CONTENTS

1. PURPOSE 2
2. BACKGROUND TO THE CONTRACTING AUTHORITY 2
3. BACKGROUND TO REQUIREMENT/OVERVIEW OF REQUIREMENT 2
4. DEFINITIONS 2
5. SCOPE OF REQUIREMENT 3
6. THE REQUIREMENT 4
7. KEY MILESTONES 7
8. NIC'S RESPONSIBILITIES 8
9. REPORTING 8
10. VOLUMES 8
11. CONTINUOUS IMPROVEMENT 8
12. SUSTAINABILITY 8
13. QUALITY 8
14. PRICE 8
15. STAFF AND CUSTOMER SERVICE 9
16. SERVICE LEVELS AND PERFORMANCE 9
17. SECURITY REQUIREMENTS 9
18. INTELLECTUAL PROPERTY RIGHTS (IPR) 10
19. PAYMENT 10
20. ADDITIONAL INFORMATION 10
21. LOCATION 10

1. PURPOSE

1.1 The purpose of this requirement is to conduct a study of the impact of increasing reliance on digital systems for infrastructure resilience. This is expected to include reviewing relevant literature (academic publications, grey literature and methods of analysis) on topics such as complex systems, normal accidents, high reliability organisations and the potential role of new technology. It should identify potential implications (both opportunities and threats) as well as providing a summary of good practice to ensure the resilience of future infrastructure systems.

2. BACKGROUND TO THE CONTRACTING AUTHORITY

2.1 The Authority (Her Majesty's Treasury) is the Government's economic and finance ministry, maintaining control over public spending, setting the direction of the UK's economic policy and working to achieve strong and sustainable economic growth.

3. BACKGROUND TO REQUIREMENT/OVERVIEW OF REQUIREMENT

3.1 The National Infrastructure Commission ("NIC") is an independent body (an Executive Agency of HM Treasury) which provides the government with impartial, expert advice on major long-term infrastructure challenges. Whilst Her Majesty's Treasury is the Contracting Authority, all analysis and outputs in the requirement are commissioned by, and will be delivered by the Potential Provider exclusively to, the NIC. Analysis and outputs must not be shared or discussed with any party other than the NIC, without explicit NIC consent.

3.2 The NIC was set up in an interim basis on 5 October 2015 and formally became an Executive Agency of HM Treasury on 24 January 2017. The NIC's objectives are to support sustainable economic growth across all regions of the UK, improve competitiveness and improve quality of life.

3.3 The NIC has committed to delivering a National Infrastructure Assessment (NIA) once in every Parliament, which will assess the UK's long-term infrastructure needs (across a 10-30 year horizon) with recommendations to the government. The NIA covers six infrastructure sectors (transport, energy, water and wastewater, digital communication, solid waste and flood risk management), also considering their interdependencies and wider cross-cutting issues. The delivery of the NIA will be overseen by the NIC's Commissioners, appointed by the Chancellor. The NIA is being driven by an extensive programme of stakeholder engagement, including sector workshops, regional visits and social research, as well as a public call for evidence.

3.4 The NIA will comprise two phases. The first will involve the production of a Vision and Priorities document, which will identify long-term infrastructure needs and consult on options to address these, and will be published this summer. The second phase will be preparation of the final National Infrastructure Assessment, which will include recommendations to the government, and will be published in 2018.

3.5 In May 2016, the NIC published a consultation on the scope and methodology of the NIA. This consultation closed in August 2016 and the NIC published its response in October 2016.

3.6 The NIC recognises the importance of assessing future infrastructure resilience as part of the NIA. One area of interest is the resilience challenges posed by the development of infrastructrure that relies on digital systems and the risk of potentially catastrophic

accidents that could result. The NIC is therefore commissioning a a study of this area and its implications order to input into the NIA and potentially further work.

3.7 Potential Providers should read the NIC's consultation and subsequent response on the scope and methodology of the NIA, as well as the NIC's framework document which sets out the organisation's purpose and objectives, as well as its governance and accountability mechanisms, in order to understand the broader context for this requirement and to inform their response.

4. DEFINITIONS

4.1 **Definitions**:

Expression or Acronym	Definition
Digital systems resilience	Defined as ensuring that the emerging digital infrastructure systems (or 'system of systems'), which are widely predicted to emerge and develop in the next 10-30 years as infrastructure assets become increasingly connected to each other and the internet, operate as intended without incident.
Normal accidents	A theory which predicts that, as systems become more tightly coupled and processes become more complex, the potential for unintended interactions to cause failure becomes so high that accidents occur with such frequency that they become 'normal'. The theory was popularised by American sociologist Charles Perrow (1981, 1999), but is referred to widely in literature across different disciplines.
High reliability organisation	An organisation operating in an environment susceptible to 'normal accidents', which has successfully managed to avoid catastrophes through certain corporate and organisational best practices. Notable works on this topic include Sagan (1993) and Weick and Sutcliffe (2007).

