Invitation to Quote

Invitation to Quote (ITQ) on behalf of Science and Technology Facilities Council (STFC)

Subject UK SBS PS17097 Technical Assistance on the design and implementation of Current UKCRIC Database and modelling capability for STFC

Sourcing reference number PS17097

UK Shared Business Services Ltd (UK SBS)
www.uksbs.co.uk

UKSBS
Shared Business Services

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Section 1 – About UK Shared Business Services

Putting the business into shared services

UK Shared Business Services Ltd (UK SBS) brings a commercial attitude to the public sector; helping our customers improve efficiency, generate savings and modernise.

It is our vision to become the leading provider for our customers of shared business services in the UK public sector, continuously reducing cost and improving quality of business services for Government and the public sector.

Our broad range of expert services is shared by our customers. This allows our customers the freedom to focus resources on core activities; innovating and transforming their own organisations.

Core services include Procurement, Finance, Grants Admissions, Human Resources, Payroll, ISS, and Property Asset Management all underpinned by our Service Delivery and Contact Centre teams.

UK SBS is a people rather than task focused business. It's what makes us different to the traditional transactional shared services centre. What is more, being a not-for-profit organisation owned by its customers, UK SBS' goals are aligned with the public sector and delivering best value for the UK taxpayer.

UK Shared Business Services Ltd changed its name from RCUK Shared Services Centre Ltd in March 2013.

Our Customers

Growing from a foundation of supporting the Research Councils, 2012/13 saw Business, Energy and Industrial Strategy (BEIS) transition their procurement to UK SBS and Crown Commercial Services (CCS – previously Government Procurement Service) agree a Memorandum of Understanding with UK SBS to deliver two major procurement categories (construction and research) across Government.

UK SBS currently manages £700m expenditure for its Customers.

Our Customers who have access to our services and Contracts are detailed here.

Section 2 – About Our Customer

Science and Technology Facilities Council (STFC)

STFC is a world-leading multi-disciplinary science organisation, whose goal is to deliver economic, societal, scientific and international benefits to the UK and its people – and more broadly to the world.

STFC support an academic community of around 1,700 in particle physics, nuclear physics, and astronomy including space science, who work at more than 50 universities and research institutes in the UK, Europe, Japan and the United States, including a rolling cohort of more than 900 PhD students.

The organisation's large-scale scientific facilities in the UK and Europe are used by more than 3,500 users each year, carrying out more than 2,000 experiments and generating around 900 publications.

The combination of access to world-class research facilities and scientists, office and laboratory space, business support, and an environment which encourages innovation has proven a compelling combination, attracting start-ups, SMEs and large blue chips such as IBM and Unilever.

Examples of funded research

- STFC is providing the design infrastructure for the £23bn UK microelectronics sector that underpins strategically important industries worth £78bn to the UK economy
- STFC's ISIS facility and its users, working in partnership with the NHS, developed a novel material to improve the treatment of cleft lip and palate, speeding up healing times and reducing operating costs
- STFC's Synchrotron Radiation Source was used to understand how conventional anti-malarial drugs work, allowing the development of more effective treatment to reduce the devastating global impact of malaria
- STFC's ISIS facility is identifying new materials that can safely and conveniently store hydrogen, enabling the development of hydrogen-fuelled cars reducing reliance on fossil fuels and cutting carbon emissions

www.stfc.ac.uk

Section 3 - Working with UK Shared Business Services Ltd.

In this section you will find details of your Procurement contact point and the timescales relating to this opportunity.

Section 3 – Contact details		
3.1	Customer Name and address	The Science and Technology Facilities Council (STFC) of Polaris House, North Star Avenue, Swindon, SN2 1SZ
3.2	Buyer name	Ben Oborne
3.3	Buyer contact details	professionalservices@uksbs.co.uk
3.4	Estimated value of the Opportunity	Maximum contract value £80,000.00 excluding VAT
3.5	Process for the submission of clarifications and Bids	**All correspondence shall be submitted within the Emptoris e-sourcing tool. Guidance Notes to support the use of Emptoris is available here. Please note submission of a Bid to any email address including the Buyer will result in the Bid not being considered.**

Section 3 - Timescales		
3.6	Date of Issue of Contract Advert and location of original Advert	06/07/2017 Contracts Finder
3.7	Latest date/time ITQ clarification questions should be received through Emptoris messaging system	13/07/2017 11.00am
3.8	Latest date/time ITQ clarification answers should be sent to all potential Bidders by the Buyer through Emptoris	14/07/2017 14.00pm
3.9	Latest date/time ITQ Bid shall be submitted through Emptoris	20/07/2017 14.00pm
3.10	Date/time Bidders should be available if face to face clarifications are required	Not Required
3.11	Anticipated rejection of unsuccessful Bids date	28/07/2017
3.12	Anticipated Award date	28/07/2017
3.13	Anticipated Contract Start date	01/08/2017

3.14	Anticipated Contract End date	31/01/2018
3.15	Bid Validity Period	60 Days

Section 4 – Specification

Introduction:

About STFC

The Science and Technology Facilities Council (STFC) is one of Europe's largest research organisations. We're trusted to support, enable and undertake pioneering projects in an amazing diversity of fields. Our Scientific Computing Department (SCD) develops leading edge software, computer and data storage infrastructures to support the work of world class science both within STFC and internationally. The expertise of our staff is key to making our research happen. We work with the latest technologies to drive advances in both hardware and software that have genuine real world applications. Whether it is the search for the Higgs Boson and dark matter, analysing climate data or genomics, our systems tackle the biggest and most challenging problems in scientific computing.

About UKCRIC

The UK Collaboratorium on Research in Infrastructure & Cities (UKCRIC – www.ukcric.com) has been established to enable the UK to develop a world class national infrastructure research capability to inform the UK's infrastructure development agenda. It is a £137.6m capital investment committed within the government's Budget of March 2015. STFC is a delivery partner of the Data Analytics Facility for National Infrastructure (DAFNI), one of the three main strands of UKCRIC with an investment of £8M

Aims:

The aim of DAFNI is to provide new data intensive hardware and software infrastructure to enable significant new advances in infrastructure systems research. DAFNI is the first of its kind in the UK and globally, dedicating to complex infrastructure systems research using advanced computational techniques. The core of DAFNI will be located at Rutherford Appleton Laboratory in Oxfordshire with satellite capabilities at the Universities.

The aim of the tender is to embed expertise into the STFC-DAFNI team to enable them to gain understanding of the current systems and processes in place such that this expertise can be handed over to the new DAFNI Technical Architect when recruited as part of a separate exercise.

It is envisaged that this team will be embedded at STFC for the duration of the contract.

Objectives:

This tender seeks responses to supply a team of individuals to be embedded at STFC for a 6 month project to assist in the technical design and implementation of DAFNI.

Main Objectives:

1. A report detailing the current use of data and modelling resources
2. A new technical design to meet DAFNI's requirements
3. Technical assistance in the deployment of a project pilot

Further details of the DAFNI project proposal is available in Appendix B – DAFNI Project Proposal.

The Requirment

The successful supplier will provide a team that will be embedded in the STFC-DAFNI project team.

(1) Write a report on the Current Systems and processes (15 paper copies plus pdf)
    a. Architectural diagrams of end-to-end processes including data flows.
    b. Inventory of Datasets and Models
    c. Licensing issues
    d. Current Technologies
        i. Implementations and configurations
    e. Custom Software
        i. Code repositories
        ii. Maintenance processes
    f. Operational procedures
        i. Managing and Monitoring systems
    g. Hardware
    h. Data and Operational Security
        i. Data and system security policies for data transmission, storage, access, backup & recovery, and archiving

(2) Create a new technical design to meet DAFNI's requirements building on current systems and processes (15 paper copies plus pdf)
    i. Scalability
    j. Performance
    k. Portability
    l. Reliability
    m. Resilience

(3) Hands on technical assistance in the deployment of a project pilot based on the technical information gained as part of the report, including deployment, testing, and benchmarking of a selection of existing datasets, data flows, and model codes on STFC infrastructure.

It is expected that the successful company will deploy a team which will be based at the STFC Rutherford Appleton Laboratory. The team is expected to be onsite unless agreed with his STFC manager.

The team must provide an email address and phone number so that they can be contacted Desks will be provided whilst the team is onsite at STFC

Scope:

Staff time and resources needed to complete the report are included.

Travel expenses will be re-imbursed separately and the consultant must follow STFC's travel policy, detailed in Appendix A - Research Council Travel, Subsistence and Expenses Policy.

All outputs from the work of the supplier will be owned by STFC.

Timetable:

WP	Time	Input	Output
Discovery	2 weeks	Project Proposal and Discussions with the STFC and UKCRIC DAFNI Project Teams (see collaborators list in Appendix B)	Plan (< 5 pages) detailing the consultation process with STFC and the UKCRIC-DAFNI research partners
Current System and Processes report This objective is fundamental to the project	6 weeks	Using the consultation plan to talk with partners. STFC and UKCRIC DAFNI Project Teams	Weekly releases to track progress to the STFC-DAFNI Project Team Final report -15 paper copies plus pdf)
A new technical design	2 weeks	Current Systems and Processes Report STFC and UKCRIC DAFNI Project Teams	Brief report on recommendations for improvement 15 paper copies plus pdf
Part of implementation team for a project pilot based on the outputs of the report and recommendations	12 Weeks	Report and recommendations plus existing UKCRIC infrastructure.	Documentation of the Proof of concept pilot, e.g. benchmarking, setup, and improvements
Handover to newly recruited Technical Architect (STFC employee)	2 weeks	Knowledge and experience gained during the project	New appointed Technical Architect fully informed

Terms and Conditions

Bidders are to note that any requested modifications to the Contracting Authority Terms and Conditions on the grounds of statutory and legal matters only, shall be raised as a formal clarification during the permitted clarification period.

Section 5 – Evaluation model

The evaluation model below shall be used for this ITQ, which will be determined to two decimal places.

Where a question is 'for information only' it will not be scored.

The evaluation team may comprise staff from UK SBS, the Customer and any specific external stakeholders the Contracting Authority deems required. After evaluation the scores will be finalised by performing a calculation to identify (at question level) the mean average of all evaluators (Example – a question is scored by three evaluators and judged as scoring 5, 5 and 6. These scores will be added together and divided by the number of evaluators to produce the final score of 5.33 (5+5+6 =16÷3 = 5.33)

Pass / fail criteria

Questionnaire	Q No.	Question subject
Commercial	SEL1.2	Employment breaches/ Equality
Commercial	SEL3.11	Compliance to Section 54 of the Modern Slavery Act
Commercial	FOI1.1	Freedom of Information Exemptions
Commercial	AW1.1	Form of Bid
Commercial	AW1.3	Certificate of Bona Fide Bid
Commercial	AW3.1	Validation check
Commercial	AW4.1	Contract Terms
Price	AW5.5	E Invoicing
Price	AW5.6	Implementation of E-Invoicing
Quality	AW6.1	Compliance to the Specification
-	-	Invitation to Quote – received on time within e-sourcing tool

Scoring criteria

Evaluation Justification Statement
In consideration of this particular requirement the Contracting Authority has decided to evaluate Potential Providers by adopting the weightings/scoring mechanism detailed within this ITQ. The Contracting Authority considers these weightings to be in line with existing best practice for a requirement of this type.

Questionnaire	Q No.	Question subject	Maximum Marks
Price	AW5.2	Price	30%
Quality	AW6.2	Methodology	10%
Quality	AW6.3	Skills and Expertise	40%
Quality	AW6.4	Risk and Project Plan	10%
Quality	AW6.5	Quality Monitoring	10%

Evaluation of criteria

Non-Price elements

Each question will be judged on a score from 0 to 100, which shall be subjected to a multiplier to reflect the percentage of the evaluation criteria allocated to that question.

Where an evaluation criterion is worth 20% then the 0-100 score achieved will be multiplied by 20.

Example if a Bidder scores 60 from the available 100 points this will equate to 12% by using the following calculation: Score/Total Points available multiplied by 20 (60/100 x 20 = 12)

Where an evaluation criterion is worth 10% then the 0-100 score achieved will be multiplied by 10.

Example if a Bidder scores 60 from the available 100 points this will equate to 6% by using the following calculation: Score/Total Points available multiplied by 10 (60/100 x 10 = 6)

The same logic will be applied to groups of questions which equate to a single evaluation criterion.

The 0-100 score shall be based on (unless otherwise stated within the question):

0	The Question is not answered or the response is completely unacceptable.
10	Extremely poor response – they have completely missed the point of the question.
20	Very poor response and not wholly acceptable. Requires major revision to the response to make it acceptable. Only partially answers the requirement, with major deficiencies and little relevant detail proposed.
40	Poor response only partially satisfying the selection question requirements with deficiencies apparent. Some useful evidence provided but response falls well short of expectations. Low probability of being a capable supplier.
60	Response is acceptable but remains basic and could have been expanded upon. Response is sufficient but does not inspire.
80	Good response which describes their capabilities in detail which provides high levels of assurance consistent with a quality provider. The response includes a full description of techniques and measurements currently employed.
100	Response is exceptional and clearly demonstrates they are capable of meeting the requirement. No significant weaknesses noted. The response is compelling in its description of techniques and measurements currently employed, providing full assurance consistent with a quality provider.

All questions will be scored based on the above mechanism. Please be aware that the final score returned may be different as there may be multiple evaluators and their individual scores will be averaged (mean) to determine your final score.

Example
Evaluator 1 scored your bid as 60
Evaluator 2 scored your bid as 60
Evaluator 3 scored your bid as 40
Evaluator 4 scored your bid as 40
Your final score will (60+60+40+40) ÷ 4 = 50

Price elements will be judged on the following criteria.

The lowest price for a response which meets the pass criteria shall score 100.
All other bids shall be scored on a pro rata basis in relation to the lowest price. The score is

then subject to a multiplier to reflect the percentage value of the price criterion.

For example - Bid 1 £100,000 scores 100.
Bid 2 £120,000 differential of £20,000 or 20% remove 20% from price scores 80
Bid 3 £150,000 differential £50,000 remove 50% from price scores 50.
Bid 4 £175,000 differential £75,000 remove 75% from price scores 25.
Bid 5 £200,000 differential £100,000 remove 100% from price scores 0.
Bid 6 £300,000 differential £200,000 remove 100% from price scores 0.
Where the scoring criterion is worth 50% then the 0-100 score achieved will be multiplied by 50.

In the example if a supplier scores 80 from the available 100 points this will equate to 40% by using the following calculation: Score/Total Points multiplied by 50 (80/100 x 50 = 40)

The lowest score possible is 0 even if the price submitted is more than 100% greater than the lowest price.

Section 6 – Evaluation questionnaire

Bidders should note that the evaluation questionnaire is located within the **e-sourcing questionnaire.**

Guidance on completion of the questionnaire is available at http://www.uksbs.co.uk/services/procure/Pages/supplier.aspx

PLEASE NOTE THE QUESTIONS ARE NOT NUMBERED SEQUENTIALLY

Section 7 – General Information

What makes a good bid – some simple do's ☺

DO:

7.1 Do comply with Procurement document instructions. Failure to do so may lead to disqualification.

7.2 Do provide the Bid on time, and in the required format. Remember that the date/time given for a response is the last date that it can be accepted; we are legally bound to disqualify late submissions.

7.3 Do ensure you have read all the training materials to utilise e-sourcing tool prior to responding to this Bid. If you send your Bid by email or post it will be rejected.

7.4 Do use Microsoft Word, PowerPoint Excel 97-03 or compatible formats, or PDF unless agreed in writing by the Buyer. If you use another file format without our written permission we may reject your Bid.

7.5 Do ensure you utilise the Emptoris messaging system to raise any clarifications to our ITQ. You should note that typically we will release the answer to the question to all bidders and where we suspect the question contains confidential information we may modify the content of the question to protect the anonymity of the Bidder or their proposed solution

7.6 Do answer the question, it is not enough simply to cross-reference to a 'policy', web page or another part of your Bid, the evaluation team have limited time to assess bids and if they can't find the answer, they can't score it.

7.7 Do consider who your customer is and what they want – a generic answer does not necessarily meet every customer's needs.

7.8 Do reference your documents correctly, specifically where supporting documentation is requested e.g. referencing the question/s they apply to.

7.9 Do provide clear and concise contact details; telephone numbers, e-mails and fax details.

7.10 Do complete all questions in the questionnaire or we may reject your Bid.

7.11 Do check and recheck your Bid before dispatch.

What makes a good bid – some simple do not's ☹

DO NOT

7.12 Do not cut and paste from a previous document and forget to change the previous details such as the previous buyer's name.

7.13 Do not attach 'glossy' brochures that have not been requested, they will not be read unless we have asked for them. Only send what has been requested and only send supplementary information if we have offered the opportunity so to do.

7.14 Do not share the Procurement documents, they are confidential and should not be shared with anyone without the Buyers written permission.

