SFIA 8 - New Skill Proposal

# Computational Science Skills

Digital technology and computational numeracy are becoming increasingly important to all aspects of life and this is also true for the way science is done. Our increasing reliance on data, sensor networks, numerical modelling, data mining, machine learning and inference and inversion techniques require a different and emerging skillset to develop critical science outcomes for the future. These disciplines are collectively referred to as [Computational Science](https://en.wikipedia.org/wiki/Computational_science) and the associated skills are in high and growing demand – especially in Australian Public Sector science organisations like Geoscience Australia, the Bureau of Meteorology, Commonwealth Scientific and Industrial Research Organisation, Defence Science and Technology Group and the Australian Nuclear Science and Technology Organisation.

Version 7 of the Skills Framework for the Information Age (SFIA) describes several digital skills used in science related roles, but has not yet incorporated those of computational science. This document proposes new computational science skills for the next version of the [SFIA](https://sfia-online.org/en/sfia-7/all-skills-a-z) framework (SFIA 8). By specifying these skills in sufficient detail within SFIA, organisations may be able to map out the skills needs and ultimately be better able to attract, grow and retain talent and capability.

The skills proposed below were developed through a series of workshops with scientific computing practitioners from the above listed science organisations.

In summary, the following three new skills were identified

* **Scientific Modelling**
* **Numerical Analysis**
* **High Performance Computing**

We propose a new Subcategory under Development and Implementation**: Computational Science**.

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| **Category** | **Subcategory** | **Skill** | **Skill Code** | **Levels** |
| Development and implementation | Computational Science | Scientific Modelling | SCMD | 4,5,6,7 |
| Numerical Analysis | NUMA | 4,5,6,7 |
| High Performance Computing | HPCC | 4,5,6,7 |

The following are proposed as a first-cut description for each of the proposed skills and their recommended levels of applicability.

# Scientific Modelling (SCMD)

## Overall skill description

The identification of the relevant mathematical principles and scientific theory within an information systems framework, to solve real-world problems. The creation, testing and tuning of scientific models through the application of computing. The validation and interpretation of models implemented in information systems against the reality which models attempt to represent.

## Scientific Modelling: Level 7

Directs the creation and review of a cross-functional, enterprise wide approach and culture for scientific modelling. Leads the development of the organisation’s scientific modelling capabilities and champions its use in solving real world problems.

## Scientific Modelling: Level 6

Sets standards and initiates the creation, testing, improvement and application of mathematical model frameworks that represent real world systems and scientific theories. Oversees the representation of science and mathematics principles and theories in models to ensure appropriate, consistent and effective usage. Develops or introduces new mathematical techniques where necessary.

## Scientific Modelling: Level 5

For a given real world problem, identifies the lack of existing models and creates new mathematical representations of the underlying science that can be implemented in an information systems framework. Applies advanced programming techniques to implement scientific models and apply these for problem solving. Analyses the functioning of existing models to improve accuracy and performance. Communicates limitations such as uncertainty and systematic errors. Ensures appropriate usage of models.

## Scientific Modelling: Level 4

Analyses the real world problem, then selects appropriate physical and mathematical models to approximate the phenomena under investigation. Applies relevant mathematical techniques to simulate the problem. Conducts quality and performance assessments on model outputs and makes improvements to the models. Provides advice and guidance to those using these models.

# Numerical Analysis (NUMA)

## Overall skill description

Numerical analysis is the area of mathematics and computer science that creates, analyses, and implements algorithms for solving numerically the problems of mathematics. Numerical Analysis is concerned with floating point arithmetic and the resulting accumulation of rounding errors as opposed to integer arithmetic which has different considerations. Numerical analysis is required for most applications that implement simulations of physical systems, machine learning, data analytics etc.

Numerical analysis skills are about the creation, analysis, implementation, testing and improvement of algorithms for numerically solving mathematical problems. Consideration of the numerical stability, condition numbers, accuracy, computational complexity and usability of algorithms that solve mathematical problems.

## Numerical Analysis: Level 7

Directs the creation and review of a cross-functional, enterprise wide approach and culture for numerical analysis. Leads the development of the organisation’s numerical analysis capabilities and champions its use in solving real world problems.

