for information and further updates

4.3.2 Crisis Management in the context of RTGS

Findings

263. The Bank has never rehearsed its response to a RTGS failure at a Bank-wide level. An external audit of Crisis Management for RTGS in August 2014 noted that there should be a Bank-wide response structure to manage a RTGS event and that this should be rehearsed.

264. Roles and responsibilities for managing a RTGS disruption between CHAPS Co. and the Bank are not clearly understood. The current MOU defines responsibilities for the Bank and CHAPS Co. in the event of a disruption, however these are focused predominantly on contingency solutions for operational and technical processes and systems. Internal and external stakeholders interviewed (including CHAPS members) expressed frustration over what they perceived to be a disjointed response between the Bank and CHAPS Co. to managing the incident:

a) The number of 'TOC' calls hosted by CHAPS Co. throughout the day (8 in total) was driven by when information was expected to be available or when remediation steps were due to commence. As often is the case in such situations, information was either not available on the call or steps had not progressed as quickly as the Bank had anticipated and a further call was rescheduled, resulting in what internal and external stakeholders perceived as a saturation of calls with limited information

b) The Bank's decisions not to invoke MIRS and to reactivate CHAPS members' accounts in a predetermined order were not discussed with CHAPS Co. or CHAPS members, creating a perception that the Bank lacked transparency and openness during the incident

c) On the day, the Bank asked that it has sight of any press communications being issued by CHAPS Co. From CHAPS Co.'s perspective this was not a reciprocal process as they did not receive the Bank's press statements in advance of their release. There was no formal bi-lateral process to share and agree press statements between the Bank and CHAPS Co. prior to publication.

d) CHAPS members interviewed expressed surprise over the lack of pre-prepared arrangements for member redress in such a scenario, and, despite it only taking two days, the time it took to for an official line on compensation to be agreed and announced externally

Lessons to be learnt

265. In the context of an RTGS disruption the Bank's Crisis Management approach should be aligned with CHAPS Co., so that it is clear how the member impact should be managed. To achieve this requires the following:

a) External co-ordination and communications in the event of any future RTGS outage should reflect the fact that RTGS provides high value payments services to the public, corporates and Government as part of its role as an interbank payments system with financial stability implications

b) The roles and responsibilities in the MOU with CHAPS Co. relating to handling an RTGS outage should be re-examined and a joint response plan developed, enabling both parties to fulfil those roles and responsibilities, co-ordinate their involvement and support each other

c) The Bank and CHAPS Co. should consider setting up an access point (on-line) where affected parties can go to for information and updates on an RTGS outage. One

possibility is the CHAPS Co. website given this is a location that end-users (e.g. CHAPS members and solicitors) would naturally turn to. The role of the website already established for major operational disruptions under the ARF should also be considered in this context

d) The Bank should consider reviewing the approach to customer redress and compensation in the event of an RTGS outage and include these in the RTGS Managers' Contingency manual

e) A scenario based rehearsal of a prolonged RTGS outage should be conducted as soon as the work above is completed, involving all necessary parties (including external stakeholders). The rehearsal should test escalation protocols, information flows, lines of communication (internally and externally) and key decisions over contingency options and recovery procedures

4.4 Contingency plans and back-ups

4.4.1 Barriers to invoking MIRS

Findings

266. Although the preference to fix and resolve issues with RTGS on the day was the right one, there are currently a number of barriers preventing the early invocation of MIRS, which could have helped mitigate the immediate impact on the 'real economy'. These include:

a) The ability to switch back to MIRS intraweek has not been tested

   i. There was a reluctance on the day to switch to MIRS on the understanding that a return to RTGS could only take place on the weekend, given the time required to deactivate MIRS, transfer the balances from MIRS to RTGS and prepare RTGS to take over from the Monday morning. The process for an intraweek switch back is the same as a weekend and in testing has been shown to take about 2 hours, but there was concern that as a manual process there would be an increased risk of error if attempted overnight. The reluctance to switch to MIRS was compounded by the reduced functionality of MIRS, including the absence of LSM functionality, which would remain in effect until a weekend deactivation. Given the increased likelihood of an outage occurring on Monday morning, there is a preference to try and fix RTGS, even if this means a prolonged intra-day outage, rather than fail over to MIRS for the remainder of the week

b) An assumption that MIRS is only an option of last resort

   i. The MIRS contingency option was originally conceived to provide additional resilience in the event of a *catastrophic loss* of, or access to, RTGS and at the time had not been considered as a possible solution for a potential loss of integrity scenario. The assumption on the day was that all other options needed to be attempted first, including a detailed reconciliation, meaning that a switch to MIRS would, by the very fact it was considered as an option of last resort, only be attempted later in the day by which time customers (including house buyers) had already been impacted