7.15 Do not seek to influence the procurement process by requesting meetings or contacting UK SBS or the Customer to discuss your Bid. If your Bid requires clarification the Buyer will contact you.

7.16 Do not contact any UK SBS staff or Customer staff without the Buyers written permission or we may reject your Bid.

7.17 Do not collude to fix or adjust the price or withdraw your Bid with another Party as we will reject your Bid.

7.18 Do not offer UK SBS or Customer staff any inducement or we will reject your Bid.

7.19 Do not seek changes to the Bid after responses have been submitted and the deadline for Bids to be submitted has passed.

7.20 Do not cross reference answers to external websites or other parts of your Bid, the cross references and website links will not be considered.

7.21 Do not exceed word counts, the additional words will not be considered.

7.22 Do not make your Bid conditional on acceptance of your own Terms of Contract, as your Bid will be rejected.

Some additional guidance notes

7.23 All enquiries with respect to access to the e-sourcing tool and problems with functionality within the tool may be submitted to Crown Commercial Service (previously Government Procurement Service), Telephone 0345 010 3503.

7.24 Bidders will be specifically advised where attachments are permissible to support a question response within the e-sourcing tool. Where they are not permissible any attachments submitted will not be considered.

7.25 Question numbering is not sequential and all questions which require submission are included in the Section 6 Evaluation Questionnaire.

7.26 Any Contract offered may not guarantee any volume of work or any exclusivity of supply.

7.27 We do not guarantee to award any Contract as a result of this procurement

7.28 All documents issued or received in relation to this procurement shall be the property of the Contracting Authority.

7.29 We can amend any part of the procurement documents at any time prior to the latest date / time Bids shall be submitted through Emptoris.

7.30 If you are a Consortium you must provide details of the Consortiums structure.

7.31 Bidders will be expected to comply with the Freedom of Information Act 2000 or your Bid will be rejected.

7.32 Bidders should note the Government's transparency agenda requires your Bid and any Contract entered into to be published on a designated, publicly searchable web site. By submitting a response to this ITQ Bidders are agreeing that their Bid and Contract may be made public

7.33 Your bid will be valid for 60 days or your Bid will be rejected.

7.34 Bidders may only amend the Contract terms if you can demonstrate there is a legal or statutory reason why you cannot accept them. If you request changes to the Contract and the Contracting Authority fail to accept your legal or statutory reason is reasonably justified we may reject your Bid.

7.35 We will let you know the outcome of your Bid evaluation and where requested will provide a written debrief of the relative strengths and weaknesses of your Bid.

7.36 If you fail mandatory pass / fail criteria we will reject your Bid.

7.37 Bidders are required to use IE8, IE9, Chrome or Firefox in order to access the functionality of the Emptoris e-sourcing tool.

7.38 Bidders should note that if they are successful with their proposal the Contracting Authority reserves the right to ask additional compliancy checks prior to the award of any Contract. In the event of a Bidder failing to meet one of the compliancy checks

the Contracting Authority may decline to proceed with the award of the Contract to the successful Bidder.

7.39 All timescales are set using a 24 hour clock and are based on British Summer Time or Greenwich Mean Time, depending on which applies at the point when Date and Time Bids shall be submitted through Emptoris.

7.40 All Central Government Departments and their Executive Agencies and Non Departmental Public Bodies are subject to control and reporting within Government. In particular, they report to the Cabinet Office and HM Treasury for all expenditure. Further, the Cabinet Office has a cross-Government role delivering overall Government policy on public procurement - including ensuring value for money and related aspects of good procurement practice.

For these purposes, the Contracting Authority may disclose within Government any of the Bidders documentation/information (including any that the Bidder considers to be confidential and/or commercially sensitive such as specific bid information) submitted by the Bidder to the Contracting Authority during this Procurement. The information will not be disclosed outside Government. Bidders taking part in this ITQ consent to these terms as part of the competition process.

7.41 From 2nd April 2014 the Government is introducing its new Government Security Classifications (GSC) classification scheme to replace the current Government Protective Marking System (GPMS). A key aspect of this is the reduction in the number of security classifications used. All Bidders are encouraged to make themselves aware of the changes and identify any potential impacts in their Bid, as the protective marking and applicable protection of any material passed to, or generated by, you during the procurement process or pursuant to any Contract awarded to you as a result of this tender process will be subject to the new GSC from 2nd April 2014. The link below to the Gov.uk website provides information on the new GSC:

https://www.gov.uk/government/publications/government-security-classifications

The Contracting Authority reserves the right to amend any security related term or condition of the draft contract accompanying this ITQ to reflect any changes introduced by the GSC. In particular where this ITQ is accompanied by any instructions on safeguarding classified information (e.g. a Security Aspects Letter) as a result of any changes stemming from the new GSC, whether in respect of the applicable protective marking scheme, specific protective markings given, the aspects to which any protective marking applies or otherwise. This may relate to the instructions on safeguarding classified information (e.g. a Security Aspects Letter) as they apply to the procurement as they apply to the procurement process and/or any contracts awarded to you as a result of the procurement process.

USEFUL INFORMATION LINKS

- Emptoris Training Guide
- Emptoris e-sourcing tool
- Contracts Finder
- Tenders Electronic Daily
- Equalities Act introduction
- Bribery Act introduction
- Freedom of information Act

Appendix A - Research Council Travel, Subsistence and Expenses Policy

RESEARCH COUNCIL TRAVEL, SUBSISTENCE AND EXPENSES POLICY

Content

Policy statement

The Research Council may require staff to travel on official business, and will reimburse claimants for the costs of travelling. The preferred purchasing route for travel services is through the Research Council's appointed agents, who will be paid directly. Travel and subsistence claims, as all Research Council expenditure, are met from public funds, and attract public attention therefore it is imperative that there is full compliance with this policy and that claims are processed in a consistent and effective manner. All those travelling on Research Council business, and making claims under this policy are expected to recognise their obligations to consider whether the trip is necessary, to consider alternative, cheaper options, and to make claims only in respect of costs properly incurred. Claimants should be aware that travel and expenses claims may be disclosed under the Freedom of Information Act (see section 13).

In line with the Research Council commitment to environmental sustainability, claimants are encouraged to consider and try to minimise environmental impact of journeys made on behalf of the Research Council (see section 4.3)

This document incorporates the policy for travel on Research Council business, including related aspects such as overnight accommodation. The purpose is to achieve travellers' service requirements in the most convenient and cost-effective manner. The Research Council will reimburse the actual additional costs necessarily incurred by claimants when they are away from home or their normal place of work on Research Council business.

This policy applies to all Research Council employees of a permanent and temporary nature. It may also apply to non Research Council employees such as visitors, agency staff, and students. For advice on the application of the Policy contact the Research Council HR team.

The Travel, Subsistence, and Expenses policy has been agreed with the Trade Union Side and complies with statutory legislation and HM Revenue & Customs requirements.

The UK Shared Business Services (UK SBS) provides HR Services across the Research Councils. However some employees are deployed at establishments/facilities/ ships that do not access services from SBS. In these cases references to the SBS or System will not apply and employees should refer to their Research Council HR team for assistance.

1. Principles

1.1 The objectives of the Research Council Travel, Subsistence, and Expenses policy are:

- To reimburse claimants promptly for expenses properly incurred on Research Council business;
- To obtain maximum value for money from the Research Council's expenditure on travel and subsistence, within Government policy and taking account of the safety and wellbeing of employees and environmental considerations.
- To ensure that the Research Council's expenditure on travel and subsistence represents only the necessary and reasonable costs incurred by or on behalf of those who are properly engaged on Research Council business;
- To minimise the cost of administering this expenditure, especially indirect costs represented by the time spent by claimants on making travel arrangements and submitting claims for reimbursement of expenses;

1.2 All expenses processed through the Research Council accounts will be treated as if they were paid for by public funds irrespective of the actual source of funds.

1.3 The reimbursement of expenses is normally on a receipted actual basis (within the maximum limits stipulated in Appendix 2 or, in the case of overseas expenses, within the maximum limits set by the HMRC's benchmark scale rate payments). (See 1.9 for exceptions).

1.4 Reimbursement of expenses is regulated by the rules set out by HM Revenue & Customs (HMRC) and therefore this policy complies with those requirements.

1.5 Some of the provisions detailed within this policy are subject to tax in line with HMRC rules. Expenses paid to employees that are considered taxable will be reimbursed with the monthly salary payment and will be subject to Income Tax and National Insurance contributions. If an expense is reimbursed to a non-Research Council employee that is considered taxable, the Research Council will notify the HMRC and the tax due will need to be paid to HMRC by the claimant.

1.6 Expenses will only be reimbursed if they are claimed in line with this policy.

1.7 The cost of travel between home and the normal place of work is the responsibility of the claimant, and will not normally be reimbursed.

1.8 Expense claims are not to be used to purchase equipment, materials or services that should be bought through the normal procurement process e.g. computers, phones.

1.9 The Research Council recognises that in exceptional circumstances (e.g. emergency situations, inability to obtain a receipt, travelling in certain countries abroad) a claimant may have to deviate from the Research Council's policy. In relation to travel abroad it should be discussed and agreed in advance whether claiming the HMRC daily rate would be more appropriate.

1.10 Individual claims must be approved and may be checked for compliance with the requirements of this policy.

1.11 Localised policies that override the Research Council Travel, Subsistence, and Expenses policy are not permissible.

2. Definition of terms

2.1 Travel

2.1.1 The terms of this policy cover short visits away from the vicinity of the employee's usual place of work for up to a maximum of 30 working days on Research Council business. For visits lasting for more than 30 working days, please refer to section 8.1.

2.1.2 Also excluded is daily travel to and from an establishment or home visits at weekends when the employee is working on secondment.

2.2 Subsistence

2.2.1 The actual necessary and reasonable cost of meals and/or accommodation incurred by those engaged on official Research Council business, whilst away from the employee's normal place of work or other establishment where it has been agreed they will work for a fixed period.

2.3 Claimant

2.3.1 A person making a claim within the provisions of this policy.

2.4 Authorising manager

2.4.1 An individual appointed by the Director or his/her nominee will authorise all claims and provide justification where policy limits are non-compliant.

3. Claim forms

3.1 Research Council employees

3.1.1 Research Council employees should submit their expenses via the System.

3.2 Non- Research Council employees

3.2.1 Non-Research Council employees must submit their expenses claims on a **Non Employee Expenses Claim Form** which is available on the System or accessed through the Research Council HR or Finance teams.

3.3 Interview expenses

3.3.1 The Research Council may offer to pay applicants' expenses to travel by the most economic route to the interview venue at the manager/units discretion. Interview related expenses should be claimed in line with this policy.

3.3.2 Applicants must submit their expenses claims on a **Non Employee Expenses Claim Form**. (see 3.2.1 above)

4. Travel claims

4.1 Travel approval

4.1.1 All travel must be approved by the authorising manager prior to being booked and undertaken.

4.1.2 Establishments will have their own local arrangements for giving permission to travel on official Research Council business but in each case approval needs to be given by the authorising manager in accordance with the provisions of this policy.

4.2 Mode of travel

4.2.1 Claimants should use the recommended service for booking travel.

4.2.2 Claimants may choose their own form of transport subject to the overriding consideration of value for money, although the Research Council's preference is for employees to use public transport or, where that is not practicable, to use Research Council-owned vehicles or self-drive hire cars (where these are better value for money than using privately owned vehicles - see section 4.6 on insurance requirements). It is recognised that a combination of modes of travel may need to be used for particular journeys.

4.2.3 The use of taxis may be justified in certain circumstances (see paragraph 4.11).

4.3 Environmental impact of travel

4.3.1 Before booking travel claimants should consider whether the trip is necessary or whether teleconferencing or video conferencing offer a viable alternative.

4.3.2 When arranging travel, the Research Council encourages claimants to use the mode of travel that results in the least environmental impact, as carbon dioxide from transport, particularly from air and road travel, is a key contributor to climate change.

4.3.3 Where choosing a more environmentally friendly mode of travel results in an increase in costs, the employee must raise this in advance of making any bookings, with their authorising manager.

4.4 Public transport - Class of travel

4.4.1 Claimants are normally expected to travel standard class by train and economy class by air. All claimants should actively seek value for money where it is practical and feasible.

4.4.2 Claimants should refer to section 4.5 below regarding first class travel.

4.4.3 All air travel should be booked through the Research Council's recommended service.

4.4.4 All rail travel should be booked through Research Council's recommended service.

4.4.5 It is recognised that this may not be possible at short notice or when the claimant is away from the office. In these circumstances the claimant may purchase the ticket and recharge the cost.

4.5 Exclusion of first class travel

4.5.1 Research Council employees and other claimants are not permitted to travel by first class on any form of transport including air and rail. This exclusion also applies to business class air travel.

4.5.2 Alternatives to first class travel must be sought in all but exceptional circumstances.

4.5.3 Exceptions to this include where a claimant with a medical condition clearly requires first class rail travel or an employee requires a single berth sleeper cabin. The claimant must seek authorisation from their Director or appropriate authorising manager prior to booking these.

4.5.4 Travellers are welcome to upgrade from standard to premium economy, business or first class at their own expense (or use of personal reward miles) but the Research Council can only cover the cost of the standard fare.

4.6 Privately owned vehicles

4.6.1 When undertaking a journey on Research Council business the driver is responsible for ensuring the vehicle is in a roadworthy condition. There is no obligation or expectation that privately owned vehicles should be used.

4.6.2 Claimants must ensure they comply with the provisions of the Research Council's Driving and Use of Vehicles at Work policy/guidance, which provides an effective system of controlling the risk to employees who drive on Research Council business.

4.6.3 When using their own vehicle, claimants must ensure that it is licensed, appropriately insured (see section 4.7 and Appendix 1) and has a valid MOT certificate. Provided the insurance and ownership requirements are satisfied, claimants may use privately owned motor vehicles and claim the appropriate mileage allowance rate (see Appendix 2) except when:

- there is suitable Research Council provided transport readily available; or
- there is room for another passenger in another vehicle which is to be used for an official journey over the same route at about the same time;
- public transport is better value for money.

4.7 Insurance and ownership requirements

4.7.1 Claimants who use their own vehicles on Research Council business are required to take out insurance cover for business use of the vehicle. It is a legal requirement that any vehicle user must be insured against liability in respect of any third party. It is the individual's personal responsibility to ensure that they fulfil the insurance and

ownership requirements for using a private motor vehicle on official business. These are set out in Appendix 1.

4.7.2 Claimants are reminded that failure to adhere to these requirements is a disciplinary offence.

4.7.3 The formal undertaking (Appendix 1a) must be completed and handed to the designated person at the permanent place of work before any claimant first uses their private motor vehicle on official business.

4.8 Mileage allowances

4.8.1 Payment for using a privately owned vehicle(s) on official business will be by one of the ways set out below:

a) The HMRC's approved rates for payment of mileage allowances will be made for journeys when it is of benefit to the Research Council for an individual's private car/motorcycle to be used;

b) Payment of a bicycle allowance for journeys when an individual uses a privately owned bicycle.

4.8.2 The allowances above are not subject to income tax or National Insurance contributions.

4.8.3 Details of the current rates of the allowances are set out at Appendix 2.

4.8.4 The Research Council will only pay the HMRC approved mileage rate for the appropriate journey. These rates are subject to change by HMRC and such changes will be actioned by the Research Council at the time they are made.

4.9 Passenger supplement

4.9.1 A passenger supplement per passenger per business mile, may be claimed in conjunction with the mileage allowances in 4.8 in respect of each official passenger carried whose fare would otherwise be payable from Research Council funds.

4.9.2 The current passenger supplement rate is listed in Appendix 2 of this document.

4.10 Parking, congestion charges, tolls, ferries and other driving-related penalties

4.10.1 Reasonable expenses incurred on parking, congestion charges, tolls and ferries may be claimed in respect of journeys which qualify for the mileage allowances in section 4.8 above. Receipts or other documentary evidence should be submitted as part of the claim.

4.10.2 Charges for overnight parking will be paid only when subsistence expenses are payable for the night(s) in question.

4.10.3 Should an employee be liable for clamping or other parking / congestion charge penalty (e.g. because a meeting over runs or due to non-payment of a congestion charge) then reimbursement of the charge will not be made. Similarly, reimbursements will not be made to an employee who receives a fine or other

financial penalty relating to an offence committed whilst driving on Research Council business (e.g. for speeding or for using a hand held mobile phone or similar device). Given the possible impact on the Council's vehicle insurance premium, employees are required to notify the Research Council of any such offences and penalties.

4.11 Taxis and self-drive car hire

4.11.1 It is recognised that the use of taxis can be in the interest of the Research Council (e.g. when the journey by public transport would be considerably longer and more difficult or if an employee has very heavy luggage, etc.).