## Numerical Analysis: Level 6

Sets standards and initiates the creation, testing, improvement and application of numerical algorithms that solve real world mathematical problems. Sets strategy and leads the implementation of numerical analyses capabilities to ensure appropriate, consistent and effective usage across the organisation.

## Numerical Analysis: Level 5

Creates, tests and improves complex algorithms that numerically solve real world problems. Develops mathematical and computational techniques to assist with numerical analysis. Communicates limitations such as uncertainty and systematic errors. Reviews algorithms for their conformance to design and performance standards.

## Numerical Analysis: Level 4

Creates moderately complex algorithms using a range of mathematical techniques in consultation with experts as appropriate, and with sensitivity to the limitations of the techniques. Uses sophisticated scientific computing and visualisation environments. Assesses the stability, accuracy and efficiency of algorithms and makes or recommends improvements to them.

# High Performance Computing (HPCC)

## Overall skill description

The application of computing resources to achieve very high volumes of computation, including high speed sequential processing, scalable parallel processing, and emerging computational technologies. The development and application of techniques and algorithms that enable the effective use of advanced computer systems.

## High Performance Computing: Level 7

Directs the creation and review of a cross-functional, enterprise wide approach and culture for high performance computing. Leads the development of the organisation’s high performance computing capabilities and champions its use in solving real world problems.

## High Performance Computing: Level 6

Sets standards and initiates the creation, testing, improvement and application of algorithms that solve real world problems in high performance computing environments. Sets strategy and leads the implementation of organisational capabilities to ensure appropriate, consistent and effective usage of high performance computing.

## High Performance Computing: Level 5

Creates, tests and improves complex high performance computing solutions to address real world problems. Works with stakeholders to ensure high performance computing solutions are effective at addressing their problems. Guides development teams in the appropriate and effective use of high performance computing resources

## High Performance Computing: Level 4

Develops moderately complex solutions that use high performance computing environments to address real world problems. Applies a range of high performance computing techniques in consultation with experts as appropriate, and with sensitivity to the limitations of the techniques. Analyses the complexity, scalability and performance of high performance computing algorithms, including massively parallel implementations, and makes or recommends improvements.

For comparison purposes, the already existing SFIA 7 skill of Analytics is presented below.

# Analytics (INAN)

## Overall skill description

The application of mathematics, statistics, predictive modelling and machine-learning techniques to discover meaningful patterns and knowledge in recorded data. Analysis of data with high volumes, velocities and variety (numbers, symbols, text, sound and image). Development of forward-looking, predictive, real-time, model-based insights to create value and drive effective decision-making. The identification, validation and exploitation of internal and external data sets generated from a diverse range of processes.

## Analytics: Level 7

Directs the creation and review of a cross-functional, enterprise-wide approach and culture for analytics. Leads the provision of the organisation’s analytics capabilities. Leads the organisation's commitment to efficient and effective analysis of textual, numerical, visual or audio information.

## Analytics: Level 6

Develops analytics policy, standards and guidelines. Establishes and manages analytics methods, techniques and capabilities to enable the organisation to analyse data, to generate insights, create value and drive decision-making. Sets direction and leads the introduction and use of analytics to meet overall business requirements, ensuring consistency across all user groups. Identifies and establishes the veracity of the external sources of information which are relevant to the operational needs of the enterprise.

## Analytics: Level 5

Evaluates the need for analytics, assesses the problems to be solved and what internal or external data sources to use or acquire. Specifies and applies appropriate mathematical, statistical, predictive modelling or machine-learning techniques to analyse data, generate insights, create value and support decision-making. Manages reviews of the benefits and value of analytics techniques and tools and recommends improvements. Contributes to the development of analytics policy, standards and guidelines.

## Analytics: Level 4

Applies a range of mathematical, statistical, predictive modelling or machine-learning techniques in consultation with experts if appropriate, and with sensitivity to the limitations of the techniques. Selects, acquires and integrates data for analysis. Develops data hypotheses and methods, trains and evaluates analytics models, shares insights and findings and continues to iterate with additional data.

## Analytics: Level 3

Undertakes analytical activities and delivers analysis outputs, in accordance with customer needs and conforming to agreed standards.