5. SCOPE OF REQUIREMENT

5.1 This requirement covers the range of available literature, data and other evidence in the field of normal accidents and high reliability organisations, where a robust case can be made as to their relevance to the Commission's stated interest of digitally connected infrastructure systems. Please refer to Section 6 for detailed guidance on the scope of the requirement. Potential Providers should note that the following issues are not part of the scope of this procurement, and should be excluded or avoided except where they relate directly to – and would clearly help to illustrate or support arguments to address – the issues and questions covered in this requirement:

5.1.1 A general critique of any of the theories or concepts in the literature, except where this has direct relevance to their applicability to digitally connected infrastructure systems;

5.1.2 Cyber-security and national security threats;

5.1.3 Non-digital interdependencies and linkages between the different sectors;

5.1.4 Non-digital resilience issues such as the threats posed to infrastructure assets and services from flooding and climate change.

6. THE REQUIREMENT

6.1 The increased use of information technology across sectors is predicted to radically change the use and treatment of infrastructure assets in the medium-term, leading to networks of digitally connected systems. In particular, the further development of the Internet of Things and cloud computing could make infrastructure services more efficient and flexible, facilitating autonomous vehicles and 'smart' homes, grids and cities.

6.2 However, such changes will also make the components of future infrastructure systems more tightly coupled and complex – a combination which, Perrow (1981, 1999) predicts, makes accidents more likely, to the extent that they become 'normal'. For example, the reliance on digital communications and uninterrupted power across different locations combined with the increasing complexity and interdependence of infrastructure systems increases the possibility of unintended consequences through unexpected and incomprehensible interactions. These normal accidents are expected to result in system failures affecting large populations, such as widespread or prolonged loss of energy or water supplies, or transport gridlock.

6.3 As part of the NIA, the NIC is keen to explore the trend towards digital infrastructure systems from a resilience perspective. More specifically, the NIC's interest is in the potential for such systems to lead to frequent and highly disruptive accidents, distinct in origin (although not necessarily impact) from malicious acts. The focus of this procurement is to use the available literature, data and evidence (e.g. academic and market research literature, among other sources – sources should be referenced) to identify and explore key issues – producing a set of recommendations including further issues to review. The NIC may decide to commission further work on this topic, depending on whether it sees benefit to the NIA or other studies, based on the outputs of this procurement.

6.4 The NIC expect outputs from the procurement will constitute a report covering four areas, but these are not intended to be prescriptive and alternative approaches may be proposed.

6.5 The NIC would be keen for Potential Providers to have academics (with a relevant background e.g. in engineering, computer science and/or social science) on their staff or to be able to demonstrate how they would be able to access this expertise to test their thinking during the project.

6.6 **The first section of the report is expected to cover the following analysis and outputs:**

6.6.1 Using the available literature, data and evidence, the NIC would like an assessment of whether digitally connected infrastructure systems, as they are

currently predicted to develop, are likely to make normal accidents inevitable. The NIC would expect this to explore the concepts of 'complexity' and 'tight coupling' in detail, and their applicability to these systems. This section should draw on the wide body of interdisciplinary literature on normal accidents and related concepts to identify the points most relevant to the NIC's interests. This section should also outline whether this assessment is likely to vary from sector to sector. The section should make a conclusion based on these assessments, with the evidence underpinning this clearly set out.

6.7 **The second section of the report is expected to cover the following analysis and outputs:**

6.7.1 Using the available literature, data and evidence, the NIC would like to understand how the development of these systems could be made more resilient. This section draw on the wide body of interdisciplinary literature on high reliability organisations and related concepts to identify the points most relevant to the NIC's interests. The NIC would expect the following issues to be considered in detail as part of this section:

6.7.1.1 Corporate and organisational best practices for reducing the risk of normal accidents and their impact. This section should consider 'negative synergies', where the sum of equipment, design and operator errors is far greater than the consequences of individual failure, and how this could be neutralised. The NIC would expect this to include a critique of leading work in this area (including Sagan 1993; Weick and Sutcliffe 2007), contrasting similarities and differences, and bringing together evidence and data from other sources to support this. Relevant practices to consider here include the following (with case studies of good and poor practice where possible): identifying and resolving latent errors; accident reporting and subsequent analysis of investigation findings; whistleblowing; clear lines of responsibility; continuous training; simplified procedures (including producing reliable indicators for review in emergencies); the use of small-scale 'trial and error' approaches and uniform actions. Case studies should include details of whether these practices were developed and implemented at an organisation or sector/industry-level, and what involvement, if any, there has been from national governments. Any potential limitations of introducing these practices into the sectors covered in the NIA should be detailed. The ease of implementing these practices retrospectively into digital infrastructure systems that are already up and running should also be considered;

6.7.1.2 The potential for decoupling and simplifying components and processes in such systems, including consideration of how this could be embedded into decision-making at an early stage. An appreciation should be shown for organisational contradictions; for example, whilst decentralised decision-making processes can help speed up decision-making in emergencies, allowing

decisions to be taken by those in the field with more complete information, a degree of centralisation is necessary in tightly coupled systems. Decentralisation can also dilute accountability arrangements;

6.7.1.3 Considerations for how best practice can be implemented where there is fragmented ownership and responsibility for these systems across a range of different actors (including between both public and private sectors).