4.11.2 Claimants who would find public transport impractical or inconvenient (e.g. claimants with disabilities) or those who would perceive themselves to be at higher risk should be reimbursed the cost of taxis. A receipt must be provided which must include journey details and dates.

4.11.3 Claimants should use the Research Council's recommended service for booking a hire car and may claim for the cost of the fuel for that specific journey.

4.12 Concessionary travel for additional or late attendances at work

4.12.1 The cost of travel between home and the normal place of work is the responsibility of the employee, and will not normally be reimbursed.

4.12.2 However, the cost of any extra (i.e. above that normally occurred in a working day) travelling expenses will be reimbursed if an employee is, for Research Council work reasons, obliged to:

a) return to the place of work at the weekend, for Research Council work reasons;

b) return to the place of work again in the evening after already having travelled home from work earlier in the day;

c) exceptionally remain late in the evening;

d) return to the place of work on a public or privilege holiday.

4.12.3 When a day off is taken in lieu of having worked at the weekend, or on a public or privilege holiday, the normal daily travelling cost will not be reimbursed for the time at work since travelling costs will not have been incurred on the day off.

4.12.4 Claimants are not eligible for payment if:

a) they are attending as part of a regular rostered commitment; or

b) they are in receipt of shift allowance which takes account of irregular attendance or hours.

4.12.5 Payment for such extra travel between home and place of work is normally subject to income tax (exception - see paragraph 4.12.2). Claims must therefore be made using the Research Council's arrangements for claiming taxable expenses.

4.12.6 However, claimants obliged to finish work after 2100 hours on an infrequent and irregular basis will be reimbursed necessary additional expenses, e.g. for taxi or hire

car, of travel home tax free under the terms of the relevant HMRC concession. Detailed advice as to whether or not the concession can be applied can be obtained from the Payroll Manager at the UK SBS.

4.12.7 For the purposes of this concession, the requirements which should be met are:

a) late working is regarded by the HMRC as frequent if it occurs on more than 60 occasions in a tax year;

b) late working is regarded by the HMRC as regular if there is a predictable pattern.

4.13 During a public transport emergency

4.13.1 During a public transport emergency, claimants who are required to attend work and who thereby incur extra unavoidable travelling expenses will be reimbursed tax free under the terms of the relevant HMRC concession. Detailed advice as to whether or not the concession can be applied can be obtained from the UK SBS Payroll Manager.

4.14 Loyalty points awarded by airlines, hotel chains etc.

4.14.1 Claimants may not specify a particular supplier solely to gain Air Miles or any other loyalty points.

4.14.2 Air Miles or Loyalty Points which are accrued to an individual as a result of official travel on behalf of the Research Council must only be used to offset the costs of future official journeys, and not for personal use.

4.14.3 The Research Council will not reimburse claims where private Air Miles or Loyalty Points have been used for Research Council travel and the cash equivalent is sought upon redemption.

4.14.4 Where use of a personal credit card for payment attracts benefits associated with the card these are not covered by this section, but the overriding factor in choice of travel remains value for money.

5. Accommodation

5.1 Overnight accommodation – standards

5.1.1 When overnight accommodation is required it is normally expected that claimants at all levels will obtain accommodation which meets the standards set out in Appendix 3 at the most economical rate available.

5.1.2 Appendix 2 provides the maximum normal limits for accommodation rates in the UK. Where, in exceptional circumstances, these rates need to be exceeded this should be approved by the authorising manager prior to booking.

5.1.3 A guide for overseas accommodation rates is available from the HMRC and these rates should be taken into account when booking accommodation.

5.2 Overnight accommodation - choice of hotels

5.2.1 The Research Council expects claimants to use hotels at which discounts have been negotiated or to use centralised booking arrangements where these are available.

5.2.2 However, the preference of individual claimants in their choice of hotel will be respected subject to the overriding consideration of value for money.

5.2.3 Where such "discounted" accommodation is known to be available, reimbursement for bed and breakfast will be restricted to the amount that would have been spent if that accommodation had been used.

5.2.4 Flexibility may be applied in certain circumstances and claimants should discuss this with their authorising manager in advance, for example when:

- discounted accommodation is not available
- claimants have disabilities
- there are other practical needs e.g. where an employee travelling alone may incur extra accommodation costs through safety and security need.

5.2.5 Employees may stay with friends or family, as an alternative to hotel accommodation (see Appendix 2).

5.3 Overnight accommodation - hotel costs

5.3.1 Subject to the restrictions set out in section 5.2 the actual costs incurred will be reimbursed.

6. Other subsistence

6.1 Day subsistence (meals and beverages)

6.1.1 Claimants may claim the reasonable costs of meals taken in the course of business travel provided that they are:

a) Absent from their normal place of work or other agreed place of work for a fixed period (e.g. if on secondment for a fixed period) for more than five hours; or

b) Exceptionally, are required to work until 20.00 hours or later in addition to normal day duty (but are not staying away from home overnight). However, in these circumstances payment will be liable to income tax and claims must therefore be made using the Research Council's arrangements for claiming taxable expenses.

6.1.2 Meals should be of a reasonable cost and standard. Appendix 2 provides the maximum normal limits for meals expenses in the UK. This limit is inclusive of additional extras including tips. Where, in exceptional circumstances, these rates need to be exceeded this should be approved by the authorising manager.

6.1.3 Reimbursement will not be made to claimants:

a) working after 20:00 at their normal place of work if they work night duty instead of day duty;

b) working after 20:00 at their normal place of work, whose conditions of service require them to work at night, or to be on call at night, in addition to normal day duty;

c) who are in receipt of an accommodation allowance (see section 8.1) unless eligible because of absence from the place of work at which they are on an extended visit;

d) where the place visited is five miles or less by the most direct route from their normal place of work or other agreed place of work for a fixed period.

6.1.4 On the occasions where it is necessary for claimants to stay overnight in a hotel, the Research Council will reimburse the cost of a reasonable evening meal within the limits listed in Appendix 2.

6.1.5 Reimbursement will not be made where a suitable meal is provided e.g. full board is provided.

6.1.6 Authorising managers may not authorise a claim for a meal (or similar) covering several people if they themselves were one of the party.

6.2 Tips and alcoholic beverages

6.2.1 Tips or discretionary service charges not exceeding 10% of the total bill will be reimbursed where such payment is included in the receipt, and are included in the limits of Appendix 2.

6.2.2 Expenditure on alcoholic beverages will only be reimbursed when drinks are taken with a meal, and are included in the limits of Appendix 2.

6.3 Personal Incidental Expenses (PIE)

6.3.1 Claimants required to stay overnight on Research Council business may claim a flat-rate Personal Incidental Expenses allowance to cover incidental out of pocket expenses.

6.3.2 When full board is included in the cost of the overnight stay, no subsistence will be reimbursed but a limited Personal Incidental Expenses will still be payable.

6.3.3 The current Personal Incidental Expenses allowance is listed in Appendix 2.

7. Specific provisions for overseas travel

7.1 Visa fees for overseas travel

7.1.1 Claimants required to travel overseas on Research Council business will be reimbursed the cost of visa fees when necessary for the travel on production of a receipt.

7.2 Exchange rates

7.2.1 Where expenditure has been incurred in a foreign currency the claimant should use the exchange rate prevailing at the time that they purchased the currency, or incurred the expenditure to calculate the cost in British pounds. This calculation must be accompanied by supporting paperwork e.g. a receipt for changing currency, credit card statement.

7.2.2 Where there is no evidence of the specific exchange rate (as in paragraph 7.2.1) then the expense claim should be made in the currency of the receipt.

7.3 Currency exchange commission

7.3.1 Claimants required to travel overseas on Research Council business will be reimbursed the cost of currency exchange commission when accompanied by a receipt/documentary evidence.

7.4 Immunisation and inoculations for overseas travel

7.4.1 Claimants required to travel overseas on Research Council business will be reimbursed the cost of any immunisation treatments required for the travel on production of receipts provided that the travel has been approved and the employee does not foresee any reason why they would not be able to travel overseas at the required time.

7.4.2 If the appointed Research Council Occupational Health Service is able to provide the immunisation treatment, claimants can be treated by the Service at no cost to the individual.

7.5 Support from other bodies

7.5.1 An employee may, subject to the approval of his/her Director, or their nominee, apply to another body for expenses for attendance at overseas conferences.

7.5.2 Where such approval has been obtained, this may be stated in the application to the other body.

7.5.3 Claimants may not claim the same expenses from the Research Council and another body.

7.5.4 There are occasions where the Research Council buys a ticket for travel for a claimant and/or reimburses the claimant for the expenses, pending payment to the claimant by a third party. In these circumstances the claimant is obligated to repay the Research Council at the earliest opportunity. Failure to repay expenses which have been met by the Research Council and are then reimbursed by a third party may constitute fraud in line with section 9.3 of this policy.

7.6 Overseas travel insurance

7.6.1 Claimants (including non-Research Council employees) travelling overseas on approved Research Council business are usually covered by the Research Council Group Travel Insurance Scheme. If employees have any reason to suspect that they may not be covered by the Scheme, they should get in touch with their Research Council HR or Finance team.

7.6.2 The scheme covers personal accident, disablement and medical expenses as well as personal baggage, loss of money, cancellation, travel delays, passport indemnity, personal liability and legal expenses up to certain limits. All claimants must keep receipts if they want to claim any of these costs back.

7.6.3 Claimants will be given details of the policy and a card with all the contact details before they travel (this will be issued by local administration).

7.6.4 The Research Council will not reimburse the cost of any additional insurance cover claimants wish to take out, for personal travel/holiday before or after their Research Council business trip.

7.6.5 The insurance policy only covers claimants on authorised Research Council business. Full details of the insurance scheme are available from the Research Council Finance or HR team.

8. Other expenses

8.1 Visits lasting more than 30 working days

8.1.1. When a visit from the normal place of work extends beyond 30 working days the arrangements described above will be replaced by a specially determined package.

8.1.2 The Director will determine this package in consultation with the Research Council HR lead and the Finance team at the SBS.

8.1.3 The Director (or nominee), with the SBS, will also determine the arrangements for the reimbursement of living costs, accommodation and other related costs. Normally, the employee will be expected to move into self-catering accommodation.

8.2 Other non-travel related expenditure

8.2.1 In line with the principles of this policy expense claims are not to be used to purchase equipment, materials or services that should be bought through the normal procurement process e.g. computers, phones.

8.2.2 In exceptional circumstances (e.g. emergency situations) a claimant may, in the interests of research, need to purchase equipment and reclaim this via the expenses claim process. Such exceptional claims must be accompanied by an explanatory note from the Director or nominee.

8.2.3 Reimbursement will be permitted if the explanation is accepted and the claim approved by the Director.

8.3 Extension of business trip for personal reasons (including personal research)

8.3.1 An employee must use the normal holiday application process using the System when applying for an extension of a business trip for personal reasons.

8.3.2 Incremental costs relating to extension must be paid for personally. It must be clearly demonstrated that Research Council business was the primary purpose of the visit. Leave records should be appropriately completed.

8.3.3 The Research Council insurance does not cover claimants for the additional days of any extension of a business trip for personal reasons.

8.3.4 Should the time spent on personal business in any one trip exceed seven days the claimant must contact the Payroll team at the UK SBS for guidance on the taxation position of any reimbursement made by the Research Council.

8.4 Family travel

8.4.1 The Research Council will not meet any costs relating to the accompanying spouse/partner or family member of an employee travelling on Research Council business.

8.4.2 Where spouses or companions accompany Research Council employees, the costs must be separated appropriately e.g. if a single room costs £70 and a twin/double £100, the £30 difference must be deducted from the claim (or refunded to the Research Council, if paid initially via the Research Council's travel agent).

8.5 Miscellaneous travel related expenses

8.5.1 Consideration will be given to the reimbursement of other travel related expenses not covered elsewhere in this policy.

9. How to claim reimbursement

9.1 Claiming expenses and receipts

9.1.1 Claims for the reimbursement of expenses from the Research Council employees must be submitted via Employee Self Service on Oracle, using the " iExpenses User" responsibility, or where the employee does not have access to the System, via local arrangements.

9.1.2 Following submission of the claim, receipts must be sent to UK SBS. Receipts should be individually attached to the claim form and put into an envelope marked with claimant's name, Council and claim reference. Claimants are advised to keep a scanned copy or photocopy of the receipts submitted.

9.1.3 Small items of incidental expenditure, up to £5 total per day, can be claimed without a receipt if not available.

9.1.4 All expenditure over £5 must be accounted for with receipts. Reimbursement for items over £5 without receipts will only be met in exceptional circumstances. In each

case the claimant should contact the Payroll Manager at the UK SBS to establish whether any tax liability will apply.

9.1.5 Any claims without receipts should be supported by evidence, if available. Claims should not be approved unless the authorising manager is satisfied that the expenditure was incurred wholly, exclusively and necessarily in the performance of the duties of the claimant's role in the Research Council.

9.1.6 Such claims will be referred to the Payroll team at the UK SBS, to adjudicate on the taxation position and to determine how reimbursement should be made. These claims may be deemed taxable through the PAYE system and tax will therefore be deducted from the claim.

9.1.7 Expense claims against transactions on credit card statements must be supported by individual original receipts.

9.1.9 Where a claimant incurs expenses when working at an establishment that is different from the one they are employed at, the claimant should claim expenses from their employing establishment.

9.2 Time limit for claims/reimbursement

9.2.1 Expenses claims should be submitted for payment within 60 days of the expense being incurred. Properly-completed and authorised claims will normally be paid within three working days.

9.2.2 If, exceptionally, this proves to be impossible, the claim form should be accompanied by a brief note explaining the circumstances.

9.3 False/Fraudulent claims

9.3.1 All claimants are responsible for completing claims accurately.

9.3.2 Any attempt to claim expenses in breach of the Research Council Travel, Subsistence, and Expenses policy or to assist another work colleague to breach the Research Council Travel, Subsistence, and Expenses policy will be considered a serious disciplinary offence and will be dealt with under the Research Council Disciplinary policy.

9.4 Travel/subsistence advances

9.4.1 The Research Council's processes are designed to ensure that an employee is not materially out of pocket for a significant period when travelling on business. For this reason, advance payment to cover anticipated costs of travel and subsistence will only be made in exceptional circumstances e.g. an extended period of overseas travel. In such cases, claimants can make an application for a travel and subsistence advance payment prior to travel, provided they have no reason to believe they will not be able to carry out such travel.

9.4.2 The amount advanced will be determined by the Research Council on a case-by-case basis; in all cases, it will be less than 100% of the anticipated travel and subsistence costs.

9.4.3 Applications can be made on the appropriate form in the System.

9.4.5 Advances should be ordered in time for the trip but not significantly prior to the trip.

9.4.6 The authorised advance will be paid into the claimant's bank account

9.4.7 After returning from travel the claimant should submit an expense claim and their receipts via the normal process, specifying the amount that they had already been advanced.

9.4.8 Any overpayment will need to be reimbursed to the Research Council by the claimant.

9.5 Reimbursement of cancellation charges

9.5.1 Where a claimant has unavoidably to cancel travel/accommodation plans and cancellation charges are incurred these will be reimbursed by the Research Council if the following conditions are met: 1) claims are accompanied by supporting documentation, and 2) the authorising manager is satisfied that cancelling the travel/accommodation was unavoidable.

9.5.2 The claimant is expected to assist the Research Council in recovering costs from the Research Council Group Travel Insurance scheme.

9.6 Claimants leaving the Research Council

9.6.1 All expenses claims must be authorised and submitted to the SBS prior to the claimant's last working day with the Research Council. Claims received after this date will not be processed.

10. Claimants with disabilities

10.1 It is recognised that claimants with disabilities may have extra needs when travelling and staying in hotel accommodation. Therefore, as part of the Research Council's Equalities and Diversity policy, claimants with disabilities who incur extra cost for facilities for the disabled will be reimbursed; these costs must be stated within the claim.

10.2 Claimants with disabilities should not suffer inconvenience resulting from the failure to apply discretion and flexibility. Where a claimant with a disability requires a mode of travel or accommodation which, although is more expensive for the Research Council, they consider to be a more practical and convenient method of transport for them, the claimant should raise this with their authorising manager for discussion in advance of making any bookings. Once the authorising manager has given their approval, the employee can make arrangements and will be reimbursed for the cost for the agreed mode of transport and accommodation.

10.3 The insurance and ownership requirements in Appendix 1 must be met when using a private vehicle.

11. Application of the procedures

11.1 The aim of this policy is for fair and effective application of the procedures. All reasonable expenditure will be reimbursed and it is therefore important that all those who authorise claims share a consistent interpretation of what constitutes "reasonable".

12. Appeals

12.1 Research Council employees who consider that their claim or circumstances have not been considered or authorised fairly may follow the Research Council grievance procedure as a method of appeal against decisions taken. However, claimants are encouraged, in the first instance, to seek advice and guidance on their concerns from their Research Council HR team.