c) A lack of clear decision criteria for invoking MIRS

i. The MIRS contingency option was discussed at several points during the day, although it was always considered by the operational and technical resolution teams that the 'fix forward' plan was the best option. Interviews conducted revealed a concern amongst the Governors involved on the day over the lack of defined and understood activation criteria for MIRS, which limited their ability to challenge resolution plans formulated and implemented at the working level Additionally there are no clear criteria to support decision making for MIRS in the context of mitigating impacts to the housing market and 'real economy' transactions

ii. The lack of clear decision criteria was compounded by the fact that the limitations to switching to MIRS were not widely understood either by those Governors who had decision making responsibilities for invoking MIRS on the day, or across the industry. Combined with the limited communications on the day, this frustrated several CHAPS members interviewed who felt that the decision of whether or not to invoke MIRS should have been more widely discussed with members on the day

Lessons to be learnt

267. Work should be undertaken to remove or reduce the barriers to invocation of MIRS so that the Bank can "switch and fix" in parallel and in confidence. This should focus on testing the process to fail-back to RTGS intraweek (which is the primary barrier to invocation). If it is not possible to reduce this barrier, consideration should be given to enhancing the resilience and functionality within MIRS. In addition the Bank may wish to consider other back-up options for RTGS.

268. The decision criteria for the invocation of MIRS needs to be clearly defined to aid decision making in a similar event and build internal and external confidence in contingency arrangements for RTGS. The decision criteria should be documented in the RTGS Managers' Contingency Manual and should include the impacts and implications for various market segments against a range of decision times for invocation.

269. The understanding and awareness of key internal and external stakeholders of the MIRS contingency option (what it provides, when it would be used and the implications of using it) should be enhanced (this in part can be achieved through the recommended scenario based rehearsal).

4.4.2 Contingency planning for an RTGS outage

Findings

270. The RTGS Managers' Contingency Manual was not used on the day because it was not considered appropriate to respond to the particular scenario faced. The scenarios covered in the Manual focus on sudden infrastructure loss, where causes and impacts are understood. It does not include scenarios characterised by an evolving problem where the degree of certainty over what has happened and the overall complexity and containment of the issue may be unclear. Specifically, the Manual does not include a 'loss of integrity' scenario which meant there were no pre-prepared scripts, tools or templates to support a quick reconciliation, at scale, which is required prior to a controlled start. This meant time was needed to develop and evolve an approach for the first stage reconciliation and design, review and test scripts needed for this on the day.

Lessons to be learnt

271. The RTGS Managers' Contingency Manual should be updated to:

a) Address a 'loss of integrity' scenario. This should include development of the necessary scripts and templates to facilitate faster reconciliation

b) Set out the decision criteria for invocation of MIRS, including the impacts and implications for various market segments against a range of decision times for invocation of MIRS

272. The RTGS Managers' Contingency Manual should be subject to stress testing to validate documented assumptions, actions, roles and responsibilities.

273. The Bank should consider reviewing media communication strategies and the approach to redress and compensation in the event of an RTGS outage, and include these in the Manual.

4.4.3 Contingency options for time critical CLS Sterling payments-in

Findings

274. The manual contingency option available for time critical CLS sterling payments-in, whilst regularly tested, is labour intensive and prone to error. On the day of the incident this option was invoked at 08:24 but it was too late to avoid a breach of service levels with 'Early Closing' (Asian) markets by CLS.

Lessons to be learnt

275. The Bank should reconsider adoption of the CLS Central Bank Automated Contingency solution (it has been adopted by Switzerland, New Zealand and Canada; the Bank does not have a date scheduled for adoption). This would replace the need for manual fax authentications in the event that contingency is invoked and, in a similar outage, would enable a faster reconciliation of the CLS Sterling account position with payments-in on the RTGS system.

Appendix A: RTGS timeline

The table below details the key RTGS milestones from its introduction to date.

1993	RTGS Programme established jointly by the Bank of England and CHAPS
1994	Development started, designed around existing CHAPS architecture, using bespoke CHAPS messaging standards and the CHAPSNet X.25 network
1996	RTGS goes live in sterling, linking an adapted CHAPS Network with a real-time accounting system at the Bank of England, in which settlement accounts are held
1999	RTGS enhanced to encompass CHAPS Euro and TARGET
2001	New CHAPS project goes live. Migrated CHAPS Sterling onto the SWIFT FIN-Copy service (the existing CHAPS Euro platform). Central Scheduling introduced
2001	RTGS enhanced to include Delivery versus Payment in Central Bank Money
2003	Migrated CHAPS Euro from to (CHAPS Sterling already on)
2006	Remunerated reserves accounts become operational in RTGS as part of the Bank's Money Market Reforms
2008	CREST Euro DvP migrated to the Central Bank and Financial Services Authority of Ireland
2008	TARGET2 migration completed. CHAPS Euro and TARGET become obsolete
2010	Full FIN Copy introduced
2013	Liquidity Savings Mechanism goes live
2014	RTGS begins to lockstep with the SWIFT owned MIRS contingency