Example Role Profiles

These real-life role profiles demonstrate the application of the proposed Computational Science skills, together with other SFIA skills.

# Summary

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| **Role** | **SFIA Skills & Levels** | | | | |
| Research Scientist | SCMD-5 | NUMA-4 |  |  | PRMG-5 |
| Hydrodynamic Modeller | SCMD-5 | NUMA-6 | HPCC-5 | PROG-4 | RLMT-5 |
| Hazard Modeller | SCMD-4 | NUMA-4 |  |  | INAN-4 |
| Scientific Computing Specialist |  | NUMA-5 | HPCC-4 | PROG-4 |  |

Research Scientist - EL1

# SCMD (5), NUMA (4), PRMG (5)

# The Role

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| The Nuclear Monitoring Section within Geoscience Australia provides scientific advice to the Australian Government in support of its goal to enhance national and international security through limiting the proliferation of nuclear weapons. In particular the Section provides independent notification on the detection and evaluation of possible nuclear weapons tests and technical support for the establishment and maintenance of the international verification regime for the Comprehensive Nuclear-Test-Ban Treaty (CTBT).  The section monitors for nuclear explosions using an international network of seismic, hydroacoustic and infrasound stations to monitor the underground, the large oceans and the atmosphere respectively. Data from the network is continuously monitored and signals of interest are analysed, interpreted and reported.  This role will make a significant contribution in the work of the section through:   * monitoring, analysing and reporting on possible nuclear explosion events * undertaking scientific research with the goal of enhancing the section’s technical capability * managing relationships and engaging with internal and external stakeholders to ensure that timely data and advice relating to nuclear explosion monitoring is made available |

# What you will do

Working with a level of independence, in this role you will:

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| * contribute to the operational nuclear explosion monitoring work of the section through high level scientific analysis, interpretation and provision of advice on events of interest * conduct more complex scientific research relevant to the waveform technologies used for monitoring (primarily seismic, but possibly also including infrasound and hydroacoustics) with the goal of achieving practical improvements to existing monitoring capability * lead the implementation of new operational services within the section based upon your research and the latest developments in nuclear explosion monitoring * engage and collaborate with internal and external stakeholders to identify opportunities, achieve mutually beneficial outcomes and facilitate cooperation * provide expert scientific advice and assistance to team members performing technical work * contribute to and support a strategic direction that influences the development of the CTBT verification system through targeted research and analysis * report results in the form of presentations, project reports, peer-reviewed publications, journal articles and other professional publications, to deliver information to stakeholders * coordinate the use of specialist project service providers, including contractors and consultants * represent the agency at conferences and other stakeholder engagements in a professional and specialist context * maintain professional knowledge and continue to develop knowledge and expertise in various aspects of nuclear explosion monitoring science * support the Director, Nuclear Monitoring section and contribute as a proactive member of the branch’s senior leadership team. |

# Demonstrating success

To be successful in this role, you will have the ability to:

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| * monitor projects against plans; manage priorities and agree adjustments to milestones as required; maintain focus on quality to achieve key outcomes; adhere to documented procedures and see tasks through to completion * understand the strategic objectives of the organisation and develop work plans accordingly * communicate with others regarding the purpose of their work and the relationship between operational activities and organisational goals * build and sustain relationships; liaise with a range of stakeholders including other teams, peers and colleagues across the organisation, and in other organisations * anticipate the needs of clients and provide courteous, prompt and professional service; offer reciprocal assistance in achieving mutually beneficial outcomes * contribute own expertise and encourage others to draw upon this knowledge; consult internal and external experts and tap into their technical and professional knowledge and experience to improve work outcomes for the benefit of the business unit * construct project plans that have clear and appropriate goals, timeframes and budgets; anticipate change and build contingencies into plans * present messages clearly and confidently and focus on gaining a clear understanding of others’ comments by listening, asking clarifying questions and reflecting back * make time for people despite competing priorities; provide guidance and offer full support when required * provide clear, constructive and timely feedback (both positive and negative) in a manner that encourages learning and achieves any required resolution * adhere to the Australian Public Service Values and Code of Conduct and consistently behave in an honest, ethical and professional way. |