13. Disclosure of information relating to expenses claimed

13.1 From time to time the Research Council may be required to publish information relating to expenses claimed from the Research Council by employees and non-Research Council employees, for instance in response to a Freedom of Information request.

13.2 In such cases the Research Council would normally release information at an aggregate or summary level.

13.3 Where a request involves the expenses of Directors, other senior managers and others who it may be possible to identify from the data, those involved will, wherever possible, be given the opportunity to comment in advance on the information likely to be released.

13.4 In any other instances where the public interest may favour disclosure the individuals affected would, wherever possible, be given the opportunity to comment on any information likely to be released.

13.5 Where copies of receipts or invoices are requested these will be made available as appropriate, taking into account any issues relating to personal data.

14. Review of policy

14.1 This policy will be regularly reviewed to incorporate any legislation changes. The TU may request that a policy is reviewed.

15. Amendment history

Version	Date	Comments/Changes
V2.0	November 2014	Para 1.3 Further clarification provided and reference made to HMRC who set overseas benchmark scale rates and not the Foreign and Commonwealth Office
V2.0	November 2014	Para 5.1.3 reference made to HMRC and not the Foreign and Commonwealth Office
V2.0	November 2014	Para 1.9 Final sentence removed, employees should refer to para 2.4
V2.0	November 2014	Para 7.2.2 Final sentence removed as the calculation of the exchange rate by UKSBS does not happen in practice.
V2.0	November 2014	Para 7.2.3 removed as the entering of claims onto the system is not policy related.
V2.0	November 2014	New Para 8.5 relating to miscellaneous travel related expenses
V2.0	November 2014	Appendix 2, Section 1 providing clarification that all rates include all expenses incurred in the use of a vehicle including fuel
V3.0	01 August 2015	Para 1.10 amended to confirm that all claims must be approved
V3.0	01 August 2015	Para 2.4.1 amended to confirm that all claims will be authorisation

APPENDIX 1

INSURANCE AND OWNERSHIP REQUIREMENTS TO BE FULFILLED BY CLAIMANTS USING THEIR PRIVATE MOTOR VEHICLES ON RESEARCH COUNCIL BUSINESS

1. Principles

Whilst using their private vehicle on Research Council business (or travelling as an official passenger in another claimant's vehicle) an employee is deemed to be in the course of their duty for the purpose of the injury benefit provisions of the Research Council Injury Benefits Scheme. Details of this scheme can be found in the Research Council Pension Scheme Rule Book.

They are also covered by the Social Security Act 1975, subject to the decision of the Statutory Authorities in a particular case.

In other respects provision for injury or death due to accident while using a private motor vehicle on official business is the claimant's own responsibility.

2. Insurance

All claimants using their private motor vehicles on Research Council business must satisfy the following insurance conditions:

a) they must have a valid motor insurance policy for the vehicle which insures the holder against liability in respect of any third party;

b) the insurance policy must include a clause permitting the owner to use the vehicle for business purposes. If the vehicle is not owned by the claimant, the insurance policy should specifically cover the use of the vehicle on Research Council business

3. Ownership

To qualify for motor mileage allowance(s) the following will be regarded as the employee's private vehicle:

a) a vehicle owned or being bought on hire purchase and registered in the claimant's name;

b) a vehicle hired by the claimant under a long term contract i.e. for at least a year:

c) a vehicle registered in the name of the employee's partner provided that:
   - the normal insurance requirements (see 2 above) are fulfilled and the insurance specifically covers the use of the vehicle by the claimant on Research Council business
   - the vehicle is available for use by the claimant on Research Council business whenever required and, for cars only, to carry official passengers.

4. Formal undertaking

Before first using a private motor vehicle on official business every claimant must give a written undertaking by signing the declaration at Appendix 1a that he or she knows and understands the insurance requirements; that he or she is covered accordingly; and that he or she will immediately notify his or her Director (or nominee) of any change in insurance cover which results in less than the rules require.

Appendix 1a - Formal undertaking letter

To: The (Insert Name) Research Council

I ..... have received and read a copy of the 'Insurance and ownership requirements to be fulfilled by claimants using their private motor vehicles on Research Council business' section of the Research Council's Travel and Subsistence Policy (Appendix 1).

I understand and accept these requirements as governing the use of my motor vehicle(s) on official Research Council business and, in agreeing to comply with them, undertake to ensure that I am adequately insured and to advise my Director (or nominee) immediately of any change which means that the insurance falls short of what is required, under the Research Council Travel, Subsistence and Expenses Policy.

Signed.....

Date.....

Location.....

APPENDIX 2

Expenses allowances with effect from 1 January 2014

1. Mileage allowances for the use of privately owned vehicles (section 4.8)

HM Revenue & Custom Mileage rates will be reviewed annually.

	First 10,000 business miles in tax year	Each business mile over 10,000 in the tax year
Cars and vans	**45p**	**25p**
Motorcycles	**24p**	**24p**
Bicycles	**20p**	**20p**

The above rates include all expenses incurred in the use of a vehicle including fuel.

2. Passenger Supplement – cars and vans (section 4.10)

Per passenger per business mile for carrying fellow employees in a car or van on journeys which are also work journeys for them.	**5p**

3. Maximum accommodation rates in the UK (section 5.1)

London and Edinburgh (including breakfast)	Maximum **£170 inc VAT** per night
Elsewhere in the UK (including breakfast)	Maximum **£120 inc VAT** per night
Staying with friends or relatives *	Flat rate £25 per night

* this taxable allowance should be claimed via the taxable expenses claim process

4. Maximum meals expenses in the UK (section 6.1)

Total per day for lunch and evening meal	**£40 inc VAT**
Breakfast meal limit (where not included in B&B tariff)	**£7.50 inc VAT**
Lunch meal limit	**£15 inc VAT**
Evening meal limit	**£25 inc VAT**

5. Personal Incidental Expenses (section 6.3)

Per 24 hour period	**£5 inc VAT**

APPENDIX 3

Overnight accommodation standards

STANDARDS OF OVERNIGHT ACCOMMODATION NORMALLY EXPECTED BY RESEARCH COUNCIL CLAIMANTS ON SHORT VISITS

1. Single occupancy rooms with:
   - en suite facilities (shower or bath)
   - TV
   - tea/coffee making facilities
   - a telephone in the room
   - internet access in the room is desirable; costs will be reimbursed provided that there is a demonstrable business need

2. There should be adequate space and where it is necessary to work in the room, facilities (light, writing surface, telephone, etc.) for doing this.

3. The accommodation should have satisfactory personal security arrangements and adequate emergency procedures.

4. Restaurant facilities should be available either on the premises or locally, offering full breakfast and a reasonably priced menu for lunch and dinner.

5. Extras such as newspapers, room service, mini-bar, film/DVD hire should be met by the claimant - please note this list is not exhaustive.

Please note:
Claimants with special requirements, e.g. for managing a disability or complying with a religious obligation, are asked to ensure that these needs will be able to be met before any overnight accommodation is booked. In case of difficulty please contact your Research Council HR team. Any personal information provided in these circumstances would, of course, be treated as confidential.

Appendix B – DAFNI Project Proposal

National Infrastructure Database, Modelling, Simulation and Visualisation Facilities

Contents

1. Motivation for the UKCRIC National Infrastructure Database, Modelling, Simulation and Visualisation Facilities (NIDMSVF)

Planning, designing and managing national infrastructure systems is a high cost, and often high-risk, endeavour. It involves making difficult choices on a range of different timescales. The extended life of infrastructure, the consequent potential for lock-in to the wrong decisions and the potentially catastrophic consequences of infrastructure failure, means that infrastructure planning, investment and design decisions are particularly critical. It is customary to use a wide range of technical, economic and environmental information in these choices. Ever-increasingly, that evidence is based on the outputs and insight from models. Indeed modelling in every infrastructure sector (energy, transport, digital communication, water, waste, flood protection) has become more or less central to the process of decision making. Modelling provides the opportunity to explore scenarios, simulate and optimise solutions and visualise the performance of designs to inform major investment commitments. Modelling and simulation are areas where the UK has academic strength [1]. The UK has developed distinctive capability in system-of-systems modelling that integrates across infrastructure sectors: energy, transport, digital communications, water, waste and flood defence. That research strength is reflected in the UK's positioning in global collaborations on infrastructure systems simulation with leading North American, European, Asian and Australasian institutions. There has been a high level of uptake of research outputs, for example in water resources planning and in identification of critical infrastructure hotspots.

These research achievements have been underpinned by a range of computational facilities. UKCRIC partner institutions have invested extensively in computational infrastructure and use has been made of shared infrastructure (for example N8HPC) and commercial cloud computing facilities. Further exploitation of these existing facilities and new investments is to be expected by the UKCRIC community in the future as part of the usual business of modelling and simulation research. However, there are fundamental limits to what can be achieved via this incremental and fragmented approach.

Modelling, in its broadest sense, is underpinned by data. This extends from modelling of physical processes (for example of flooding or pipe flow) to empirical modelling (e.g. machine learning) from big datasets. Significant steps have now been made to establish a database of national infrastructure [2] for the UK, based on a new infrastructure data schema. Model-based infrastructure research is still severely limited by the availability of relevant infrastructure data, from every-day operation conditions and extreme disruption events, and accompanying socio-economic and environmental datasets. Many other research communities have managed to make substantial advances thanks to a centralised approach to high quality common datasets. The infrastructure research community has not managed to achieve that yet.

Identification of research needs

The needs for database, modelling, simulation and visualisation facilities were explored during a two-day workshop held in Oxford in March 2016, supported with EPSRC Institutional Sponsorship funds. At the workshop we heard multiple perspectives on EPSRC funded infrastructure research, including transport, energy, water and urban systems. As well as representatives from within and beyond the UKCRIC partner universities, the workshop included participation from industrial (e.g. Microsoft Research, utilities,

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[1] A National Infrastructure for the 21st Century: Council for Science and Technology, 2009 http://webarchive.nationalarchives.gov.uk/20130705054945/http://www.bis.gov.uk/assets/cst/docs/files/whats-new/09-1631-national-infrastructure.pdf

[2] Bar, S., Alderson, D., Ives, M.C and Robson, C. Database, simulationmodelling and visualisation for national infrastructure assessment in Hall, J.W., Tran, M., Hickford, A.J. and Nicholls, R.J. *The Future of National Infrastructure: A System of Systems Approach*, Cambridge University Press, 2016.

engineering consultants) and government (e.g. Ordnance Survey) organisations. The workshop identified two main priorities which could transform infrastructure systems analysis.

1. **A national infrastructure database (NID).** UK infrastructure data is held by a range of infrastructure owners and operators. Concerns about security, confidentiality and commercial sensitivity limit the availability of data. This is a major obstacle to understanding how national infrastructure operates at a system-of-systems scale. NID would provide a national secure facility for assembling, hosting and creating datasets on infrastructure assets and networks and the human and natural environments in which they are located. It would provide a secure, scalable and trusted repository for national infrastructure data; and a new platform for analysis of big datasets, including standard simulation test cases. It would become a hub for infrastructure researchers in the UK and for business and government organisation. It would involve tiered security arrangements to deal with secure data and simulation results and multiple licencing arrangements. It would also support the extension of the open data concept to infrastructure.
2. **National infrastructure modelling, simulation and visualisation facilities (MSVF).** UK researchers have made pioneering steps in developing simulation models of national infrastructure, supporting network operation, strategic planning and risk analysis. Models can be used to simulate the physical performance of technological systems and the dynamic relationship between infrastructure systems, the environment, economy and society, making use of growing expertise in very large-scale agent-based modelling. A related strand of innovation is in the integration of large datasets that are acquired from pervasive monitoring systems, and the modelling of individual consumer behaviour. The modelling and simulation platform would provide an e-science environment which would represent a step-change in capability by (i) linking seamlessly with the national infrastructure database (ii) conveniently accessing high performance computing facilities (iii) enabling coupling of simulation modules to enable system-of-systems simulation and (iv) linking with visualisation facilities to enable scrutiny and communication of complex and high dimensional simulation results.

   Visualisation facilities would enable scrutiny of big datasets and complex model outputs. Facilities will also be developed for the engagement of decision makers and broader stakeholder groups in infrastructure decisions.

These new capabilities would provide the capacity to develop a new generation of engineering models and tools to inform infrastructure system planning, design and management. The new facilities would be designed to meet the multiple needs of UKCRIC and other institutions. The existence of facilities of this type, which do not exist anywhere else in the world (other than perhaps in the UK National Laboratories, where they are not accessible to the research community) would provide unprecedented capability to (i) secure the UK's position as a leader in national infrastructure modelling, simulation and visualisation and (ii) provide benefits to industry and government in infrastructure planning, risk analysis and the management of interdependencies.

The co-location of infrastructure datasets with computation resource and an e-science platform supporting infrastructure modelling would add significant value by i) lowering the barriers to entry to conduct analysis of infrastructure systems, ii) facilitate new collaborations through the linking of previously isolated infrastructure simulation modelling efforts, iii) generate new knowledge and understanding through the interface of the simulation models with one another, with previously unavailable data, and new audiences through the visualisation and dissemination of results and insights.

2. Proposed facility

The UKCRIC National Infrastructure Database, Modelling, Simulation and Visualisation Facilities (NIDMSVF) will provide shared resources enabling the UK's computer modelling capabilities to be scaled up and applied to problems of much greater complexity at district, city, national and supra-national scales. The modelling will be based on databases, computation and visualisation facilities.

There is a diversity of computer modelling and data analysis taking place in UK universities, but much to be gained by having greater sharing and integration of model development and readily accessible national datasets.

The concept of the NIDMSVF is one of a national hub used by multiple institutions. It will entail capital investments in delivery of an e-science system and accompanying staged implementation of new computational and database hardware. Smaller investments in UKCRIC institutions will facilitate the use of the centralised facilities e.g. through new visualisation screens ('walls') and local databased buffering.

There are many different types of computer modelling taking place in UKCRIC institutions, including, for example, highly computer-intensive optimisation problems and computational mechanics simulations of the behaviour of materials. These computational tasks are already making use of high performance computing within UKCRIC universities and various shared facilities e.g. ARCHER. It would not be appropriate for UKCRIC to seek to duplicate or replace these very expensive facilities. Individual researchers should seek to access the most appropriate computational facilities for their modelling challenges. **The concept of UKCRIC is to add value to existing infrastructure systems modelling by providing new facilities that would not otherwise be available. The design of the UKCRIC NIDMSVF is therefore focussed upon, for the first time, (i) assembling and curating shared national infrastructure datasets and (ii) enabling modellers to use these datasets and couple their models with other teams through the development of common interfaces and an e-science modelling platform**. Whilst it is therefore clear that some stand-along computational modelling lies outside the remit of the NIDMSVF and is best directed towards other HPC facilities; it is equally clear from our consultations that there is a large untapped potential for novel research based on new infrastructure systems datasets and the coupling of models to simulate processes and interactions that have hitherto defied analysis. The NIDMSVF aims to address this need.

In overview, the NIDMSVF will comprise of the National Infrastructure Database (NID) and the National infrastructure modelling, simulation and visualisation facilities (MSVF) along with accompanying centralised and local hardware investments.

National Infrastructure Database

The national Infrastructure database (NID) will provide two key roles within the NIDMSVF. First it will act as a data storage facility for both the most commonly employed data-sets used within infrastructure systems simulation and modelling. Table 1 lists typical datasets that are being used for infrastructure systems modelling at present – these are merely examples to illustrate the diversity of datasets and their relevance to infrastructure systems.

Table 1 Examples of typical national infrastructure datasets to populate NID

Name	Size/volume (GB, approx.)	Number of records/features (millions, approx.)	Number of attributes (per record)	Source	Data Type	Description
OSMasterMap - Areas	975	1948	12	Ordnance Survey	Vector (Polygon)	Used to characterise/understand infrastructure demand at building stock level.
UK Census - output area attributes	6	0.23	344	CENSUS	Tabular	Used to parametrise geodemographic demand in infrastructure demand/supply modelling.
UK Census - output area geography	1	0.23	3	CENSUS	Vector (Polygon)	Used to parametrise geodemographic demand in infrastructure demand/supply modelling.
NISMOD-LP - TR Road Link Hourly	118	138	92	NISMOD-LP national road infrastructure model	Tabular	Result-set generated by national transport model, used to subsequently parametrise sub-models.
EA Rainfall points	10	29	22	Environment Agency	Vector (Point)	Data used in infrastructure spatial vulnerability and risk analysis.
Address Layer 2 Address Point	45	31	107	Ordnance Survey	Vector (Point)	Data sued to characterise location of critical infrastructure assets in the UK.
Gridded antecedent rainfall	126	2592	4	CEH	Grid/Raster	Data used in infrastructure spatial vulnerability and risk analysis.
Electricity Transmission/Distribution Network	1	168,000 nodes, 172,000 edges	8	ITRC compiled from National Grid/Ordnance Survey data	Topological Network	Complex hierarchical topological network model of national electricity network.
High resolution embankment Lidar	65	256,000,000	4	Commissioned helicopter LIDAR	Vector (Point)	High resolution topographic data sue in engineered infrastructure embankment models of failure.
Laser Scanned Track Infrastructure	1,000,000	1,150,000,000	1	Network Rail train-based rail scanner	Vector (Point)	High resolution track scanner data used to understand track condition/state.

