Advancing the Field of Research Software

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What is scholarly research?

- Intended to advance knowledge
- Often collaborative
- Can be exploratory
- Can be hypothesis-driven
- Has inputs
- Has outputs
- Research software can be part of all above points in an increasing number of cases

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What are roles of research software?



- Research software is a component of our instruments
- Research software is the instrument
- Research software analyses research data
- Research software presents research results
- Research software assembles or integrates existing components into a working whole
- Research software is infrastructure or an underlying tool
- Research software facilitates distinctively research-oriented collaboration

R. van Nieuwpoort and D. S. Katz, "Defining the roles of research software," https://doi.org/10.54900/9akm9y5-5ject5y



Photo by Markus Spiske on Unsplash

What is research software?

- Research Software includes source code files, algorithms, scripts, computational workflows and executables that were created during the research process or for a research purpose
- Additional 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 et al., "Defining Research Software: a controversial discussion," 2021 https://doi.org/10.5281/zenodo.5504016



Why do we care about research software?

- Funding
 - ~20% of NSF projects over 11 years topically discuss software in their abstracts (\$10b)
 - 2 of 3 main DOE ECP areas are research software (~\$4b)
 - \$300m of FY2021 NIH projects include "software development"
- Publications
 - Software intensive projects are a majority of current publications
 - Most-cited papers are methods and software
- Researchers
 - >90% of US/UK researchers use research software
 - ~65% would not be able to do their research without it
 - ~50% develop software as part of their research

Collected from http://www.dia2.org in 2017

Collected from https://reporter.nih.gov in 2022

Nangia and Katz; <u>10.1109/eScience.2017.78</u> "Top 100-cited papers of all time," Nature, 2014 <u>10.1038/514550a</u>

S. Hettrick; <u>https://www.software.ac.uk/blog/2016-09-12-its-impossible-conduct-research-without-software-say-7-out-10-uk-researchers</u> S.J. Hettrick, et al.; <u>10.5281/zenodo.14809</u> U. Nangia and D. S. Katz; <u>10.6084/m9.figshare.5328442.v1</u>

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Where does research software come from?

- Significant fraction developed in research
- From the start of computing
 - Software appears around 1948
 - Research software (weather) in early 1950s
 - Software engineering starting in late 1960s, mostly initially applied to operational software (operating system, NASA flights, etc.)
 - Software engineering applied to research software: unclear start; in HEP, CHEP started in 1985, including aim of "enabling the exchange of ideas between physicists, computing scientists and software engineers"; are there earlier examples?
- Research software is key to "hot topics" in use today and planning for tomorrow
 - AI: Current and future core methods, workflows around them for training and use, ...
 - Quantum: simulating future systems, improving current devices, abstractions and programming languages for adoption, ...

AI: advancing scholarship beyond science

• Ted Underwood (Illinois):

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- How fast do most in-story clocks tick?
 - (or, using GPT-4 to measure the passage of time in fiction)
- The average page of literature in the 18th century covered an entire day of time; now it barely gets through an hour.



Figure 4: Moving means of average predicted elapsed narrative time per passage in the labeled training dataset (orange) and the larger HathiTrust dataset (blue). Shaded regions represent 95% confidence intervals, which do not account for prediction uncertainty.

<u>https://tedunderwood.com/2023/03/19/using-gpt-4-to-measure-the-passage-of-time-in-fiction/</u> Yauney, Underwood, and Mimno, "Computational Prediction of Elapsed Narrative Time."

Research software today

- Research software: developed and used for the purpose of research to generate, process, analyze data and knowledge within the scholarly process
- Increasingly essential in the overall research process
- But there are issues related to the software:
 - Software must be maintained to avoid collapse (it's part of a complex and changing stack)
 - Software must be updated: bugs are found, new features are needed, new platforms arise
 - Software development, updating, and maintenance are human-intensive
- And issues related to people:
 - Much software developed specifically for research, by researchers
 - Researchers know their disciplines, but often not software best practices
 - Researchers are not rewarded for software development and maintenance in academia
 - Missing developers: developers don't match the diversity of overall society or user communities

Research software challenges



12 scientific software challenges

- Software engineering
- Portability
- · Training and education
- · Incentives, citation/credit models, and metrics
- Intellectual property
- · Publication and peer review
- · Software communities and sociology
- · Sustainability and funding models
- Career paths
- · Software dissemination, catalogs, search, and review
- Multi-disciplinary science
- Reproducibility
- All are tied together

- Some of my thinking while a program officer at NSF in 2015
- Still reasonably accurate, though I left out diversity
- These challenges are high-level topics
- Specifics, work, progress, application are all context-dependent
- Contexts include discipline and geography (e.g., country)
- Let's look at
 - Credit & recognition
 - Career paths

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#1: Credit and recognition

a. Software citation b. JOSS c. Prizes



FORCE11 Software Citation Working Group (2015-16)