6.8 **The third section of the report is expected to cover the following analysis and outputs:**

6.8.1 Using the available literature, data and evidence, this section should make a detailed reflection on whether the assessment made in section one of the report is likely to change in light of potential technological changes in the next 10-30 years (the time horizon for the NIA). In particular, new and emerging technologies such as machine learning could potentially help predict and pre-empt failure, reducing the likelihood and impact of normal accidents. By contrast, the added complexity and new interactions brought about by new (and unforeseen) technologies could make future digital infrastructure systems even more tightly coupled and complex to the extent that normal accidents arise where they would not have done so before, or occur with greater frequency. This section should also consider whether future normal accident frequency can be expected to be proportionate to the pace of technological change, making reference to the available historical evidence.

6.9 **The fourth section of the report is expected to cover the following analysis and outputs:**

6.9.1 Based on the analysis and conclusions of the first three sections of the report, the fourth section should

6.9.1.1 produce a set of recommendations for the relevant actors operating in this space (for example, government, service providers, businesses, digital security experts or the public) to help ensure that digitally connected infrastructure systems develop in a resilient way; and

6.9.1.2 identify a list of further key issues for review, which may form the basis for a subsequent, separate procurement depending on whether the NIC sees benefit in doing so.

6.10 All materials (including research, notes and interim reports) used to generate the analysis should be made available to the NIC for future use.

6.11 At the start of the project the NIC would expect to hold an inception/scoping meeting with the Potential Provider, and for a short inception report to then be provided which clarifies the approach to be taken, along with a plan setting out key milestones and dates for deliverables, risks and how these will be managed etc. – for agreement, before proceeding to carry out the analysis. The Authority expects the bidder to work closely with the NIC, including through weekly meetings and other communication.

6.12 The NIC may procure studies on other infrastructure themes, including analysis for particular sectors and other work on resilience as necessary. If required by the NIC the Potential Provider should work collaboratively with other third parties contracted by the NIC. That may include, but is not limited to sharing analysis and methodologies, and developing jointly agreed assessments and conclusions to support the overall findings of individually commissioned pieces of research.

6.13 The NIC can provide relevant responses from the NIA call for evidence (which closed on 10 February 2017) and other supporting documentation. Given time constraints, the NIC would not expect the winning bidder to spend a significant amount of time meeting with or interviewing a wider range of stakeholders. The NIC has and continues to undertake a significant amount of stakeholder engagement and where appropriate will be able to provide analysis and views from those engagements.

6.14 All literature, data and evidence that is used to produce the report should be derived from a broad range of credible sources (with appropriate references and citations), in particular drawing on information and analysis that is already in the public domain, including published academic literature, market research and data.

6.15 The Potential Provider should also be prepared to present to technical and non-technical members of the NIC setting out the key findings from the report, along with underpinning evidence, assumptions, analysis and caveats to ensure that these are fully understood.

6.16 The Potential Provider should submit a final report detailing analysis, findings and comments in a clear and concise fashion – this should reflect any inputs/requests made by the NIC during the production phase. The NIC intends to publish this report.

6.17 As part of NIC's quality assurance process, the NIC can, and will likely choose to, have peer review of the output to be conducted by a third party or by the NIC's expert advisory panels. It is required that the Potential Provider will need to work proactively and collaboratively with the NIC to consider any reasonable comments and to incorporate them into their work and output accordingly.

7. KEY MILESTONES

7.1 The Potential Provider should note the following project milestones that the NIC will measure the quality of delivery against:

Milestone	Description	Timeframe
1	Project inception meeting with NIC to include: clarifying the approach to be taken, and providing a plan setting out key milestones and dates for deliverables, risks and how these will be managed etc.	By 20th April 2017
2	Interim Report for section one including draft analysis and findings.	By 19th May 2017
3	Interim Report for both section one and section two including draft analysis and findings.	By 9th June 2017

4	First draft of final report to be shared with NIC.	By 30th June 2017
5	Final draft of final report to be submitted to NIC.	By 28th July 2017

7.2 The above timetable assumes the Contract will be awarded by 18th April 2017. As such it is subject to change and is dependent upon key gateway points being met in terms of receiving information from the customer and obtaining all required approvals.