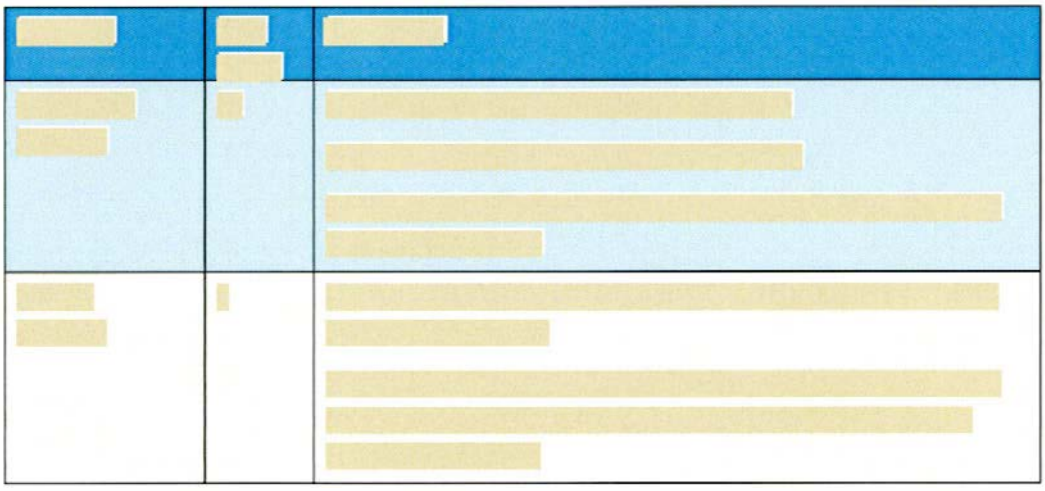
Appendix B: RTGS system component complexity

During the 18 years since RTGS was first launched, the incremental changes have moved the system from a relatively simple system, to one which is more complex and as a result more difficult to understand and maintain.

The complexity of the system was increased most following the LSM and MIRS changes. Whilst the teams supporting and operating RTGS are highly experienced, mitigating some of the risk that the complexity introduces, there are residual risks relating to the complexity and vulnerability of RTGS to incidents and outages. These risks include:

- Increased difficulty understanding the system from an operational perspective, due to the need to provide such a wide variety of functionality.
- At a technical level the system has become more difficult to support and fault finding during testing or live incidents is likely to result in increased business disruption.

In 2014, the Bank conducted its own analysis of the complexity and fragility of RTGS functions and highlighted the following



Appendix C: RTGS incident analysis

We analysed the RTGS incidents recorded between the financial year 2005/6 and 2014/15 and assigned a root cause category to determine whether there were any particular trends. The root cause categories are defined as:

- **Infrastructure/Supporting Process** – relating to hardware components such as network devices and disks or lower level supporting software (operating system, middleware or networking) unrelated to the actual functions of RTGS.
- **Human Error** – relating to outages caused by mishandling of the system such as manual closure of RTGS a few minutes earlier than planned or incorrect manual updates to reference data.
- **Run-Time Error** – relating to system processes or specific jobs being run out of planned sequence or in contention with one another, causing a processing error.
- **RTGS Functional Error** – relating to defects in RTGS which cause processing errors, abnormal results or a system outage.

We note that not every incident caused an RTGS outage or business interruption. Indeed, the infrastructure incidents, whereby individual components failed, in most cases did not cause an outage demonstrating the technical resilience and load-balancing capabilities of RTGS.

Following the introduction of LSM and MIRS, there has been a clear increase in the number of incidents categorised as either functional or run time errors suggesting the added complexity of RTGS has become more vulnerable to outage. Our analysis is presented in the graph below.