# Required skills, knowledge, experience and/or qualifications

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| * Expertise in the area of a seismo-acoustic technology (seismology, infrasound or hydroacoustics) including some or all of the following – source physics, signal propagation and signal processing and analysis. * Strong experience in the development of software to solve scientific or technical problems. * Highly developed communication and collaboration skills. * Ability to work with a high level of autonomy in identifying and developing research projects of value to the team’s mission. * Experience managing people in a scientific environment. |

Hydrodynamic Modeller – EL1

# SCMD (5), NUMA (6), HPCC(5), PROG (4), RLMT(5)

# The Role

The Community Safety Branch (CSB) in the Place, Space and Communities Division develops and delivers independent, authoritative and accessible information and advice on natural hazards and their impacts. By improving the understanding of natural hazards and community exposure, we support stakeholders in Australia and the region in their risk mitigation and community resilience policy and action.

The Hydrodynamic Modeller develops coastal hazard and risk information for disaster management and risk reduction projects, and provides scientific leadership in these areas to the Community Safety branch. You will provide advice on coastal hazards (particularly tsunamis) to a wide range of Australian and international stakeholders, and maintain relationships with international and national experts in these areas. You will also lead the development of scientific methodologies and software to support our coastal hazard work; deliver hazard and risk information for our projects; and assist internal and external stakeholders to use Community Safety's products.

You will be expected to guide other scientists in the areas of hydrodynamic modelling, hazard and risk science, and scientific computation. You will also serve as the Coastal Activity Lead for the Community Safety branch, helping maintain a coherent multi-year vision for our coastal science capabilities. You will be required to contribute to developing coastal hazards components of work programs. At times, you will also be required to manage other scientists across the branch.

The role requires extensive stakeholder interactions and management between the team, the director, the branch head, our external stakeholders, and other Geoscience Australia scientists.

# What you will do

Working with a level of independence, in this role you will:

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| * lead the Coastal Activity for the Community Safety branch, contributing to longer-term strategies that support our coastal hazards work * advise Australian and regional bodies on tsunami hazards, such as the Australian Tsunami Advisory Group (ATAG), the Joint Australian Tsunami Warning Centre (JATWC), the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS), and relevant state-government bodies (for example, the NSW State Emergency Service, Queensland Fire and Emergency Services and the Western Australian Department of Fire and Emergecy Services) * promote and maintain relationships with key national stakeholders, and international and national tsunami hazard experts * test and maintain Australia's national probabilistic tsunami hazard assessment, and provide support on its use to both internal stakeholders, and external stakeholders who are conducting hazard assessments in Australia * develop and test methodologies for tsunami inundation hazard assessment, to support best-practice hazard assessments in Australia * lead the development and testing of open source codes for probabilistic tsunami hazard assessment to provide a transparent underpinning for our science * provide ad-hoc support to Geoscience Australia scientists on modelling and scientific computing * advance our hydrodynamic modelling capacity (for example, through testing and/or development of promising new algorithms, new codes, or faster computational methods), and maintain relationships with Australian National University experts in this area * communicate and promote our work through publication in journals, technical reports, conference proceedings, and presentations at meetings and conferences * write scientific programs for high-performance computing systems, including languages such as R, python, Fortran, C, shell; using standard inter-and-intra-node communication software (MPI, OpenMP), and NetCDF. |

# Demonstrating success

To be successful in this role, you will have the ability to:

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| * contribute own expertise for the benefit of the business unit; encourage others to draw upon this knowledge; provide impartial and forthright advice * understand the strategic objectives of the organisation and develop work plans accordingly; translate high-level goals and outcomes into appropriate tasks for others * systematically analyse information to identify relationships between factors; explore various possibilities and generate innovative alternatives * identify critical information gaps and ask a range of questions to uncover valuable information; scan the organisational environment; monitor the corporate priorities, business context and organisational culture * select the best option from a range of potential solutions; demonstrate how recommendations solve the key problems identified * build and sustain relationships; liaise with a range of stakeholders including other teams, peers and colleagues across the organisation, and in other organisations * operate in a professional manner when representing the organisation in public and internal forums * make time for people despite competing priorities; provide guidance and offer full support when required * provide clear, constructive and timely feedback (both positive and negative) in a manner that encourages learning and achieves any required resolution * adhere to the APS Values and Code of Conduct and consistently behave in an honest, ethical and professional way. |