Working with strategic data providers (e.g., Ordnance survey, National Grid, Highways England etc.) we will develop a licensed store of generic trusted infrastructure data. Using accepted open data standards (e.g., OGC, standards adopted by the open data formats within the ONS enhanced Data Explorer API) we will where required augment the data with 'added value' community derived data-sets that have a wide applicability of use within the infrastructure modelling and simulation community. This aspect of the NID will:

- Provide the hardware data-store architecture and computational framework for rapid loading, structuring, management and access to data relevant to infrastructure modelling and simulation.
- Develop secure licensed access to strategic infrastructure data-sets provided by key infrastructure data organisations. Sensitive licensed data will be stored safely using database encryption approaches and will be accessed via appropriate tiered authentication procedures. NID will provide the meta-data architecture for data license management, authentication and secure access providing confidence to data owners of sensitive data to participate in NIDMSVF.
- Facilitate community derived open data and result sets for infrastructure systems modelling and simulation using accepted 'open' data standards. Increasingly research projects themselves generate valuable data and results that can be utilised and leveraged by others within the infrastructure systems research community. NID will provide the data upload, cleaning and validation tools required for researchers to leverage community provided data and results.
- Link to and leverage of existing related data stores and databases via accepted APIs and where possible low-latency networking. Existing RCUK data centres, such as the ESRC Consumer Research Data Centre, ESRC Urban Big Data Centre and NERC CEDA-AS, hold many primary data-sets on demographics, economics and hazards required for system-of-systems infrastructure modelling. **Seamless access to the data held by other data-stores** is essential. NID will provide the software framework and meta-data catalogue services to provide easy access to these data centres.
- Undertake a campaign of detailed data integration into NID across the spectrum of infrastructure systems modelling and simulation performed at UKCRIC institutions (multi-model integration – system of systems simulations). This will be used to assemble standard ratified high-quality data-sets and test cases (outputs) for the different categories of modelling and simulation performed within the UKCRIC community; a resource that can be used for intra-model comparison and benchmarking.

In addition to acting as a primary data store for infrastructure modelling, NID will also provide the software framework and interfaces required by the modelling, simulation and visualisation software (APIs over NID) to leverage and employ such data. It is now widely recognised that many data-sets are too large to be extracted and downloaded into models and that architectures that allow models to be brought to the data are required (e.g., NERC JASMIN). This requires appropriate database software frameworks that allow access to data rapidly and easily. To facilitate this in NID we will;

- Develop and use database architectures that optimise data storage and retrieval for the different types of data employed in infrastructure systems research modelling and simulation. Employing advances in NoSQL database technology we will provide a facility that fits the database storage to the data in order to develop scalable sustainable software data architectures for modelling and simulation purposes.
- Develop scalable graph database architectures to enable the efficient exploration, extraction and presentation of complex networks resulted from multi-model simulations and system integration ....
- Provide easy access to data regardless of the database storage architecture via a federated meta-database. This will allow users to quickly query and ascertain data within NID. Appropriate APIs will

be developed to allow easy access, retrieval and query of the data within NID that can be employed within uploaded models and simulations.

- Provide where appropriate 'open' software of the database developments implemented in NID for data management, query, retrieval and analysis for community development and extension. In order to assist modellers with gaining familiarity and confidence in using NIDMSVF a NID 'lite' architecture (with example data-sets) (a trimmed-down version) will be provided within a VM for local site model development/testing and familiarisation of the NID-MSVF interface(s).

In the first instance the focus of the NID will be upon UK infrastructure systems and relate data-sets. However, we recognise major opportunities exist for analysis of global infrastructure networks, in particular in the context of the Global Challenges Research Fund (GCRF). Thus the design of the NID will consider global as well as national datasets and ultimately provide a resource for UKCRIC and others to employ these within their research.

National infrastructure modelling, simulation and visualisation facilities

The national infrastructure modelling, simulation and visualisation facilities (MSVF) will provide a hardware–independent platform that will support modelling and simulation, integrated with access to datasets via the NID, with access to suitable modelling packages. The system will:

- Provide a platform for upload, access, deployment and development of modelling and simulation codes for new and existing models to the host computing facilities, of the appropriate scale, architecture and nature for the required modelling task. The national MSVF will be hosted centrally to maximally provide the scale and stability needed for large scale research. However, the platform software itself will be open source, allowing it to be deployed elsewhere, for example, at university computing facilities mirroring a selection of the datasets and platform capabilities for focussed research initiatives.
- Allow users to flexibly couple models across different hardware platforms, from individual workstations to large scale HPC (e.g. GPU or high memory options), within an orchestration and execution environment, so that simulations on different aspect and scales can be coordinated and shared. For example, users could be running their models within universities, and data will be sent the platform for cross scale multi-model post-analysis and sharing within the community.
- Facilitate the use of the platform for different communities within tailored, secure managed workspaces, with customised access to software and to the data resources within the NID.
- Support different user communities, with differing levels of experience via a variety of personalised user interfaces (e.g. virtual desktop, web portals, mobile apps, desktop apps), so that the system can be used by as wide a user community as possible.
- Allow users to visualise and interact with their models using geo-spatial visualisations and other information visualisation techniques so that the high dimensional models can be explored and steered in a visually intuitive manner.
- Provide access to data analytics tools for optimisation, data exploration, and uncertainty and sensitivity analysis, so that the actual and simulation data can be explored in new ways.

This functionality will require the development of a platform-independent software environment, which can be deployed on and can access different high-performance computing platforms. In particular, it will:

- Establish agreed simulation model interface standards. These standards will permit (i) model coupling and system-of system simulations and (ii) links to standard datasets in NID and (iii) incorporation of existing models used in academia and industry
- Provide a "DevOps" environment, including a code repository and continuous integration environment to support the development and deployment of validated code within a virtualised environment.
- Provide a user management and access control system to support different user communities, controlling access to software and data subject to data and software licensing.
- Provide a virtualised service so that user can remotely access and interact with their models and data within a tailored, secure managed workspace.
- Provide a loosely coupled orchestration environment for the execution of complex, coupled models and across different resources.
- Provide a set of data analytics tools to support model optimisation, data fusion, multi-model integration for uncertainty and sensitivity analysis during the evaluation and assessment process of models and high dimensional data reduction, clustering, and machine learning approaches for predictions.
- Provide a set of 2D, 3D, and geospatial visualisation tools suited for a range of interactions with the models and the modelling and simulation environment, including web and desktop applications, large scale visualisation facilities (e.g. vis walls), remote and local VR/AR applications.

The facility will be designed to help connect UK researchers to related international data sets and open-source projects (relating to data storage and modelling). Interoperability with global datasets and models will be achieved through the adoption of open standards, such as those published by the Open Geospatial Consortium (OGC), the Open Modelling Interface (Open MI), TimeseriesML for encoding data, and the OGC Catalogue Service for allowing storage and search. Connecting to data repositories such as the World Bank data services could provide a range of global data such as population growth and climate change, while data services such as the CUAHSI hydrological information system would provide data for domain-specific models. The ability to link to selected popular open-source models used internationally will help foster early adoption. Such ability will be subject to on-going reviews, e.g. i.e. new model interfaces will be needed, existing ones will need to change, and some will need to be 'retired', according to the agile project delivery approach (see Facility Delivery section).

Computer hardware

Our review and workshop identified that new computer hardware was not the first priority for UKCRIC universities. The limitation on data and data/model interoperability that NIDMSVF seeks to address is now regarded as the primary research obstacle. However, infrastructure systems modellers are already using HPC facilities and we anticipate that by unleashing the potential of shared datasets and model coupling, new computational requirements will arise. Therefore, the investment programme for NIDMSVF includes:

1. A process for specifying and procuring new centralised computational hardware at STFC to accompany the implementation of NIDMSVF.
2. Smaller targeted investments in UKCRIC institutions to enable more efficient use of the centralised facilities. Examples of such investments include:
    - Multiple screen video walls to display visualisations.
    - Local storage to cache local copies of parts of the NID (subject to satisfactory security arrangements) and buffer IO operations.

The precise allocation of these facilities will be decided during the design process. Funds will be allocated according to the governance process set out below.

Analogous facilities

Various analogous facilities exist in different disciplines and have become mainstays of the national research infrastructure:

- JASMIN (funded by NERC) provides the UK and European climate and earth-system science communities with an efficient data analysis environment. JASMIN provides new ways for scientists to collaborate in self-managing group workspaces, enabling models and algorithms to be evaluated alongside curated archive data, and for data to be shared and evaluated before being deposited in the permanent archive. The JASMIN infrastructure is hosted at the STFC Rutherford Appleton Laboratory has developed over a series of stages since Autumn 2011.
- The National Chemical Database Service (NCSS funded by EPSRC) brings together tools and resources for UK researchers in chemistry and related fields. All web-based services are freely accessible from any UK academic network.
- The Mantid project provides a software framework to manipulate, analyse, and visualise neutron science data. It was started by STFC and it has been extended to enable large scale analysis of materials data and interactive visualisation with High Performance Computing (HPC) capabilities visualisation of materials science data. Mantid has been created to manipulate and analyse Neutron and Muon scattering data, but could be applied to many other techniques.
- The National Service for Computational Chemistry Software (NSCCS) bring together software tools, computational resources, and training programme to support UK academics working across all fields of molecular sciences. Its infrastructure is also hosted at RAL by the STFC Scientific Computing Department.
- The Consumer Data Research Centre (funded by ESRC) works with consumer-related organisations to open up their data resources and make them flexibly available to trusted researchers.

Each of these facilities has a rather different focus to the NIDMSVF, but they are all examples of the benefits of shared and carefully curated datasets, coupled with appropriate computational resources.

3. Research programme

Current infrastructure and cities research initiatives that would benefit from NIDMSVF

Data analytics, modelling and simulation are central to infrastructure and cities research. These are fields in which the UK has globally leading expertise, supported by an extensive portfolio of EPSRC funded research. In Appendix 2 we list selected infrastructure modelling research projects from across UKCRIC, with a total value of £89million that would benefit from NIDMSVF. It is estimated that more than 80 academics and over £150 million of current research funding that will make use of the NIDMSVF. The projects listed in the Appendix are diverse, including:

- Simulation of flows on networks (electricity, gas, water, traffic)
- Complex topological network analysis
- Simulation of the performance/deterioration of infrastructure assets
- Modelling of spatial environmental phenomena (e.g. floods, water resource systems)
- Agent-based modelling and information on socio-economic activity
- Big data analysis of use of infrastructure systems e.g. from smart meters or in-vehicle sensing
- Spatial data analytics

- Optimisation and uncertainty analysis
- Strategic infrastructure decision analysis

These fields have progressed rapidly in recent years. However, we observe a number of limits on our research capability:

- There are computational limits to our ability to simulate and optimise large complex systems.
- Interpretation of the results of complex simulations is challenging, but can be assisted by visualisation facilities.
- High quality datasets of infrastructure systems and their performance to parameterise and validate models are rare and time-consuming to obtain.
- Coupling of models for system-of-systems analysis is very time-consuming because of a lack of agreed interfaces and protocols.

The NIDMSVF aims to address these research challenges. By doing so we foresee the UK consolidating its leading position in national infrastructure modelling and simulation by establishing a globally recognised facility.

The design and delivery process for the NIDMSVF that is described below aims to engage these researchers (though their representation in UKCRIC) in the NIDMSVF from the outset. We foresee existing modelling and simulation activities gradually migrating to NIDMSVF as its functionality develops. Accumulation of datasets and inter-operable models will progressively add to the benefits of making use of the NIDMSVF. In other words, there will be increasing returns to participation and the NIDMSVF becomes increasingly populated.

Future research programme

The research programme for the NIDMSVF aims to develop a distinctive new infrastructure systems modelling capability that will be unique to the UK. As the projects listed in the Appendix indicate, there is already a great diversity of infrastructure systems modelling taking place in the UK. Similar diversity of activity can be seen around the world. However, none of these activities has achieved the degree of systems integration or the robust linkages with national infrastructure data that we are seeking to achieve with the NIDMSVF. We know of no other country internationally that is yet in a position to establish such a facility or conduct a research programme using it.

There are four themes within the future research programme:

Research Theme 1: Complex systems modelling and simulation

The NIDMSVF will provide the capability required for a new generation of modelling and simulation of complex infrastructure and city systems. Much of that complexity arises from interactions between interdependent infrastructure networks, and between infrastructure networks, people and the environment. Models of some of these interactions already exist (for example in transport simulation models and hydro-economic models). However, we recognise a much more complex range of interactions that have not yet been simulated at scale. The NIDMSVF will enable this new research theme by (i) clarifying the interfaces between interacting modelling components (hence enabling system-of-systems simulation) and (ii) by accessing computational resources that are customised for this class of simulations (e.g. GPUs). Appendix 2 describes an existing use case in coupled model simulation and explains how that process could be enhanced by the NIDMSVF.

Research Theme 2: Data assimilation, model calibration and validation

The absence of extensive and dependable datasets has been a perennial limitation for infrastructure systems modelling. Meanwhile, many new datasets are materialising, for example from sensor networks and crowd sourcing, as well as from utilities that have progressively improved their asset management and fault reporting datasets. By populating the NID and then linking it with modelling in the MSVF we will enable a significant step in the calibration and validation of simulation models. A particular opportunity lies in the assimilation of sensor information and other observations into simulation models. Once the potential of the NID and MSVF has been recognised, we foresee major research proposals that will seek to take up these new opportunities for improving the quality of models and forecasts.

Research Theme 3: System optimisation and uncertainty analysis

Infrastructure system models are characterised by high dimensionality and often also multiple decision objectives. They are often also characterised by deep uncertainty in critical variables (e.g. population growth, price elasticity, the frequency of extreme events etc.). Thus the responsible use of these models involves extensive uncertainty and sensitivity analysis. The NIDMSVF will provide new capability for uncertainty and sensitivity analysis, by combining new general-purpose tools with underlying hardware that is optimised for that purpose. This will therefore enable new insights to be revealed about system behaviour. Similar sampling arrangements involved in system optimisation – for example optimisation of the design variables in a system. By enabling efficient use of appropriate computational facilities, the NIDMSVF will enable a step change in the scale of optimisation problems that can be addressed by UK infrastructure systems researchers.

Research Theme 4: Visual analytics and decision support

Research Themes 1-3 will all yield more complex simulation datasets that, whose interpretation will be enhanced through the use of advanced visualisation facilities. Some of these facilities will be built as part of the delivery of the NIDMSVF, but we foresee continued innovation in the use of visual analytics. There are particular opportunities in the fusion of simulation results with the infrastructure and geospatial datasets in the NID. Meanwhile, there is growing applied interest in government and business in the use of simulation modelling and big data analytics to inform the design and operation of infrastructure systems. We foresee the possibility of a growing use of the NIDMSVF by business and government to address their most challenging simulation and analytical problems. Using visual analytics to engage with these people is a research topic in its own right, which will form part of projects in Research Theme 4. Links will be established with the Decision Theatre investments in UKCRIC which are part of Newcastle University's Urban Sciences Building, to support public, industry and government engagement and engineering decision-making using research from the new UKCRIC facilities.

We anticipate that there will already be an active community of users before the operational release of NIDMSVF, who will be used in piloting and testing. We aim to have more than 20 groups using the NIDMSVF within 5 years of the operational release. The NIDMSVF is intended to have a catalytic effect on researchers, opening up data analytic and simulation possibilities that were not previously considered to be possible.

Contribution to the overall science and business case for UKCRIC

The science and business case for UKCRIC has the NIDMSVF as one of three essential strands in delivery of facilities to solve major infrastructure problems (see Figure 1). The case for modelling, simulation and visualisation is compelling, from both research and applied perspectives. Computer modelling and simulation is absolutely central to advanced research on infrastructure systems. With very few exceptions, every research project on infrastructure involves some element of modelling/simulation. For the time

being, this research has been based on university computational facilities for the most part, though some collaborative modelling and database facilities are demonstrating the added value of a collaborative approach. This comes at a time when the potential for exploiting new big databases and distributed computing facilities is increasingly recognised. The UKCRIC science case recognises the step change that could be achieved in research and industry that dedicated national facilities for infrastructure data, modelling, simulation and visualisation could provide.