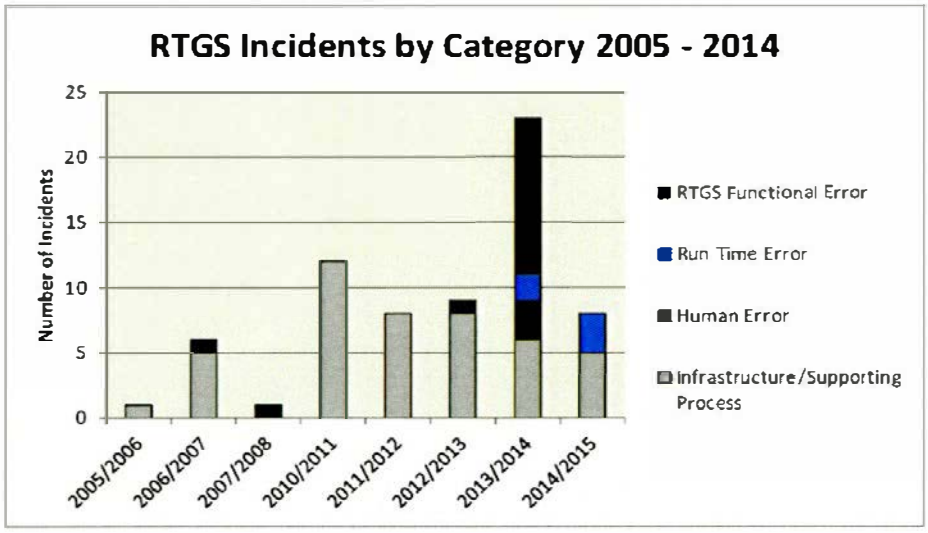


Figure 12: RTGS Incidents by Category since 2005 (excluding the RTGS outage on 20 October 2014)

Appendix D: CHAPS member table changes

Appendix E: Press releases

BANK OF ENGLAND

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Threadneedle Street
London EC2R 8AH
T 020 7601 4411
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press@bankofengland.co.uk
www.bankofengland.co.uk

News release

20 October 2014 11:14

Bank of England statement - RTGS

The Bank of England has identified a technical issue related to some routine maintenance of the RTGS payment system and has paused settlement while we resolve it. We are working to address this issue as quickly as possible, and restart the RTGS payment system in a controlled manner. The most important payments are being made manually and we can reassure the public that all payments made today will be processed.

ENDS

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20 October 2014 16:06

Bank of England statement - RTGS issue resolved

The Bank of England confirms it is now processing payments through RTGS as normal. We have extended opening hours until 20:00 hrs (BST) to maximise the opportunity for settlement.

ENDS

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20 October 2014 19:06

Bank of England statement – Independent review into RTGS payment system disruption

The Governor of the Bank of England, Mark Carney, has launched a thorough, independent review of the causes of today's disruption to RTGS, the Bank's system for settling high value payments. The review will cover the causes of the incident, the effectiveness of the Bank's response and the lessons learned for future contingency plans. Its findings will be presented to Court who will then publish the full report and the response.

ENDS

Notes to Editors

1. Bank of England statement regarding disruption to RTGS on 20 October 2014
2. Bank of England statement regarding the restoration of the RTGS service 20 October 2014
3. A Guide to the Bank of England's Real Time Gross Settlement System

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20 October 2014 21:46

Bank of England statement – Update on RTGS

RTGS closed at 20:00 hrs (BST). All 142,759 payments submitted to RTGS today before the extended deadline have now been processed. The Bank has put in place extra steps to monitor the system at the start of the day tomorrow when RTGS will open at 06:00 hrs (BST) as usual. The Bank apologises for any problems caused by the delays to the settlement of payments today and has launched a thorough, independent review of the incident.

ENDS

All releases are available online at
www.bankofengland.co.uk/publications/Pages/news/default.aspx

Appendix F: Law Society article on RTGS outage

CHAPS payment issues: survey results and making a claim

30 October 2014

On the 20 October 2014, the Bank of England identified a technical issue related to the real-time gross settlement (RTGS) system, which resulted in a delay in settlement to CHAPS payments.

The Law Society met with CHAPS Co. this week to ensure that they and the Bank of England are aware of the issues that the CHAPS payment delays caused for the legal profession and their clients on 20 October.

Some individual customers may have, through no fault of their own, incurred some direct out-of-pocket expenses due to the technical issue. If you are in that situation you are advised to speak to your own bank or payment service provider as quickly as possible.

Survey results

Last week, we asked any of you whose residential conveyancing transactions were affected by the CHAPS payment issues on 20 October 2014 to complete our online survey. Thank you to those who took the time to respond. These findings, based on a web survey, should be treated as indicative of the experiences of firms, rather than representative.

Volume of transactions and outcome

The results showed that on average:

- around 10 per cent of your residential conveyancing transactions are scheduled to take place on a Monday
- Only 18 per cent completed within the usual times
- 27 per cent completed with a delay of up to three hours
- 24 per cent completed with a delay of three or more hours
- 30 per cent didn't complete until the next day or after

Finding out about the delays

Our survey showed that:

- around 28 per cent of you heard about the delays affecting CHAPS through solicitors from other firms
- 16 per cent found out through social media or the internet
- 11 per cent received communications from CHAPS or had been on the CHAPS website
- 6 per cent heard via the TV or radio, and
- 2 per cent found out from the Bank of England or its website

The results also indicated that 57 per cent of firms did not receive any communication from their bank about the delay.

