# Amsterdam Declaration on Funding Research Software Sustainability

## Introduction

This brief introduction provides context for the Amsterdam Declaration on Funding Research Software Sustainability. This context includes the impact of digitalisation on research, the environment in which research software occurs (the 'research software ecosystem') and the potential role of funders of research software.

### *Digitalisation and research*

Over the past decades, research in all disciplines has been heavily impacted by digitalisation. These impacts include a growing demand for computational capacity, and considerably modified ways in which research data are gathered, analysed, shared, and presented. At the same time, open science[1], which largely depends on digitalisation, has gathered momentum and is becoming more and more accepted. A third change is that it has become evident that larger, complex societal issues ranging from health to climate have become essential concerns to academic research, and that they can only be addressed by communities working together. And finally, a question that has been raised over this period is the extent to which research outcomes are reproducible, which has even led to a 'reproducibility crisis.' In each of these four developments, the crucial role of research software[2] has become apparent.

Different disciplines have been impacted differently. The pace of digitalisation has varied, while needs, requirements, and resources diverge. Despite these variations, it has become manifestly apparent that research software fulfils a critical role in all disciplines. In recent years much attention has been devoted to the relevance of data for academic research. There is a good reason for this, since without data it is impossible to either obtain or validate results. But the same applies to research software. Without it, we cannot do research or advance science. Research software and the people who develop

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[1] We use the widely-accepted "open science" term to broadly represent open scholarship, which includes research in all scholarly fields.
[2] We define research software in the "Definitions" section.

and maintain it are critical to gathering, processing, and analysing data, and to generating research outcomes that are reliable, accessible, and reproducible.
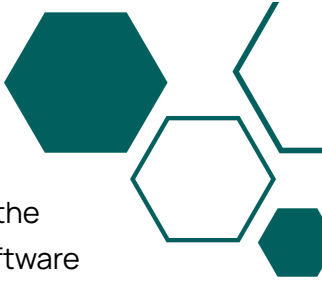
## *Research software environment*

To ensure the reproducibility of research outcomes and therefore the reliability of, and trust in, research and scholarship, it is vitally important to guarantee the sustainability of research software by integrating it into the research process as a whole. Research software sustainability is the process of developing and maintaining software that continues to meet its purpose over time. This includes such things as adding new capabilities as needed by users, responding to bugs and other problems, and adapting the software to changes in the underlying hardware and software infrastructure.

Research software sustainability has a direct bearing on the way research is funded and conducted, and necessarily involves the efficient use of financial, computational and human resources. When research software is not sustainable, resources are unnecessarily wasted, to the detriment of both research and society. However, research software sustainability cannot currently be automated and therefore depends heavily on skilled people. These people need to be trained to ensure that research software quality standards are maintained, and they have to have recognisable career paths. At the same time, research into improving automation of research software sustainability should be incentivised.

Research software sustainability is closely aligned with current discussions on changes in research culture. It is an issue that can only be resolved through cooperation across disciplinary, institutional, national, and geographic boundaries, with collaborative team efforts, and by duly recognising and rewarding the people who develop and maintain research software. Research software sustainability requires a different way of organising the research process and specifically draws attention, not only to the people who fulfil crucial roles in that process and who often remain hidden from view, but also to the global interconnections between software – the fact that most software depends on other software. Such an integral approach is best taken in the context of a 'research software ecosystem' that underlines the mutual interdependency of the research endeavour, research communities, research institutions and research funders. Considerations about the environmental and social impact of the use of research software are also part of this integral approach.

## *The role of funders*

Over the past few years, a variety of methods for sustaining research software and the people who develop and maintain it have been explored from the perspective of funders, including improving and extending funding policies and instruments. Yet funders still play

a limited role in ensuring research software sustainability. In fact, in many cases the absence of rules and conditions in assessment procedures even undermines software sustainability. Many funders support research projects over relatively short periods while the projects are actively underway, but the need for crucial deliverables like research software to remain in place after the project has ended has not been well-addressed.

It is crucial to recognise that because research software is global in nature it should be coordinated globally in the context of an international research software ecosystem. It is also important to realise and acknowledge that research software sustainability is the result of a shared effort of users, developers, maintainers, and researchers. This implies that funding instruments should accommodate different elements, such as dissemination, community, training, and maintenance. Moreover, research software sustainability is best supported through the kind of longer-term investment that is made in other forms of infrastructure. For more information, please consult Ten simple rules for funding scientific open source software.

## Purpose of Declaration

The aim of this Declaration on Funding Research Software Sustainability is to raise awareness of the role of funding practice in the sustainability of research software, and to improve that practice. The Declaration builds on actions undertaken by the Research Software Alliance (ReSA), research funding organisations, and the community surrounding it to develop awareness about the role funders can play in sustaining software in the longer term. It was initiated during an international workshop attended by representatives of funding organisations in Amsterdam on 8-9 November 2022, organised by ReSA and the Netherlands eScience Center. The Declaration is a first step towards formalising, on a global level, the basic principles and recommendations related to funding the sustainability of research software, including the people needed to achieve this goal.