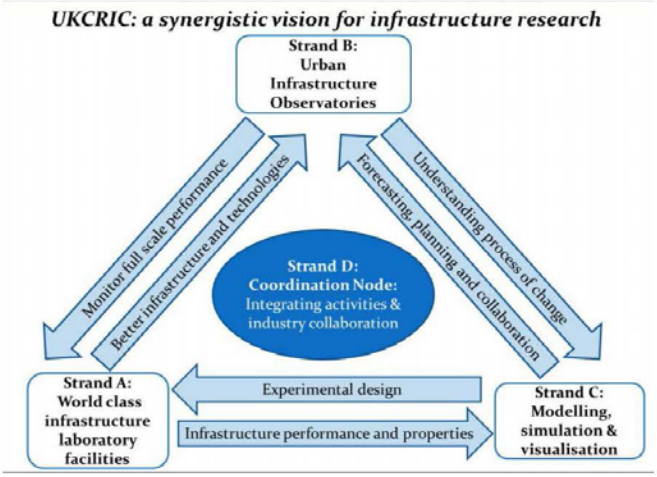


Figure 1 Overview of the UKCRIC structure

The UKCRIC business case referred to "£8M investment in nationally-coordinated database, modelling, simulation, visualisation and big data facilities, centred around a series of advanced hardware hubs. Drawing on data from strands A & B, the facilities will enable unprecedented understanding of complex cities and infrastructures to inform planning, design and management. Coupled with better data from sensors and the urban observatories outlined above this investment will produce more rapid and more reliable predictions of the impact of options in infrastructure investment across and between all infrastructure sectors; it builds on a considerable investment already made by RCUK in modelling tools and expertise, and accelerates the exploitation of that expertise into commercial organisations; this will enable further de-risking of all large scale infrastructure investments." This rationale still holds. However, in the light of consultation and identification of research needs (see Section 4), emphasis has shifted from "advanced hardware hubs" to provision of an e-science system. Hardware still forms part of the NIDMSVF programme, but is primarily aimed at facilitating local use of the e-science system e.g. through visualisation hardware and local data caching. Furthermore, some strategic hardware investments will help to leverage major planned investments in national computational facilities.

4. Facility delivery

Delivery partner

NIDMSVF will be based at the Rutherford Appleton Laboratory (RAL), Oxfordshire, managed by STFC Scientific Computing Department (SCD) and supported by the JASMIN infrastructure team. This will allow

the UKCRIC consortium i) to maximally benefit and leverage the significant[3] scientific and technical track record and expertise of STFC in delivering large scale research infrastructure for the UK and international collaborations; ii) to leverage the established delivery records of STFC using capital money to deliver infrastructure assets to government organisations and international science programmes, including BEIS (formerly BIS)[4]; and iii) to exploit and benefit from mature data, compute, and infrastructure assets[5] that will provide significant added value to NIDMSVF; significant software expertise and mature service delivery and procurement processes[6] already invested by other research councils, large science initiatives and STFC. The development of the central NIDMSVF will be strongly collaborative and multidisciplinary in nature to ensure fruitful interactions and cross-fertilisation co-development activities between UKCRIC university based and STFC based teams. See "Project Management" section for further details.

To enhance the ongoing benefits of the central capabilities of NIDMSVF, a small number of local NIDMSVF hardware investments will be made in the UKCRIC institutions to support data caching, storage and visualisation capabilities. STFC will also assist in the specification of these university facilities, which will be procured according to the process set out below.

Governance arrangements

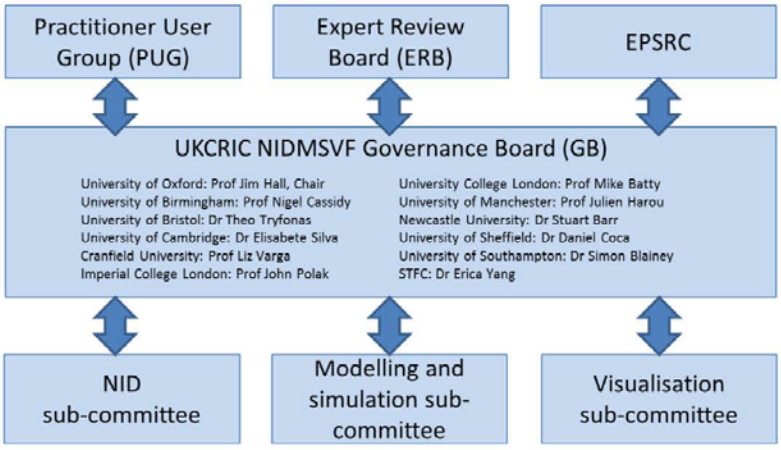


Figure 2 NIDMSVF governance structure

Overall responsibility for the governance of the NIDMSVF will be the responsibility of the Governance Board (GB), which includes all of the UKCRIC institutions who have nominate representatives:

1. University of Oxford: Prof Jim Hall, Chair
2. University of Birmingham: Prof Nigel Cassidy

[3] In the current financial year, STFC Scientific Computing Department (SCD) is responsible for delivering a significant spectrum of software and hardware infrastructure programme of work to EPSRC, MRC, BBSRC, NERC, and STFC's own facility programme, with a total of 70+ FTEs funded people resources. This is in addition to a large portfolio of R&D contracts of SCD, delivering for the EC, and other STFC science programmes.
[4] See "Appendix: STFC Track Records" for further details.
[5] e.g. £14m JASMIN "super-data-cluster" at RAL for UK and European environment datasets and models, since 2011; earth observation data from Europe's Copernicus programme comprising of historical and real time satellite data from 60+ satellites; co-location of JASMIN-CEMS commercial data hub, hosted by Satellite Application Catapult at RAL; 10GB/s fibre links available to RAL Data Centre managed by STFC
[6] e.g. STFC ISIS led Mantid software development, £1m/year, since 2007; STFC Scientific Computing led: i) CCP software service delivery to EPSRC: £2.25m/year 2016-2021, since 1996; ii) 20+ FTEs/year software and infrastructure service delivery to GridPP + annual hardware procurement, 15+ years, since 2001; iii) 20+ FTEs/year to STFC facility computing programme for large facilities, 15+ years, since 2001.

3. University of Bristol: Dr Theo Tryfonas
4. University of Cambridge: Dr Elisabete Silva
5. Cranfield University: Prof Liz Varga
6. Imperial College London: Prof John Polak
7. University College London: Prof Mike Batty
8. University of Manchester: Prof Julien Harou
9. Newcastle University: Dr Stuart Barr
10. University of Sheffield: Prof Daniel Coca
11. University of Southampton: Dr Simon Blainey

Along with STFC represented by Dr Erica Yang.

Sub-committees will be nominated with responsibilities for the (i) National Infrastructure Database, (ii) the Modelling and Simulation platform and (iii) the visualisation facilities. These committees are responsible for a) requirement coordination and validation; b) content and data sourcing, provisioning, and validation; c) software and infrastructure delivery; d) pilot research activities for providing new requirements and validating ongoing construction of the facilities; and e) delivery of the pilot demonstrations to UKCRIC key stakeholders, e.g. engineering consultancies, government agencies, and wider UK academic communities.

A Practitioner User Group (PUG) will be convened to represent the interests of end users in government and business. The PUG will advise the GB regarding their potential use of the facilities, data provision and security arrangements. We have engaged with government and business in the conception of the NIDMSVF. These organisations are already involved in many of the research projects that would make use of NIDMSVF in future, so are familiar with the use opportunities presented of simulation modelling and data analytics which will provide them with the capability to conduct analyses that they did not previously think possible. An example is the use of the data and models for policy decision support and evaluation as part of the CECAN centre for complex policy evaluation. It will also provide a new focal point for collaboration between researchers, industry and government.

An External Review Board (ERB) will be appointed to review the project at each project phase (requirements, design, implementation, verification). The ERB will be made up of individuals with experience of delivering ambitious e-science projects (Open Data Institute, Ordnance Survey, Alan Turing Institute, Institute for Environmental Analytics, EIDC etc.)

Intellectual property

Intellectual property will jointly reside with the participating institutions represented in the GB. The UKCRIC collaboration agreement sets out standard arrangements for identification and exploitation of IP. A bespoke version of the UKCRIC collaboration agreement will be developed to cover the particular characteristics of the NIDMSVF.

The platform software will be open source, subject to a liberal licence. The MSVF platform architectural design will be open and flexible to maximally accommodate both open source and proprietary software packages.

Project management

The project management structure for the NIDMSVF is illustrated in Figure 3.

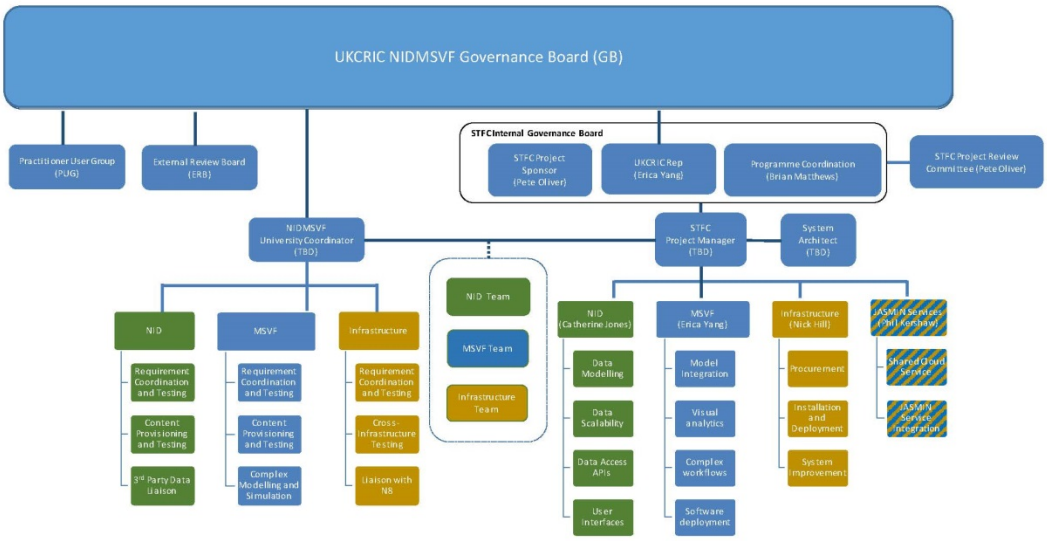


Figure 3 Project management structure for NIDMSVF

Within STFC, the project will be steered by an **Internal Project Board,** overseeing the direction of the project within STFC, considering resourcing and technical solutions, and links to the wider activities of STFC. The project within STFC will be managed on a daily basis by a dedicated **Project Manager**, who will direct the progress of work, working with a Systems Architect, responsible for the overall design and integration of the MDMSVF. The execution of the project will be divided between four teams representing the subprojects: the NID team; the MSVF team; the Infrastructure team; and the JASMIN team. The overall work of the STFC team project will be monitored by the standing **STFC Project Review Committee**, which will ensure conformance to STFC's project management standard handbook.

Outside of STFC, the board will appoint a **Coordinator** for the teams based within the universities, with teams established to contribute to the NID, MSVF and Infrastructure work. The Coordinator and Project Manager will work together to ensure that the university and STFC based teams integrate together, with joint processes and meetings within each sub-project, and coordination across the subprojects. The JASMIN team contributes to all three of the subprojects, and will participate in all the other three teams.

Delivery Methodology

The UKCRIC consortium operates in a fast moving research landscape. It is important to balance the challenging needs to i) demonstrate the competitive capabilities evolving from the developing facilities throughout the five-year programme; ii) respond to the evolving research and stakeholder engagement needs of the UKCRIC consortium; iii) ensure the maturity of these facilities at the end of the programme. Recognising these needs, our delivery methodology for the NIDMSVF facilities comprises of the following *delivery principles*.

- **A community driven, use-case based co-development approach** will be used to develop the maturity of the facilities with UKCRIC partners, key stakeholders in research, government, and industry.
- **An asset driven construction approach** will be built into the entire programme: processes and procedures will be in place to explicitly capture and develop tangible and accountable assets, including NIDMSVF software, hardware, use cases, datasets, models, pilots and demonstrations, that underpin the ongoing and future sustainability of NIDMSVF.
- **An integrated system approach** will be embedded in the delivery process to enable a national focal point at scale for the co-existence of critical infrastructure data (NID), modelling and simulation computational capabilities, and visualisation facilities, maximising the opportunity to demonstrate the collective capabilities and benefits of NIDMSVF.

As the use cases become mature and the expansion of the use cases responding to the needs of the UKCRIC community and external technological, economic, and societal stimulations, the maturity of UKCRIC NIDMSVF facilities continues to grow. An illustration of our agile delivery approach is depicted in the following schematic diagram.

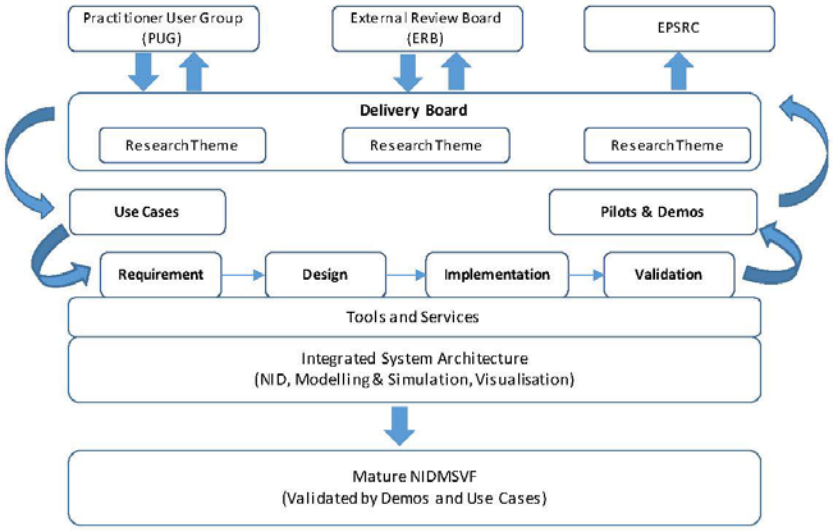


Figure 4 The NIDMSVF delivery methodology

The basic structure of our delivery plan is framed around four *logical* phases: requirement gathering, design, implementation, and verification. The ongoing progression of the phases, especially use case scoping and refinement, will be driven by the NIDMSVF delivery board based on a competitive selection process. These will take into account ongoing inputs from the UKCRIC partners throughout the project, i.e. the research theme leaders, and key stakeholders, including the Practitioner User Group (PUG) and External Review Board (ERB) (see Governance). The aim is to not only progressively improving the maturity of the delivery but also maximising the research competitiveness of the offerings and the attractiveness of these facilities. These will ensure the embedding of long term sustainability of our facilities beyond the completion of the funding period from early on of the project and on an ongoing basis.

The ultimate outcomes from the delivery process are production-ready mature software tools and accompanying hardware to underpin the delivery of NIDMSVF facilities to the UKCRIC communities and key stakeholders for the nation. The tools and services will be tested and validated by the use cases along with a critical mass of industry critical and/or society relevant pilots and demonstrations for delivering impacts throughout the project. All these will be used to facilitate and augment research dissemination, project communication, public engagement activities for the UKCRIC community. Also we anticipate that they will form a collection of tangible assets strengthening our core offerings to a wide range of industry and research communities, allowing UKCRIC to attract and leverage further investments via our existing networks and relevant stakeholders.

NIDMSVF Components

As illustrated in Figure 3, NIDMSVF components can be logically grouped into three parts: NID Facility, MSVF Facility, and NIDMSVF Hardware Infrastructure. For the detailed resources required to deliver these, see the section on "Justification of Resources" which details the roles and costs required for the delivery programme.

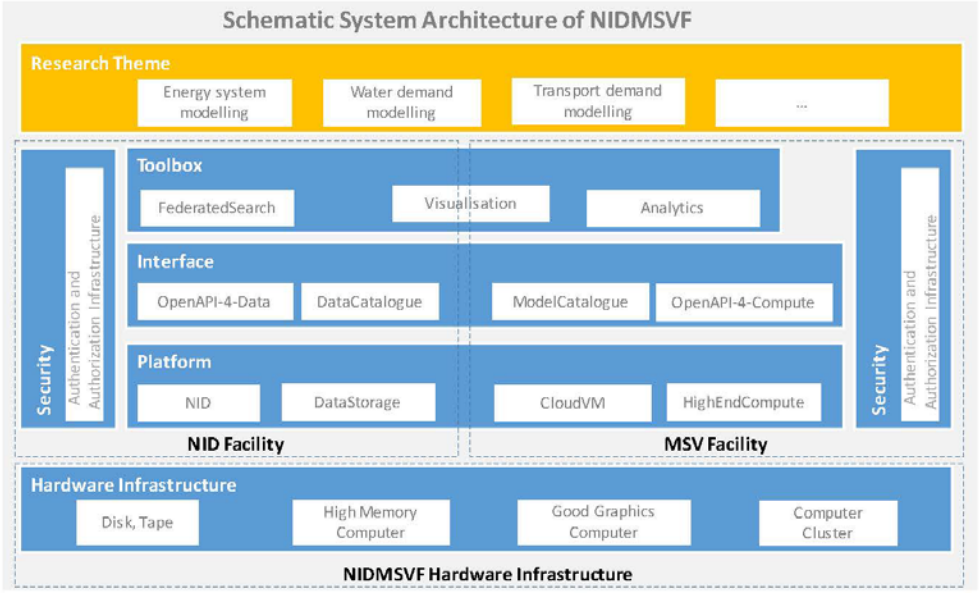


Figure 5 Overview of NIDMSVF components

NIDMSVF offers researchers three types of secure access to integrated NIDMSVF platform, including i) access via NIDMSVF interface layer; ii) access via NIDMSVF toolbox layer; and iii) direct access to integrated data and computation capabilities.