One respondent commented:

> 'The lack of information provided to us was deeply concerning - we only learned of the problem when our accounts team rang up [bank]. There had been no earlier communication. The first emailed announcement from the Bank of England was not until 12:08, by which time we had already found out about the problems. This was very unhelpful.'

Impact of the delay

About 40 per cent of you said that the delay resulted in additional communications between the parties in relation to contractual matters regarding interest charges and other costs. The results also indicated that about 40 per cent of you were charged additional interest for late payment of redemption monies. There were also a number of comments regarding additional costs incurred with removers, storage of possessions and finding alternative accommodation.

Other impacts included:

- additional work in making calls and agreeing professional undertakings, a lot of which was not charged to the client:

  'Added to workload and to pressure from client to complete. Accounts department time additionally taken up with checking [bank] site frequently to establish if the CHAPS system was up and running once more'.

- stress caused for clients and staff:

  'A very stressful day trying to explain to clients that the problem was out of our control. Time consuming with phone calls, connecting to the Bank to see if any payments were being made, staying late in order to send payments on once our money had been received'.

  'Very embarrassing and inconvenient'.

Source: http://www.lawsociety.org.uk/news/stories/chaps-payment-issues-survey-results-and-making-a-claim/?utm_source=emailhosts&utm_medium=email&utm_campaign=test+-+PU#sthash.uV5JWzjr.dpuf

Appendix G: Stakeholders interviewed

The Bank of England stakeholders interviewed

Stakeholder	Role
Charlotte Hogg	Deputy Governor, Chief Operating Officer
Minouche Shafik	Deputy Governor, Markets & Banking
Sir Jon Cunliffe	Deputy Governor, Financial Stability
Andrew Bailey	Deputy Governor, Prudential Regulation
Chris Salmon	Executive Director, Markets / Acting Director, Banking
John Finch	Executive Director, Information Services & Technology and Chief Information Officer
Jenny Scott	Executive Director, Communications
Andrew Gracie	Executive Director, Resolution
Stephen Brown	The Auditor
	Director, Financial Market Infrastructure
	Senior Manager, Markets Infrastructure Division
	Head of Division, Customer Banking
	Head of IT and Central Services Audit
	Head of Division, Market Services
	Head of Division, Property, Procurement and Security
	Head of Division, Run/Service
	Head of Division, Plan/Design
	Head of Critical Transaction Systems, PDT
	Developer, Build/Maintain
	RTGS Development Team Leader, Build/Maintain
	Senior Manager, Payment Services
	Manager, Payment Services
	Manager, Payment Services
	Business Programme Manager, Payment Services
	Analyst, Payment Services
	Testing Services Manager, Banking

Stakeholder	Role
	Test Team Leader, Banking
	Manager, Press Assistants
	Commercial & Change Manager
	Senior Manager, Resolution
	Manager, Resolution
	Private Secretary to the Governor
	Assistant Private Secretary to the Governor
	Private Secretary to Deputy Governor, Markets & Banking
	Private Secretary to Deputy Governor, Financial Stability

External stakeholders interviewed

Stakeholder
CHAPS Co.
CLS
HM Treasury
Law Society of England and Wales
Payment Systems Regulator
SWIFT
Selected direct CHAPS members
Selected indirect CHAPS member
Selected legal firm

Appendix H: Document list

The table below contains a list of documents examined as part of the review

Document name	Obtained from
Final Post Incident report - RTGS unavailable	Bank of England
RTGS - RTGS Presentation - Edited for PS	Bank of England
Process A description	Bank of England
Summary of Issues with Process B on 20_10_14 - V3	Bank of England
	Bank of England
RTGS IT Risk Review - High level Plan	Bank of England
RTGS Review - ToR for Security and Privacy Risk	Bank of England
RTGS Review - ToR for Infrastructure	Bank of England
RTGS Review - ToR for Application Risk	Bank of England
RTGS Review - ToR for Data	Bank of England
RTGS Review - ToR for Programs and Change Management	Bank of England
RTGS Managers Contingency Manual - new format Feb 2014	Bank of England
RTGS Governance Structure Summer 2014 version	Bank of England
BoE Report RTGS Crisis Capability Assessment July 2014 Final (PwC report)	Bank of England
RTGS ISAE 3402 report year ending 28 February 2014	Bank of England
Key high level timetable of Monday 20 Oct [v7 final draft]	Bank of England
ARCo meeting mins	Bank of England
P1 email updates	Bank of England
Audit report - RTGS	Bank of England
Audit report - Key control review of RTGS	Bank of England
Audit report - Key risk review - RTGS -	Bank of England
Audit report -	Bank of England
Audit report - RTGS	Bank of England
CHAPS Market Report 2013	Bank of England
CHAPS Market Report 2014	Bank of England
Update for CX on RTGS	Bank of England
A guide to the Bank of England's Real Time Gross Settlement System	Bank of England