# Required skills, knowledge, experience and/or qualifications

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| * Demonstrated expertise in hydrodynamic and statistical modelling for hazard assessment. * Demonstrated knowledge of scientific programming, including the use of scripting languages (e.g. R, python), compiled languages (e.g. Fortran, C/C++), and high-performance computing. * Experience in building and maintaining relations with both technical and non-technical stakeholders. * Experience in communicating the scientific work (papers, reports, conference presentations, workshops) for a range of technical and non-technical audiences. * Prior experience working in a developing country context with existing stakeholder networks and relationships is desirable. * A PhD in a related quantitative field (such as earth-science, mathematics, or engineering) is highly desirable. |

Hazard Modeller – APS5

# SCMD (4), NUMA (4), INAN (4)

# The Role

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| The Hazard and Risk Infrastructure and Applications (HaRIA) Section is responsible for supporting Australia’s capability to manage the impacts of natural hazards, including earthquakes, tropical cyclones, tsunamis and others. This involves activities to build our understanding of natural hazards, and provide advice to the Australian Government and other stakeholders to support risk mitigation and community resilience through data management, model development and application as well as project-based activities.  The Hazard Modeller works in HaRIA to help build our understanding of a range of natural hazard events such as tropical cyclones, tsunamis and earthquakes, using a combination of data analysis, and statistical and numerical modelling systems. You will develop applications and products based on a thorough understanding of the geophysical processes driving these events, meeting the needs of a diverse stakeholder group including:   * local and regional communities * national policy agencies * the Bushfire and Natural Hazard Commonwealth Research Centre and its stakeholders * international research groups. |

# What you will do

Working with limited guidance, in this role you will:

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| * develop and apply physical, numerical and/or statistical modelling, data analysis and visualisation products, supporting a range of geophysical hazard projects covering areas such as meteorology, hydrodynamics and seismology * use judgement and knowledge to guide decisions that impact on your work * work collaboratively on projects within the section, contributing expertise in data analysis and hazard modelling contribute to developing project and strategic plans, and assist in preparing reports on projects and related technical reports * manage data and products in line with Geoscience Australia’s data management policies, principles and guidelines to ensure they are discoverable, accessible and interoperable * contribute to presentations and training programs relating to the application of our modelling work for external stakeholders and project partners * effectively represent HaRIA and Geoscience Australia at external meetings, conferences or seminars. |

# Demonstrating success

To be successful in this role, you will have the ability to:

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| * Understand the strategic objectives of Geoscience Australia, and contribute to the development of plans, strategies and team goals; identify issues and problems and work to resolve them; identify risks and uncertainties and take account of these in planning and priority setting * be innovative and identify and implement improved work practices * draw on information from a variety of sources, analyse what information is important, and work within agreed guidelines to make decisions about the use and distribution of that information * construct project plans that have clear and appropriate milestones, goals, timeframes and budgets; monitor progress; see tasks through to completion and take personal responsibility for accurate completion of work within timeframes and quality requirements * demonstrate flexibility and cope effectively with day-to-day work changes, shifting priorities and periods of uncertainty * maintain a focus on quality to achieve outcomes, and regularly seek feedback from your supervisors to gauge their satisfaction * demonstrate awareness of the implications of issues for your own work and work area; think about the future and consider implications of own work; agree own performance standards * build and sustain relationships; liaise with a range of stakeholders including team members, other teams, colleagues and clients * operate as an effective member of the team by working collaboratively and drawing on team strengths * confidently present messages in a clear and concise manner, focussing on key points and using appropriate language and medium for the audience * adhere to the APS values and code of conduct and consistently behave in an honest, ethical and professional way |