The Declaration also includes a limited number of recommendations and an accompanying ADORE.software Toolkit. For the purposes of this Declaration, research software is defined as "all forms of software that were created during the research process or for research purposes". A fuller description is included in the accompanying ADORE.software Toolkit.

# Declaration

## Commitment

The signatories of the Amsterdam Declaration on Funding Research Software Sustainability endorse the following recommendations to improve the research software ecosystem and the research that it enables. The signatories agree to share their organisation's progress towards the adoption of the recommendations with each other and with their community. A stewardship group, comprising representatives of the signatories and supported by the ADORE.software secretariat, is responsible for overseeing and promoting the endorsement process.

Organisations that do not fully identify with the definition of 'funder' (see below) can express their support for the Declaration by issuing a 'statement of support'.

## Recommendations

### *Research Software Practice*

1. Funders should stimulate the documentation, licensing, open-source distribution, and accessibility of research software to enable the reproducibility of research outcomes.
2. Funders should incentivize the reuse and improvement of existing research software.
3. Funders should include research software in open science policies, following the principle 'as open as possible, as closed as necessary', to ensure it is a valuable and impactful research output.

### *Research Software Ecosystem*

4. Funders should stimulate the development and maintenance of a research software ecosystem, including people, communities, and infrastructure, to ensure research software sustainability.
5. Funders should share information about their investments and work in a coordinated manner, as the research software ecosystem exceeds institutional and national boundaries.
6. Funders should ensure that funding instruments are fit for purpose for both sustainability and innovation, so that research software is both maintained and developed for the longer term, to encourage a healthy research software ecosystem.

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## Research Software Personnel

7. Funders should stimulate the training, hiring, and funding of both professional research and technical staff able to reuse, develop, and maintain sustainable research software.

8. Funders should facilitate appropriate reward and recognition measures that enable career progression for all people involved in the creation and maintenance of research software.

9. Funders should require citation practices for research software that recognise substantial contributors to all aspects of the software.[3]

## Research Software Ethics

10. Funders should encourage the responsible use of appropriate indicators to assess the degree of permanence, reusability, and impact of research software.

11. Funders should explicitly consider the environmental and social impact of the use of research software.

12. Funders should explicitly recognise that diversity, equity and inclusivity are significant factors in making research software sustainable.

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[3] For a discussion on this topic, see Leem et al., "SORTÆD: Software Role Taxonomy and Authorship Definition (0.1)," https://doi.org/10.5281/zenodo.7896456.

# ADORE.software Toolkit

The ADORE.software Toolkit aims to support implementation of the Declaration. It provides examples of funder programs, policies, and resources for each of the Declaration's recommendations in the four areas of research software practice, research software ecosystem.

# Definitions

## *Research Software*

For the purpose of this Declaration, research software is defined as: "source code files, algorithms, scripts, computational workflows and executables that were created during the research process or for a research purpose. Software components (e.g., operating systems, libraries, dependencies, packages, scripts, etc.) that are used for research but were not created during or with a clear research intent should be considered software in research and not research software. This differentiation may vary between disciplines." (Gruenpeter 2021, as implemented in the FAIR for Research Software Principles (FAIR4RS)).

## *Funders*

For the purpose of the Declaration, a funder is an organisation that supports research software and/or the people who develop and maintain it. This definition fits traditional funding organisations that provide monetary and/or in-kind support to a recipient on the basis of grants or gifts, without any expectation of services or other tangible benefits from the recipient and typically with limited involvement in project management, operations and governance. A traditional funder can (and often does) direct that their grant go towards a particular project, outcome or deliverable, and can (and often does) set conditions on the way the support is utilised (adapted from Dunks 2021). Signatories and supporters of the Declaration are expected to self-identify, and could potentially range from government funding agencies and academic research institutes to private companies and philanthropic organisations.

# About ADORE.software

The Amsterdam Declaration on Funding Research Software Sustainability raises awareness of the role of funding practice in the sustainability of research software, and aims to improve that practice. Coordinated by the Research Software Alliance, the Declaration builds on actions undertaken by the Research Software Alliance, the Research Software Funders Forum, research funding organisations, and the community surrounding it to develop awareness about the role funders can play in sustaining software in the longer term. The Declaration is a first step to formalise, on a global level,

the basic principles and recommendations related to funding the sustainability of research software, including the people needed to achieve this goal.

The Declaration is the result of the International Funders Workshop: The Future of Research Software held on 8-9 November 2022 in Amsterdam, where funding organisations joined forces to explore how to effectively contribute to making research software sustainable.