Document name	Obtained from
Team A - MIRS presentation –	Bank of England
MIRS presentation to Crest	Bank of England
How MIRS will change our decision making	Bank of England
Generic LSM presentation	Bank of England
	Bank of England
	Bank of England
	Bank of England
MoU Appendices v2 0 CLEAN 20Jun13	Bank of England
MoU Appendices v2 0 Track Chgs 20Jun13	Bank of England
LSM Review Report - external circulation - FINAL	Bank of England
RTGS Outages 2005 – 2014	Bank of England
BoE RTGS Incidents 2005 – 2014	Bank of England
Tweets about RTGS	Bank of England
RTGS incident - reactive Q&A	Bank of England
RTGS Incident -	Bank of England
RTGS Incident - update on claims - w/e 28 November [BOE-Banking.FID52373]	Bank of England
RTGS Incident - update on claims - 21 November	Bank of England
Value _ Volume Chart - 20 October [NC version for Deloitte]	Bank of England
RTGS OUTAGE 20 OCTOBER 2014 - SMB thoughts for External Reviewer (as of 27 October)	Bank of England
RTGS failure on Monday 20th October 2014 - RTGS account reconciliation	Bank of England
	Bank of England
	Bank of England
LSM - Reconciling a Process C	Bank of England
CLS Contingency (RTGS and EL available for Members)	Bank of England
	Bank of England
DvP - Finishing the CREST day in Recycle Mode	Bank of England
Projected RTGS Account balances - 20141020	Bank of England
Internal Audit Learnings - 20 Oct 2014 RTGS Outage	Bank of England
RTGS reconciliation explanation documentation	Bank of England
Historic RTGS, CHAPS & CREST Availability	Bank of England
PIR RTGS 20Oct14 v1.0 C	Bank of England

Document name	Obtained from
CHAPS Co Business & Operations Post Incident Review Document: RTGS Outage 20th October 2014 (Version 1.0 dated 26th November2014)	Bank of England
CHAPS Co. written commentary on shared external extracts (dated 10 March 2015)	CHAPS Co.
HMT RTGS 20 October 2014 incident timeline	HMT

Appendix I: Glossary of terms

Term	Definition
Account	A record of balances in a single currency (typically but not exclusively GBP) on an account of an external organisation by or to (respectively) the Bank of England, maintained, both from day to day and in real time intra-day, by or on behalf of the Bank of England in the RTGS System. Accounts are also maintained in the RTGS System, recording balances referable to other areas or systems within the Bank of England. Accounts may be grouped together in 'Minimum Balance Groups' (qv). See also Settlement Account, Liquidity Account, CREST Repo Account, Reserves Account. This definition does *not* cover 'Cash Memorandum Account' or 'Liquidity Memorandum Account', which are Accounts held with EUI rather than with the Bank of England.
Bacs	Bacs is a scheme for the electronic processing of financial transactions within the United Kingdom. Direct debits and direct deposits are made using the Bacs system.
Bilateral Limit	A Central Scheduler parameter which specifies the maximum value a CHAPS Member is willing to send to another CHAPS Member in excess of value of payments received. A payment may not settle if the resulting Bilateral Position would exceed the Bilateral Limit. (not applicable to MIRS Active).
BIC	Business Identifier Code. A universal method of identifying financial institutions in order to facilitate automated processing of telecommunication messages in banking and related financial environments.
Central Scheduler	A logical process within the RTGS Processor which allows CHAPS members to manage their liquidity and control when Settlement Requests are submitted for settlement. (not applicable to MIRS Active)
CHAPS	Clearing House Automated Payment System. Refers to the same-day payment system operated by CHAPS Co. (see CHAPS System). The term is sometimes used to refer to CHAPS Co. itself.
CHAPS Co.	The CHAPS Clearing Company Limited, the scheme company which is responsible for the day-to-day management of CHAPS.