The NIDMSVF system comprises of five dependent layers, starting from "Hardware Layer" that underpins the entire facility, to three software layers - "Platform Layer", "Interface Layer", "Toolbox Layer", then, an abstraction layer representing researchers' usage of NIDMSVF – "Research Theme Layer". The system also has a cross-cutting "Security" layer which offers software capabilities to safeguard the software layers. The "Hardware Layer", i.e. computers, data centre, is protected by physical security mechanisms.

NIDMSVF-Security is a software system for providing user identity and access control management, namely Authentication and Authorization Infrastructure (AAI), for accessing data, compute capabilities (e.g. private and collaboration work space, and HPC job farms), and software packages available on NIDMSVF. It offers different types of security controls (e.g. identity-based, role-based, location-based) to these resources.

National Infrastructure Database (NID) stores detailed spatial-temporal data, information and knowledge on infrastructure assets. Based on NISMOD-DB, NID will become an integral part of NIDMSVF integrated and augmented with all other components, e.g. NIDMSVF-Security and NIDMSVF-Catalogue, NIDMSVF-OpenInterface, and NIDMSVF-ComputePlatform.

NIDMSVF-CloudVM is a flexible workspace management software layer built around virtual machine technologies to offer standalone or shared secure workspace on self-contained virtual machines that are directly connected to NID data resources. It will allow researchers to leverage interconnectivity between co-located NID and MSVF platforms to perform complex modelling and simulation tasks across a variety of datasets, and modelling and simulation packages. This will follow the JASMIN cloud model.

NIDMSVF-DataStorage is a software and hardware component for highly available hierarchical data storage solutions, e.g. using disk and tape. It integrates with NIDMSVF-Catalogue and is primarily for datasets that do not naturally fit into NID, for example, 3D BIM models for highways, point cloud laser scans for railways.

NIDMSVF-HighEndCompute is a collection of high end computing resources built upon NIDMSVF-foundation to offer access to flexible advanced processing capabilities, e.g. high performance computing on high memory nodes; large shared memory compute clusters (e.g. for MPI-based HPC codes); high throughput parallel processing capabilities based on Apache Hadoop for map-reduced jobs or real-time stream processing based on Apache SPARK; and machine learning libraries available through these high end compute resources, e.g. NVIDIA GPU based deep learning libraries for modelling and simulations.

NIDMSVF-DataCatalogue is a cataloguing software tool for managing and presenting the metadata of datasets, available on NIDMSVF. This interacts with NIDMSVF-OpenAPIs to support users to manage and browse the data. This also includes processed data from running the models. It will be built around NISMOD-DB.

NIDMSVF-ModelCatalogue is a cataloguing software tool for managing and presenting the models and their metadata available on NIDMSVF. This interacts with NIDMSVF-OpenAPIs to support users to manage and browse the models.

NIDMSVF-OpenAPI-4-Data is a software component for implementing low level Application Programming Interfaces (APIs) to allow systematic ingestion, uploading, downloading of third-party data, into NID. This could also be the processed data generated on NIDMSVF-CloudVM and NIDMSVF-HighEndCompute through running a model or compare multiple models.

NIDMSVF-OpenAPI-4-Compute is a software component for implementing low level Application Programming Interfaces (APIs) to allow systematic integration of software with MSVF compute resources, e.g. NIDMSVF-HighEndCompute to enable the software to be augmented with HPC processing capabilities and HPC software packages, e.g. machine learning libraries running on a GPU cluster for high dimensional data reduction or anomaly detection for network analysis.

NIDMSVF-FederatedSearch is a software component built upon NIDMSVF-OpenInterface and NIDMSVF-Catalogue to enable FedeatedSearch across NID and other analogous infrastructure data facilities, including CDRC funded by ESRC and BADC/JASMIN funded by NERC.

NIDMSVF-Visualisation is a collection of software components built around NID, extending capabilities of NISMOD-DB Visualisation Engines for NISMOD-LP and NISMOD-RV, for network analysis, map-based visualisation for spatial-temporal data and including new functionalities to enable visual analytics methods for data exploration and model developments, especially relevant to "what-if" scenarios in complex system-of-systems modelling tasks.

NIDMSVF-Analytics is a collection of software libraries offering algorithms for high dimensional data reduction, uncertainty quantification, for example, to enable modelling and simulation tasks that require the integration of datasets and models across multiple domains, scenarios, and modelling methods.

It is worth highlighting that NIDMSVF-CloudVM and NIDMSVF-HighEndCompute will offer computation capabilities for NIDMSVF with seamless integration with data and security management features. For example, datasets that are available to a user group on a shared VM offered through NIDMSVF-CloudVM will, by default, have the same access control permission on NIDMSVF-HighEndCompute.

Delivery Plan

The delivery plan represents a balance between:

- the need to proceed from the specification of the NIDMSVF as described in this document to a more precise scope and specification before detailed funding allocation decisions are made; and, on the other hand
- the desire to adopt an 'agile' approach to software development that obtains early feedback from users and yields rapid prototypes for testing and use.

We propose to strike this balance by going through a thorough Requirements and Design process during Year 1 (2017-18) before switching to a more agile mode for project delivery.

Phase 1: Requirements

Initial requirements for the NIDMSVF have been identified through consultation with potential users, and are outlined in this document. User requirements will be established over a period of 6 months from project approval, involving consultation with:

- UKCRIC university partners
- Other university partners who have expressed an interest in the NIDMSVF
- Potential end-users in government and business
- Data providers e.g. Ordnance Survey
- Analogous facilities, such as JASMIN, MANTID and CDRC
- Initiatives with experience of interface development, such as ODI

The consultation and requirements process will be overseen by the NIDMSVF Governance Board (see Governance) and will be led by STFC.

We anticipate monthly meetings throughout the period, along with meetings with use case oriented specialist sub-groups, comprising of researchers, stakeholders, data and technology specialists. Over this period, new versions of the requirements document will be issued initially every quarterly and the frequency will be reviewed by the Board regularly.

These consultations will lead to a requirements specification covering:

1. Initial inventory of data types and formats (noting that new datasets will be assembled during the development process).
2. Data storage requirements.
3. Initial inventory of simulation models (noting that new models will be identified during the development process), including input-output formats and computational requirements. Prioritisation and phasing of models to be made compliant with NIDMSVF.

4. Visualisation requirements and mock-ups
5. Hardware requirements (storage, computation, visualisation), including an audit of computer hardware facilities at UKCRIC partners and gap analysis.
6. Management of multiple users and arrangements for allocating resources (e.g. security, storage, computational facilities)
7. Security arrangements
8. Use cases

The user requirements will continue to evolve during the design phase and during implementation. Nonetheless, the initial requirements document is an important milestone to further refine understanding of the scope and nature of the NIDMSVF.

This will be accompanied by protocols dealing with:

- Licencing arrangements
- Intellectual property
- Operation and maintenance costs and cost recovery (for university, government and business partners)

Phase 2: Design

The design of the NIDMSVF will take place over the subsequent 6 months. STFC will be responsible for production of design documentation, which after 4 months will be submitted to the NIDMSVF Delivery Board. Further consultation will be carried out with UKCRIC institutions and business/government partners. A final version will be developed incorporating revisions agreed with the NIDMSVF Governance Board, following advice from the External Review Board. This will incorporate a thorough prioritisation for implementation.

During the design phase, an initial set of models and datasets prioritised for NIDMSVF will be assembled. Model codes for one or multiple models, will be gathered from the university partners into the central code repository and the datasets will be made available in the NID. Preliminary testing will be performed by the design team, including where possible, a set of standard tests will be established for each model and tested on the initial NIDMSVF test environment (e.g. using STFC existing computing facilities).

The database, e-science software and visualisation design will be accompanied by specification of necessary phased hardware investments. Hardware priorities in each participating institution will be agreed and quotes will be obtained from competing vendors to ensure value for money (see the Procurement approach).

Phase 3: Implementation

Following the requirements and design phase, a more 'agile' approach to implementation will be adopted, in which priority functionality identified during the Design Phase will be rapidly prototyped and trialled with users to enable rapid feedback and refinement. Key functionality is as follows:

National infrastructure database:

- security and licence arrangements
- Implement the database schemas
- Populate the database with existing infrastructure datasets
- Assemble infrastructure data from partner organisations

- Check and clean data. Where necessary develop tools for traceable data cleaning e.g. construction of topological networks

Modelling and simulation platform:

- Establish code repository
- Establish agreed model interfaces.
- Establish arrangements for model coupling
- Establish generic optimisation, uncertainty and sensitivity analysis utilities
- Develop utilities to implement modules on distributed computing facilities
- Migrate all candidate models to platform.
- Propose future-proof technologies, frameworks (e.g. GPU and deep learning), and methodologies to maximise the future success of UKCRIC
- Propose technological underpinnings and measures to maximise the impacts of UKCRIC

Visualisation facilities:

- Network visualisation
- High resolution rendering of remote sensed and mapping data
- Visualisation of multi-objective optimisation, uncertainty and sensitivity analysis
- Animations and simulations
- Building and city information

Phase 4: Verification

Verification tests will be established at the design phase and will include:

Database:

- Input/output
- Security
- Interfacing between the database and simulation models
- Verification against partner datasets

Modelling and simulation:

- Testing with large numbers of simulations with pilot models
- Verification of optimisation tools
- Testing model coupling

Visualisation:

- Testing on different visualisation facilities in partner institutions
- Testing with end user partners

Operational phase

See Section 8.

Deliverables and Release Cycles

An initial set of release cycles for NIDMSVF components have been discussed and is presented below for reference. It will be subject to further discussion ad reviewed by the partners once the project starts.

NIDMSVF Component / Release (by project month)	Security	Disk, Tape	High Memory Computer	Good Graphics Computer	CPU, GPU Cluster	NID	DataStorage	CloudVM	HighEndCompute	OpenAPI-4-Data	DataCatalogue	ModelCatalogue	OpenAPI-4-Compute	FederatedSearch	Visualisation	Analytics
NIDMSVF-m6																
NIDMSVF-m12		V1	V1			V1									V1	
NIDMSVF-m18	V1							V1								
NIDMSVF-m24		V2	V2	V1	V1	V2	V1		V1						V2	
NIDMSVF-m30	V2							V2		V1						
NIDMSVF-m36		V3	V3	V2	V2	V3	V2		V2	V2	V1	V1	V1	V1	V3	V1
NIDMSVF-m42								V3								
NIDMSVF-m48						V4			V3		V2	V2		V2	V4	V2

Procurement Approach

The proposed costs have been established based on the estimates set out in the Justification of Resources, where a cost itemisation for the NIDMSVF is provided. For software engineering costs these are based on estimates of the staff time involved in delivery of the system, based on experience with similar systems that have been delivered by STFC, such as JASMIN. For hardware costs, the estimates are based on supplier quotes and recent analogous purchases in the partner institutions.

The software and hardware costs will be refined during the requirements and design phases of the project, as the scope of the system and hardware requirements become clearer. At this time, further cost estimates will be established, always subject to the overall capital cost ceiling of £8million. The cost estimates will be overseen by the Governance Board and subject to review by the External Review Board, and EPSRC if required. To enable the Requirements and Design Phases, an initial funding release will be made to STFC, to cover the costs for Year 1 of the programme.

Before the end of Year 1, competitive tenders will be received for hardware investments in the UKCRIC partner institutions. A collective approach to hardware procurement will, as far as possible, be adopted to enable the most competitive pricing. Hardware procurement will be managed by STFC and comply to the well-established and traceable processes of STFC, in conjunction with UKSBS. Competitive quotes will be obtained for all hardware purchases, in response to detailed tender documents issued by STFC, subject to scrutiny by ERB and STFC internal review. We will also seek to identify synergies across the various partner institutions so that equipment can be used on multiple projects.

Also before the end of Year 1, the Year 2 expenditure and an update of the expenditure profile for Years 3 and 4 will be agreed with STFC, the External Review Board and EPSRC.

Staged payments will be made subject to satisfactory progress through each of the project phases. Beyond Phase 1 (the requirements phase) funds will be released subject to verified completion of agreed requirements. The flexible and sequential approach will minimize the risk of overspend. Periodic review will be provided by the ERB.

STFC is dedicated to achieving value for money in all of its procurement projects. It is highly experienced in the procurement of large and technically complex infrastructure and works closely with UKSBS to drive value by compliant procedures.

For the UKCRIC project STFC will work with its University partners to procure hardware which is, as much as is possible, industry standard and compatible with associated groups including JASMIN. All procurements will be openly competed to optimise price and full life cost will be taken into consideration within offer evaluations. Where product is available on government frameworks (and where those frameworks offer best value) mini tenders will be undertaken. If wider market competition is deemed to offer better value then tenders will be undertaken via OJEU or, depending on value, by way of the Government Contract Finder tool. All procurements will be undertaken to fully adhere to Government Procurement Regulations and will follow best practise methodologies set by the BEIS Commercial Group.

Procurement undertaken by STFC and its partners for the UKCRIC project will NOT incur any "mark up" or subsidy on the procurement element and pricing / costs will be fully transparent within the project. EPSRC and or other key stakeholders are invited and encouraged to join any or all procurement evaluation panels so as to be fully involved in the process.

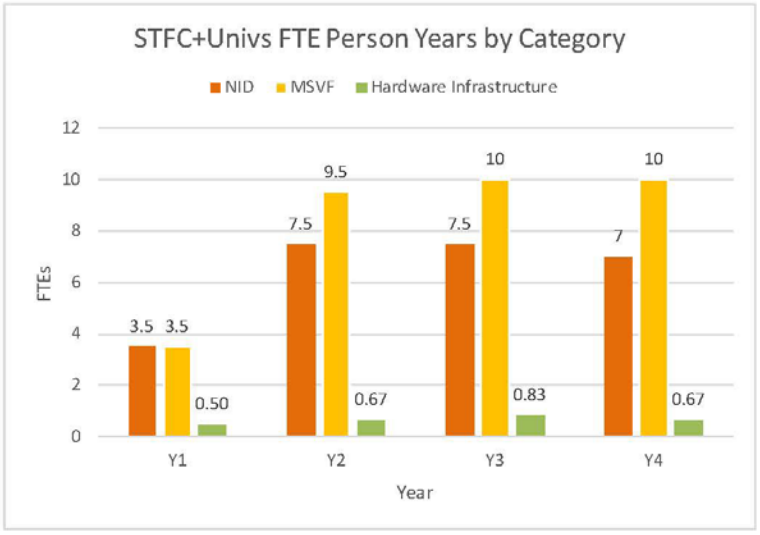


Figure 6: Full-Time Equivalents (FTEs) person years by category

The above figure shows the overall spending profile of total FTE person years, including STFC based staff efforts and university in-kind staff effort contributions, on developing NIDMSVF software and hardware infrastructure, split by three spending categories, i.e. NID, MSVF, and hardware infrastructure, throughout the 4-year programme. Note that the university in-kind contributions are estimated to be an average of 5 PDRAs/year across the five-year period.