8. NIC'S RESPONSIBILITIES

8.1 The NIC will share pertinent information received through relevant stakeholders and introduce the Potential Provider to relevant stakeholders, which can offer valuable advice on the requirement.

9. REPORTING

9.1 As set out in Section 7 (Key Milestones). Additionally, the Potential Provider will be expected to update the NIC on project progress on at least a weekly basis via a meeting or phone call, including to flag any issues or early findings.

10. VOLUMES

10.1 This is a substantial piece of work – the expectation is that the key outputs and related materials will be both extensive and of publishable standard.

11. CONTINUOUS IMPROVEMENT

11.1 The Potential Provider will be expected to give due consideration to the way in which the required Services are to be delivered throughout the Contract duration and can be continually improved.

11.2 Changes to the way in which the Services are to be delivered must be brought to the NIC's attention and agreed prior to any changes being implemented.

12. SUSTAINABILITY

12.1 N/A

13. QUALITY

13.1 The NIC will be looking to cite the findings from the project in the Vision Priorities and the final NIA. Outputs should therefore be to a publishable standard, with all assumptions and caveats clearly highlighted.

13.2 The source of data and assumptions, as well as advice on its robustness, should be clearly set out, and it will need to be demonstrated how the findings have been suitably quality assured, including through peer review and audit. The report will need to be a self-standing piece that can set out its analysis and justify its conclusions to leading experts in the fields of infrastructure and resilience.

14. PRICE

14.1 Prices are to be submitted via the e-Sourcing Suite excluding VAT. Please note Appendix E is not used for this requirement and there is a specific Price questionnaire.

14.2 Bids for the full requirement are expected to be in the range of £10,000 to £20,000 (excl. VAT).

14.3 Prices should be inclusive of all expenses and exclusive of VAT.

15. STAFF AND CUSTOMER SERVICE

15.1 The NIC requires the Potential Provider to provide a sufficient level of resource – with sufficient but not excessive senior involvement and oversight – throughout the duration of the Contract in order to consistently deliver a quality service to all Parties at value for money.

15.2 Potential Provider's staff assigned to the Contract shall have the relevant qualifications, experience and expertise to deliver the Contract. The NIC does not prescribe any single set of minimum requirements in terms of skills or qualifications, but the Potential Provider must demonstrate as part of its bid that its delivery team contains staff with sufficient expertise and skills.

15.3 The Potential Provider should not replace staff members in the team which was assembled and presented in the bidding process without informing and getting consent from the NIC.

15.4 The Potential Provider shall ensure that staff understand the NIC's vision and objectives and will provide excellent customer service to the NIC throughout the duration of the Contract.

16. SERVICE LEVELS AND PERFORMANCE

16.1 The NIC will measure the quality of the Potential Provider's delivery by:

KPI/SLA	Service Area	KPI/SLA description	Target
#1	Agreed approach	Clarifying the approach to be taken, along with a plan setting out key milestones and dates for deliverables, risks and how these will be managed etc.	By 20th April 2017
#2	Interim Report for section one and section two	An interim draft paper addressing the issues set out in the requirement for sections one and two, including draft analysis and findings.	By 9th June 2017
#3	Final Report draft of final report, publishable form	A final report covering the key outputs described in the requirement.	By 28th July 2017

17. SECURITY REQUIREMENTS

17.1 Due care must be taken by the Potential Provider to protect the confidentiality of all analysis and outputs (including in development and draft phases) relating to this requirement, to avoid pre-empting the NIC's placement of the final report or any of its contents into the public domain.

18. INTELLECTUAL PROPERTY RIGHTS (IPR)

18.1 All analysis (including research, notes and interim reports) used to generate the outputs should be provided to the NIC for future use. This analysis, and the interim and final reports, will be the property of the NIC. The Potential Provider must not disclose the report (either in part or in full) to any third parties prior to publication by the NIC, unless the NIC gives express consent to do so.

19. PAYMENT

19.1 Payment can only be made following satisfactory delivery of the pre-agreed certified products and deliverables. Payment will be made in arrears, subject to invoice(s) being submitted for work carried out.

19.2 Before payment can be considered, invoice(s) must include a detailed elemental breakdown of work completed and the associated costs.

20. ADDITIONAL INFORMATION

20.1 The Potential Provider should demonstrate that they are open to working collaboratively with other suppliers, contracted by the NIC in order to deliver related pieces of analysis.

21. LOCATION

21.1 The location of the Services will be carried out at the offices of the Potential Provider. However frequent meetings will need to take place with the NIC at the Potential Provider's offices, or at the NIC's offices in Eastcheap Court, 11 Philpot Lane, London, EC3M 8UD.