CHAPS Member	An institution that has been admitted to membership of CHAPS. Each CHAPS Member must have a Settlement Account(s) within RTGS for the purpose of settling payments in each currency. The Bank of England is a CHAPS Member and has two CHAPS identifiers: Bank of England 'BE' and Bank of England 'RT'.
CHAPS Payment	An irrevocable, unconditional sterling payment between CHAPS members settled across CHAPS members' Settlement Accounts. Payments are made via the CHAPS System in accordance with CHAPS Rules. Contingency Transfers made via the Enquiry Link, secure e-mail, or any other means acceptable to the Bank of England, are also defined as CHAPS Payments for the purposes of the Settlement Finality Directive.
CHAPS System	The payment messaging system for the making of sterling-denominated payments comprising the SWIFT network and FIN Copy service, members' payment processes and interfaces to the SWIFT network, the RTGS System [which shall include any procedures adopted during any period of RTGS contingency] and CHAPS members' Enquiry Link terminals.
Cheque & Credit Clearing Company (C&CCC)	C&CCC has responsibility for the bulk clearing of cheques and paper credits throughout Great Britain. Cheque and credit payments in Northern Ireland are processed locally.
CLS	Continuous Linked Settlement, a settlement service that provides global FX settlement in major currencies, including sterling. CLS is a CHAPS Member, enabling CLS Members to make their sterling transactions across CHAPS.
CLS Sterling Payments-In / Payments-Out	Sterling payments made by member banks into the CLS settlement service. / Sterling payments made by the CLS settlement service to the receiving markets.
CREST	The computer-based securities settlement system and associated clerical procedures operated by Euroclear UK & Ireland Limited to facilitate the transfer of gilt-edged securities, eligible debt, equity securities and other uncertified securities.
Delivery versus Payment (DvP)	A mechanism in an exchange for value settlement system that ensures that the final transfer of one asset occurs if and only if the final transfer of (an)other asset(s) occur. Assets could include monetary assets (such as a foreign exchange) securities or financial instruments. In this instance it refers to a payment in Central Bank Money.
Earmarking	In relation to CREST Minimum Balance Groups, the process by which the Available Balance on an Account Holder's CREST MBG is removed from the control of the Account Holder and reserved for CREST settlement. The Bank's only obligation in relation to the funds so earmarked is to repay the credit balance remaining after giving effect to the debits and credits resulting from the relevant CREST Settlement Cycle or Disconnection Period, in accordance with clauses 4 and 5 of the RTGS CREST Mandate Agreement.

Enquiry Link	The system that allows Account Holders in the RTGS Processor and certain other institutions to interrogate balance and other information and to perform certain other functions. This is supported by the SWIFTNet Network. (not applicable to MIRS Active)
Euroclear UK and Ireland Ltd (EUI)	The organisation that owns and operates the CREST system; part of the Euroclear group.
Faster Payments Service (FPS)	Faster Payments is a payments clearing scheme for electronic sterling payments in the UK, designed to reduce payment times between different banks' customer accounts from three working days using the long-established Bacs system, to a few hours.
Intra-day Liquidity (IDL)	Liquidity provided to Participants to help ensure that are able to make sterling payments, in addition to drawing on their reserves balances. Liquidity is credited to the appropriate account within the Payment Minimum Balance Group, either from the Collateral Management System or from TARGET2 via the euro liquidity bridge.
LINK	LINK is a not-for-profit membership association owned and governed by card issuers and ATM operators. The LINK ATM Scheme brings together banks, building societies and other institutions that operate cash machines (ATMs) and/or issue cards that can be used in these cash machines.
Liquidity Saving Mechanism, LSM	Functionality within the RTGS Processor which matches pairs or groups of CHAPS Payments, settling them in batches simultaneously to offset their liquidity needs against one another. CHAPS members use the Central Scheduler to manage their payment flows within the RTGS Processor and Process B employs algorithms to attempt to offset the queued payments. (not applicable to MIRS Active)
LSM Profiles	These are set payment profiles which CHAPS members use to define the maximum net position they may have with each other member (bilateral limits) and against all other members as a whole (multilateral limits). 'Start of Day' profiles have relatively tight limits compared to 'Peak day' and 'Contingency' profiles.
Lockstep, Lockstepping	Lockstepping is the process of keeping a remote (or standby) database in step with a primary database such that in the event of the failure of the Prime Site, the Standby Site can resume processing using the backup database. The RTGS Processor and the CREST system both Lockstep with their respective Standby Sites during normal operation. The RTGS Processor also Locksteps with SWIFT during normal operation (also known as MIRS Dormant mode).
Market Infrastructure Resiliency Service (MIRS)	A contingency payment settlement service provided by SWIFT that offers a market infrastructure operational resilience in the event of unavailability of its RTGS system. Once activated, MIRS calculates accurate balances for all RTGS accounts and provides final settlement in Central Bank Money for CHAPS Payments and Clearings and RTGS Transfers.

Process A	[redacted]
Process B	[redacted]
Multilateral Limit	A Central Scheduler parameter which specifies the maximum value a CHAPS Member is willing to send to all other CHAPS members in excess of value of payments received. A payment may not settle if the resulting Multilateral Position would exceed the Multilateral Limit. (not applicable to MIRS Active)
Note Circulation Scheme (NCS)	The scheme operated by the Bank in respect of the circulation of bank notes on the terms published by the Bank and as amended from time to time.
Participant	A CHAPS Member who agrees to be legally bound by the published RTGS Account Mandate Terms & Conditions and by relevant annexes covering use of the Account including, inter alia, Reserves Accounts and CHAPS. The term "participant" is also used in the RTGS Reference Manual to refer to participation elsewhere, e.g. MIRS or SMF, in which case it is explicitly stated.
Real Time Gross Settlement (RTGS)	The accounting arrangements established for the settlement in real time of sterling payments across Settlement Accounts maintained in the RTGS System.