Risk Management

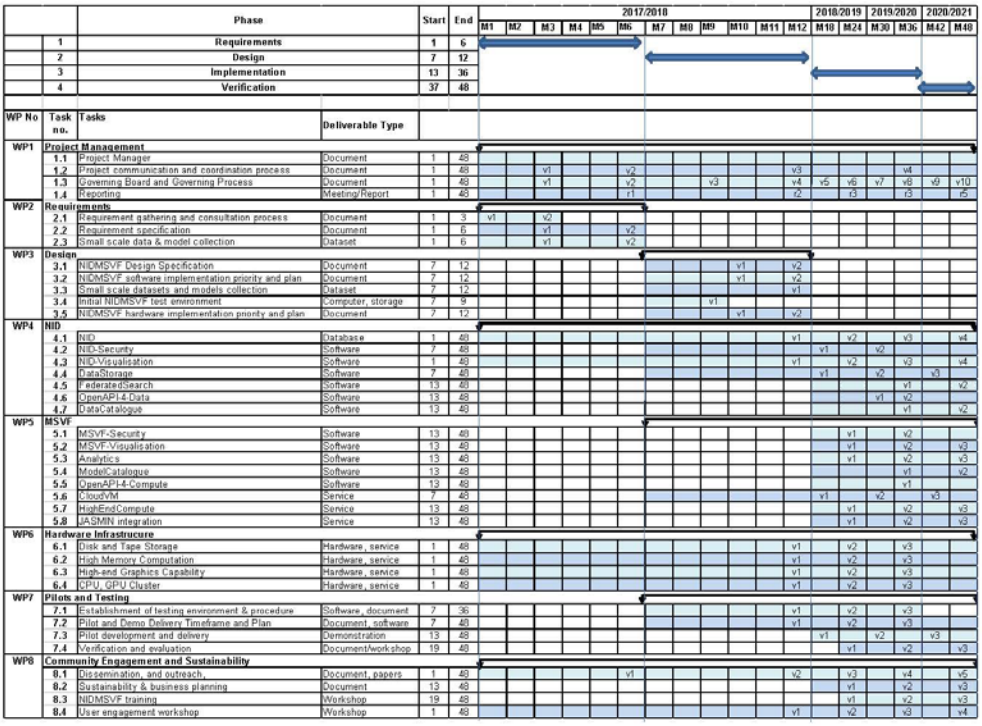
Risk	Severity (likelihood and consequence)	Risk management
Database cannot cope with the	L	The research community already has experience of dealing

heterogeneity of infrastructure data types		with heterogeneous datasets of varying quality. The diversity of data formats will be established during the requirements phase
Insufficient datasets are uploaded to the database for it to become a truly 'national facility'	M	Extensive datasets already held within the UKCRIC partner institutions are ready to be uploaded. Collaboration with the PUG and the ERB will help to access necessary datasets and overcome obstacles.
Security concerns inhibit participation by key data providers	H	Early consultation with the PUG and ERB will address security concerns and establish requirements for system design.
Diversity of model platforms inhibits interoperability	L	Virtualization (e.g. Docker) provides platform interoperability, though at the cost of some computational overhead
Benefits of using a national system do not outweigh overheads of not running models locally	M	Some of the most challenging research opportunities lie in understanding and simulating the interactions between systems from a 'system of systems' perspective. The aim of NIDMSVF is to reduce the barriers to entry for this type of research.
Computational capacity is not sufficient to cope with demands	L	All UKCRIC institutions have on-going programmes of hardware investments, along with collective investments e.g. via STFC, ARCHER, N8HPC etc.
Hardware investments duplicate existing facilities in UK universities	L	The NIDMSVF hardware investments will all be reviewed by the GB to ensure that they add value to existing facilities.
Hardware investments are under-utilised	M	We observe rapidly growing computational demands. Provision of the NIDMSVF e-science system will facilitate convenient use of computational hardware, lowering barriers to entry.
Participating universities do not have the staff resources to fully participate in the design and verification process	M	Universities have made significant in-kind commitments to the delivery of NIDMSVF. STFC will provide software engineering support to university teams.
Revenues during the operation phase do not cover operation/maintenance costs	M	Plans for a self-maintenance phase are already under development and will be finalised during Phase 1 of the project delivery. The level of research activity and user interest is commensurate with the required operation and maintenance funding.

Project Plan

An initial set of release cycles for NIDMSVF components have been discussed and is presented below for reference. It will be subject to further discussion ad reviewed by the partners once the project starts.

The work-packages of the project, including their main tasks, sequencing, and release of versions of major deliverables, are given in the following project plan. We relate this plan to the four phases of the project, namely Phase 1 – Requirement, Phase 2 – Design, Phase 3 – Implementation, and Phase 4 – Verification. These phases determine the main milestones of the project, which occur at Months: 6, 12, 36 and 48. Note that this plan is given in greater details for the first 12 months, and then is in outline. We would expect that this plan would be subject to ongoing revision, with the delivery of a detailed annual plan.



		Phase	Start	End	2017/2018												2018/2019				2019/2020		2020/2021	
					M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M18	M24	M30	M36	M42	M48		
	1	Requirements	1	6																				
	2	Design	7	12																				
	3	Implementation	13	36																				
	4	Verification	37	48																				

WP No	Task no.	Tasks	Deliverable Type	Start	End	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M18	M24	M30	M36	M42	M48
WP1	Project Management																						
	1.1	Project Manager	Document	1	48												v3				v4		
	1.2	Project communication and coordination process	Document	1	48			v1			v2							v5	v6	v7	v8	v9	v10
	1.3	Governing Board and Governing Process	Document	1	48			v1			v2			v3			v4						
	1.4	Reporting	Meeting/Report	1	48						r1						r2		r3		r3		r5
WP2	Requirements																						
	2.1	Requirement gathering and consultation process	Document	1	3	v1		v2															
	2.2	Requirement specification	Document	1	6			v1			v2												
	2.3	Small scale data & model collection	Dataset	1	6			v1			v2												
WP3	Design																						
	3.1	NIDMSVF Design Specification	Document	7	12										v1		v2						
	3.2	NIDMSVF software implementation priority and plan	Document	7	12										v1		v2						
	3.3	Small scale datasets and models collection	Dataset	7	12												v1						
	3.4	Initial NIDMSVF test environment	Computer, storage	7	9									v1									
	3.5	NIDMSVF hardware implementation priority and plan	Document	7	12										v1		v2						
WP4	NID																						
	4.1	NID	Database	1	48												v1		v2		v3		v4
	4.2	NID-Security	Software	7	48													v1		v2			
	4.3	NID-Visualisation	Software	1	48												v1		v2		v3		v4
	4.4	DataStorage	Software	7	48													v1		v2		v3	
	4.5	FederatedSearch	Software	13	48																v1		v2
	4.6	OpenAPI-4-Data	Software	13	48															v1	v2		
	4.7	DataCatalogue	Software	13	48																v1		v2
WP5	MSVF																						
	5.1	MSVF-Security	Software	13	48														v1		v2		
	5.2	MSVF-Visualisation	Software	13	48														v1		v2		v3
	5.3	Analytics	Software	13	48														v1		v2		v3
	5.4	ModelCatalogue	Software	13	48																v1		v2
	5.5	OpenAPI-4-Compute	Software	13	48																v1		
	5.6	CloudVM	Service	7	48													v1		v2		v3	
	5.7	HighEndCompute	Service	13	48														v1		v2		v3
	5.8	JASMIN integration	Service	13	48														v1		v2		v3
WP6	Hardware Infrastrucure																						
	6.1	Disk and Tape Storage	Hardware, service	1	48												v1		v2		v3		
	6.2	High Memory Computation	Hardware, service	1	48												v1		v2		v3		
	6.3	High-end Graphics Capability	Hardware, service	1	48												v1		v2		v3		
	6.4	CPU, GPU Cluster	Hardware, service	1	48												v1		v2		v3		
WP7	Pilots and Testing																						
	7.1	Establishment of testing environment & procedure	Software, document	7	36												v1		v2		v3		
	7.2	Pilot and Demo Delivery Timeframe and Plan	Document, software	7	48												v1		v2		v3		
	7.3	Pilot development and delivery	Demonstration	13	48													v1		v2		v3	
	7.4	Verification and evaluation	Document/workshop	19	48														v1		v2		v3
WP8	Community Engagement and Sustainability																						
	8.1	Dissemination, and outreach,	Document, papers	1	48						v1						v2		v3		v4		v5
	8.2	Sustainability & business planning	Document	13	48														v1		v2		v3
	8.3	NIDMSVF training	Workshop	19	48														v1		v2		v3
	8.4	User engagement workshop	Workshop	1	48												v1		v2		v3		v4

Note that each work-task for a component of the project has a frequent release cycle, with an annual major release for each component, with the expectation of more frequent developer releases. This reflects a "release early release often" approach, maximising the opportunity for use input.

Work-packages, tasks and the major deliverables

Workpackage 1	**Project Management**	**M1-M48**	
Description: This workpackage will be responsible for the overall coordination and management of the project. This includes, operating the project strategic governance and executive decision making, operational management, coordination of partners, and project reporting. This workpackage will span all phases of the project.			
Task	**Task Name**	**Description**	**Deliverable**
1.1	Project Manager	Running the project office, and undertaking the daily operational management of the project, setting and monitoring tasks, integration and re-planning.	
1.2	Project communication and coordination process	Setting project standards and processes, including quality assurance, risk management, stakeholder management and internal communications	Project procedures, risk management, quality assurance and communications plans. Established in Phase 1 and reviewed annually.

1.3	Governing Board and Governing Process	Executing the project governance procedures, holding board meetings.	Governance board, including 6 monthly board meetings.
1.4	Reporting	Reporting on project progress to the governing board and other stakeholders, including funders.	Annual report to board and funding bodies.

Workpackage 2	**Requirements**	**M1-M6**	
Description: This workpackage is responsible for the definition of the full requirements for the NIDMSVF through consultation with potential users. These requirements will be established over a period of 6 months from project approval, as phase 1 of the project. The details of this approach are outlined in Section 5: Delivery Plan.			
Task	**Task Name**	**Description**	**Deliverable**
2.1	Requirement gathering and consultation process	Intensive requirements gathering exercise, consulting with UKCRIC partners and other stakeholder groups.	Requirements approach and survey
2.2	Requirement specification	Requirements analysis based on survey results, to form consolidated baseline requirements of the project.	Consolidated requirements.
2.3	Small scale data & model collection	Identification of suitable small scale data sets and models suitable for ongoing testing during implementation phase.	Small scale data & model

Workpackage 3	**Design**	**M7-M12**	
Description: This workpackage is responsible for the definition of the initial detailed design of the through consultation with potential users and taking into account the results of the requirements capture process. These requirements will be established over a period of 6 months in Phase 2 of the project. The details of this approach are outlined in Section 5: Delivery Plan above.			
Task	**Task Name**	**Description**	**Deliverable**
3.1	NIDMSVF Design Specification	Detailed design process for the NID, the MSVF and their integration and use. This includes detailed component and interaction systems for the overall software and hardware infrastructure of NIDMSVF.	Design specification.
3.2	NIDMSVF software implementation priority and plan	Development of a detailed implementation plan giving software technology approaches and design choices, together with prioritisation and	Detailed implementation plan, including detailed description of software development, testing,

		detailed release plan. Establishment of software development and integrated testing process, code repository, and change control procedure	change control and validation procedures
3.3	Small scale datasets and models collection	Identification of suitable small scale data sets and models suitable for ongoing testing during implementation phase. This is a continuation of Task 2.3 above, with more detail.	Small scale data & model
3.4	Initial NIDMSVF test environment	Design and establishment of an initial test environment for the NIDMSVF	Test approach and environment for NIDMSVF
3.5	NIDMSVF hardware implementation priority and plan	Planning for h/w procurement and installation for the project – detailing the hardware delivery plan to support the design specification from Task 3.1	Hardware delivery plan

Workpackage 4	**NID**	**M1-M48**	
Description: This workpackage is responsible for implementation of the National Infrastructure data base. This includes the delivery of the main components as detailed in Section 5: NIDMSVF components; we refer to that section for details of the tasks. This workpackage is primarily within Phase 3: implementation, but continues with a revised version Phase 4 Verification. The workpackage also starts in phase 1 and 2 with an evaluation and installation of the current prototype NID as an initial starting point.			
Task	**Task Name**	**Description**	**Deliverable**
4.1	NID	Development of the core National Infrastructure database.	National Infrastructure database.
4.2	NID-Security	Development of the NID-Security component.	The NID-Security component.
4.3	NID-Visualisation	Development of the NID-Visualisation component.	The NID-Visualisation component.
4.4	DataStorage	Development of the Data Storage component.	The Data Storage component.
4.5	FederatedSearch	Development of the Federated search component.	The Federated search component.
4.6	OpenAPI-4-Data	Development of the OpenAPI-4-Data component.	The OpenAPI-4-Data component.
4.7	DataCatalogue	Development of the Data Catalogue component.	The Data Catalogue component.

Workpackage 5	**MSVF**	**M7-M48**	

Description: This workpackage is responsible for implementation of the UKCRIC Modelling, Simulation and Visualisation Facility. This includes the delivery of the main components as detailed in Section 5: NIDMSVF components; we refer to that section for details of the tasks. This workpackage is primarily within Phase 3: implementation, but continues with a revised version Phase 4 Verification. The workpackage also starts in phase 2 with an evaluation and installation of the JASMIN Cloud VM system so that this component can be established early in the implementation phase as a basis for development and testing.			
Task	**Task Name**	**Description**	**Deliverable**
5.1	MSVF-Security	Development of the MSVF-Security component.	The MSVF-Security component.
5.2	MSVF-Visualisation	Development of the MSVF-Visualisation component.	The MSVF-Visualisation component.
5.3	Analytics	Development of the Analytics component.	The Analytics component.
5.4	ModelCatalogue	Development of the Model catalogue component.	The Model catalogue component.
5.5	OpenAPI-4-Compute	Development of the OPenAPI-4-Compute component.	The OPenAPI-4-Compute component.
5.6	CloudVM	Establishment of the CloudVM service	The CloudVM service
5.7	HighEndCompute	Establishment of the high-end computing service	The high-end computing service
5.8	JASMIN integration	Establishment of the interoperation of the MSVF and JASMIN	Interoperation of the MSVF and JASMIN

Workpackage 6	**Hardware Infrastructure**	**M1-M48**	
Description: This workpackage is responsible for specification, procurement, installation and operation of hardware services for the consortium. This will deliver hardware infrastructure in 3 tranches through the project, at months 12, 24 and 36 via an annual procurement cycle. The capability and capacity of these hardware infrastructure will be progressively increased at scale and complexity. The delivery of hardware infrastructure components will be coordinated with the rest of the project, supporting the growth and expansion of NIDMSVF software and system capabilities, as well as ongoing engagement with the research communities and stakeholders. (See "Justification of Resource" section for hardware investment profile.) Exact requirement for the procurement will be determined in an annual hardware review, taking into account the changing needs of the community and the available advances in technology. This work package is cross all phases of the project.			
Task	**Task Name**	**Description**	**Deliverable**
6.1	Disk and Tape Storage	Specification, procurement, installation and operation of persistent storage media.	Availability of persistent storage media.
6.2	High Memory Computation	Specification, procurement, installation and operation of high memory computation nodes for	Availability of high memory computation nodes

		locally data intensive applications.	
6.3	High-end Graphics Capability	Specification, procurement, installation and operation of high end graphics and display capability for advanced visualisation	Availability of high end graphics and display
6.4	CPU, GPU Cluster	Specification, procurement, installation and operation of CPU/GPU compute nodes for modelling, simulation and analytics.	Availability of CPU/GPU compute nodes

Workpackage 7	**Pilots and testing**	**M13-M48**	
Description: This workpackage is responsible for the definition and operation of pilot use cases to demonstrate and test the NIDMSVF and feedback on performance, usability, and further requirements. These pilots will be specified and executed in Phase 3: Implementation, and continued in the Phase 4: Verification to evaluate the use of the NIDMSVF.			
Task	**Task Name**	**Description**	**Deliverable**
7.1	Establishment of testing environment & procedure	Establishment of testing environment within the NIDMSVF, and the development of procedure and plans to test the NIDMSVF within pilots.	Testing environment and testing plan
7.2	Pilot and Demo Delivery Timeframe and Plan	Detailed design of pilot demonstrations and planning of delivery of those demonstrations.	Plans for pilots.
7.3	Pilot development and delivery	Working with research teams and stakeholders to design and deliver pilot demonstrations tailored for	Demonstrations and experience reports from pilots.
7.4	Verification and evaluation	An evaluation of the overall results of the NIDMSVF.	Synthesis and evaluation report from the pilots.

Workpackage 8	**Community Engagement and Sustainability**	**M1-M48**	
Description: This workpackage is responsible for disseminating and promoting the results of the project, for outreach into existing and new user communities. Further, it is responsible for working with the implementation workpackages to scope, prepare and deliver training materials for UKCRIC partners and external users. Finally, the workpackage should explore options for sustainability of the MIDMSVF infrastructure for the long term. This activity spans all phases of the project.			
Task	**Task Name**	**Description**	**Deliverable**

8.1	Dissemination, and outreach,	Dissemination activities, including papers and presentations, website, publicity and exhibitions, press releases, websites, social media etc.	Dissemination plans and progress reports.
8.2	Sustainability & business planning	Exploring options and models for sustaining the NIDMSVF beyond the lifetime of the project, working in close conjunction with the Governing Board.	Sustainability and business plans.
8.3	NIDMSVF training	Preparation and delivery of training materials suitable for different audience and levels of expertise within and without the UKCRIC .	Training materials and courses.
8.4	User engagement workshops	Workshops to engage wider user communities in the use of the NIDMSVF within particular domains.	User engagement workshops.