# Required skills, knowledge, experience and/or qualifications

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| * Demonstrated experience in numerical modelling of physical systems, preferably in the meteorological, hydrodynamic or seismological sciences, using either open-source or proprietary software. * Knowledge of key physical processes that influence weather and climate hazards, and experience in analysing those would be an advantage. * Demonstrated experience in data analysis and statistical/mathematical modelling using a computing environment such as Python or R programming languages, and working with high-performance data such as netCDF; ability to work within high-performance computing environments. * An ability to work effectively as a member of a highly productive interdisciplinary team under limited guidance from supervisors. * Ability to communicate with influence to convey the outcomes of the work, and potential implications for stakeholders. * A degree in meteorology, climatology, physical oceanography, hydrology, mathematics, or a related field is highly desirable. |

Scientific Computing Specialist – EL1

# NUMA (5), HPCC(4), PROG (4)

# The Role

# The Geoscientific Computing team, within the Information Services Section of the Minerals Energy and Ground Water Division, has primary responsibility for the design, development and maintenance of scientific workflow software for data modelling, processing and visualization The team collaborates closely with geoscientists to delivery high value data-intensive projects including geochemical mapping using machine-learning and predictive analytics, AusArray Passive Seismic Tomography and AusLAMP Magnetotelluric Imaging. The team uses high performance computing platforms such as National Computing Infrastructure (NCI) and AWS cloud on a daily basis to develop and operate a wide range of scientific software.

# Reporting to the team leader, the scientific computing specialist role will work in a team to develop software in suitable programming languages such as Python and Linux shell script. The role interacts with geoscientists and provides software solutions, science algorithms implementation and optimisation.

# What you will do

Working with a level of independence, in this role you will:

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| * design, implement and test scientific computing software algorithms in suitable languages (such as Python, Linux Shell, etc) in high performance Linux environments * in collaboration with domain experts/scientists, implement and improve scientific algorithms for data processing and modelling * develop user-friendly interfaces (for example, command-line or GUI), as needed * apply software development best practices including continuous integration/delivery, refactoring, unit-testing, and automation * prepare and update systems documentation, including user guides and developer manuals * assist with the delivery of user-training workshops * support the team lead, and take on scientific computing tasks assigned by the team lead * present and publish scientific computing results in appropriate professional conferences/forums * to ensure quality outcomes, innovative ideas and ongoing improvement, this role will collaborate with scientific/domain specialists, team members, other teams, working groups, and other relevant people/groups. |

# Demonstrating success

To be successful in this role, you will have the ability to:

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| * identify issues and assess their significance; take appropriate action to resolve them * source information on best practice approaches; explore new ideas with an open mind * deal positively with uncertainty and cope effectively in an environment characterised by change; share appropriate information with colleagues during times of change; help others adapt to ensure a smooth transition * regularly seek feedback from stakeholders to gauge their satisfaction; ensure work is delivered to a high standard * monitor projects against plans; manage priorities and agree adjustments to milestones as required * build and sustain relationships; liaise with a range of stakeholders including other teams, peers and colleagues across the organisation, and in other organisations * operate as an effective member of the team; work collaboratively and cooperatively; draw on team strengths * consult and share information with own team and upwards; ensure people are kept informed of progress and issues * maintain effective performance levels in highly charged or high-pressure situations; demonstrate persistence and work hard to achieve objectives * structure messages clearly and succinctly, both orally and in writing; present messages confidently and select the appropriate medium for maximum effect * make time for people despite competing priorities; provide guidance and offer full support when required * provide clear, constructive and timely feedback (both positive and negative) in a manner that encourages learning and achieves any required resolution * adhere to the APS Values and Code of Conduct and consistently behave in an honest, ethical and professional way. |

# Required skills, knowledge, experience and/or qualifications

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| * Demonstrated high level experience with Python programming languages and open source libraries (including numpy, scipy, pandas, scikit-learn, tensorflow and mpi4py.); and a familiarity with Linux high-performance computing environments. * High level experience in big, complex data processing, cleaning, analysing and modelling; experience in applying software engineering best practices. * Experience in and knowledge of STEM (Science, Technology, Engineering or Maths). * Awareness of and experience using emerging technologies in digital science, such as cloud computing, machine learning and artificial intelligence. * Agile mindset and well-developed communication skills, both written and oral. * Proven ability to write systems documentation, such as design specifications, installation guides, and user manuals; write and present quality scientific reports and publications. |