Reserves Account	An Account held at the Bank of England for the purpose of the Bank's Reserves Account Facility as described in the "Documentation for the Bank of England's Sterling Money Market Operations" as published by the Bank and amended from time to time. CHAPS members and CREST Settlement Banks are automatically members of the Reserves Scheme, and their Reserves Accounts will be the same as their Payment Settlement Accounts (or, for CREST-only banks, their Sterling Ordinary Accounts).
RTGS Processor	That part of the RTGS Central System developed and operated by the Bank of England to effect real-time postings across Accounts.
RTGS System	A collective term which covers the RTGS Central System and MIRS.
Securities Settlement System	Any of CREST, the settlement system of Clearstream Banking, société anonyme, Luxembourg, the Euroclear settlement system operated by Euroclear Bank S.A./N.V. and any other Securities Settlement System as may be specified in the RTGS Reference Manual from time to time.
Settlement	The movement of funds on Settlement Accounts in respect of a CHAPS or CREST Settlement Request or a RTGS Transfer.
[redacted]	[redacted]
Standby Site	The location of the computers that are available to run either the RTGS Processor and SWIFT CBTs, or CREST system, in tandem with the Prime Site, and from which these components can be run should the Prime Site be unavailable.
SWIFT	Society for Worldwide Interbank Financial Telecommunication. The bank-owned co-operative which supports the financial data communication and processing needs of the financial community worldwide.
TARGET	Trans-European Automated Real-time Gross Settlement Express Transfer system. A payment system composed of one RTGS System in each of the countries which participate in Stage Three of EMU and the European Central Bank payment mechanism. RTGS Systems of non-participating EU members may also be connected, provided that they are able to process the euro alongside the national currency. The RTGS Systems and the European Central Bank (ECB) payment mechanism will

	be interconnected according to common infrastructures and procedures (the Interlinking System), to allow payment orders denominated in euro to move from one system to another. Superseded over the migration period Nov 2007 - May 2008 by TARGET2 (qv).
TARGET2	The 2nd-generation TARGET System for pan-European settlement of euro payments. See www.ecb.int for details.
VISA	The card system for electronic payments

Appendix J: Terms of Reference additional guidance

Guidance to the Terms of Reference for an Independent Review of the RTGS Outage on 20 October 2014

1. **Causes of the incident**

    a. Conduct a root cause analysis

Guidance: What was the proximate cause of the outage and what was the chronology of events and information flows in the lead up to the incident? Were changes made over the preceding weekend appropriately categorised (as major or minor changes), tested and managed? Generally, are there effective change management arrangements – including clear sign-offs and accountabilities - and are these being followed?

    b. Evaluate the robustness of the system

Guidance: Is the Bank's desired level of availability for RTGS clearly defined and appropriate? Is there an appropriate, and sufficiently understood, balance between ensuring the integrity of the system and its availability? Does the design of RTGS and supporting processes facilitate the efficient management of the system and resolution of problems? Is ongoing work to assess the robustness of the system sufficient?

    c. Review the governance of the system

Guidance: Is ownership of RTGS clear and are the governance arrangements appropriate to its criticality and status as the system for inter-bank settlement across the central bank's balance sheet? Is there effective review and oversight of the system?

2. **Effectiveness of the Bank's response**

    a. Assess the Bank's response on the day

Guidance: What was the chronology of the Bank's response to the incident and how long did each step take? Was there clear ownership of the incident, were the appropriate resources engaged and was there timely involvement of senior management in decision making? Was there appropriate engagement with all relevant areas of the Bank? Why was the system not "rolled back" (re-instating an earlier, stable version of the system) or back-up systems activated sooner? Were appropriate choices made in deciding between recovering the system or rolling back / activating back-up plans? Was there appropriate communication with banks to prioritise certain types of payments? Was communication with markets and the public timely and appropriate?

    b. Evaluate the effectiveness of incident management and back-up plans

Guidance: Is there a clear and effective incident / crisis management procedure, and was it followed on 20 October 2014? Are there suitable (i.e. easy enough to use) and appropriately tested backup arrangements and alternative processing plans? Is it clear when such arrangements should be invoked?

3. **Lessons learned**

Guidance: On the basis of the review's findings provide lessons learned and (where possible costed) recommendations for addressing any weaknesses identified.