- Documented differences between software and data; defined software citation challenges
 - Katz DS, Niemeyer KE, et al. (2016) Software vs. data in the context of citation. PeerJ Preprints 4:e2630v1. DOI: <u>10.7287/peerj.preprints.2630v1</u>
 - Niemeyer KE, Smith AM, Katz DS. (2016) The challenge and promise of software citation for credit, identification, discovery, and reuse. ACM Journal of Data and Information Quality, 7(4):16. DOI: <u>10.1145/2968452</u>
- Created software citation principles
 - Smith AM, Katz DS, Niemeyer KE, FORCE11 Software Citation Working Group. (2016) Software Citation Principles. PeerJ Computer Science 2:e86. DOI: <u>10.7717/peerj-cs.86</u> and <u>https://www.force11.org/software-citation-principles</u>

FORCE11 The Future of Research Communications and e-Scholarship

<u>https://www.force11.org/group/software-citation-working-group</u> Co-Chairs: Arfon M. Smith, Daniel S. Katz, Kyle E. Niemeyer

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Software is a critical part of modern research...



Image courtesy of DataCite

... yet there is little support for its acknowledgement and citation

DOI: 10.7717/peerj-cs.86 and https://www.force11.org/software-citation-principles

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FORCE11 Software Citation Implementation Working Group (2017-present)

- Initial goals:
 - Write out the "small amount" of detail needed to implement the principles
 - Coordinate research & other work going on in many areas
 - Work with communities to actually implement the principles
- Realized "small amount" of detail wasn't small, scattered progress wasn't sufficient, underlying challenges not being addressed
 - D. S. Katz, et al., "Software Citation Implementation Challenges", <u>arXiv 1905.08674</u> [cs.CY], 2019.
 - Technical challenges include complexity of software types and identifiers, where to store metadata, ...
 - Social challenges need groups that work on implementation in context (disciplinary communities, publishers, repositories & registries, indexers, funders, institutions) to come together and run pilots to establish norms



https://www.force11.org/group/software-citation-implementation-working-group Co-Chairs: Neil Chue Hong, Martin Fenner, Daniel S. Katz

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Responses to citation challenges (1)

- Guidance task force
 - For paper authors who want to cite software
 - N. P. Chue Hong, et al., "Software Citation Checklist for Authors," Zenodo, 15-Oct-2019. 10.5281/zenodo.3479198
 - For software developers who want to make their software citable
 - N. P. Chue Hong, et al., "<u>Software Citation Checklist for Developers</u>," Zenodo, 15-Oct-2019. <u>10.5281/zenodo.3482768</u>
- CodeMeta task force
 - Following CodeMeta project
 - Aiming to understand metadata for software, not just for use in citation
 - Built a crosswalk of existing metadata standards for software
 - Then developed a CodeMeta standard to describe software based on these crosswalks
 - Updating the CodeMeta standard
 - Describing everything in CodeMeta using schema.org properties
 - Moving CodeMeta into a community group, with governance

Responses to citation challenges (2)

- Software Registries Task Force
 - Developed best practices document
 - Task Force on Best Practices for Software Registries, "Nine Best Practices for Research Software Registries and Repositories: A Concise Guide," 2020. <u>arXiv 2012.13117</u>
 - Community continuing in SciCodes: Consortium of scientific software registries and repositories, <u>https://scicodes.net/</u>
- Journals Task Force
 - Working with publishers to provide generic guidelines for journals and conferences to provide to authors
 - They then provide specific guidelines, with community-accepted language and examples
 - D. S. Katz, et al., "Recognizing the value of software: a software citation guide [version 2; peer review: 2 approved]," F1000Research 9:1257, 2021. <u>10.12688/f1000research.26932.2</u>
 - Tracked by CHORUS in <u>Software Citation Policy Index</u>
 - Also working on publication processing
 - How citation information moves from author provided to internal publisher/contractor systems and then to indices
 - S. Stall, et al., "Journal Production Guidance for Data and Software Citations", Scientific Data 10, 656, 2023. https://doi.org/10.1038/s41597-023-02491-7

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Responses to citation challenges (3)

- Considered institutions task force
 - Institutions: places where people work
 - Universities, laboratories, industry, government, etc.
 - Want to affect policies and practices
 - How do they encourage software citation
 - How do they use software citation information in hiring & promotion
 - Collect and share examples
 - Help form communities
 - But insufficient interest from FORCE11 WG members
 - However, related <u>RDA & ReSA: Policies in Research Organisations for Research Software (PRO4RS) WG</u> started Oct 2023
- Given progress to date, what else makes sense to do, and who can do it?
 - Software citation workshop summer 2022 addressed this; report available
- WG finished May 2023, but community is interested in continued discussion
 - Currently writing a blog post to suggest topics and venues

Journal of Open Source Software (JOSS)

- A developer friendly journal for research software packages
 - "If you've already licensed your code and have good documentation then we expect that it should take less than an hour to prepare and submit your paper"
- Everything is open:
 - Submitted/published paper: <u>https://joss.theoj.org</u>
 - Code itself: where is up to the author(s)
 - Reviews, reviewers & process: <u>https://github.com/openjournals/joss-reviews</u>
 - Adapted from rOpenSci
 - Expedited process for software already reviewed by rOpenSci & pyOpenSci
 - Code for the journal itself: <u>https://github.com/openjournals/joss</u>
 - Reused for Journal of Open Source Education (JOSE) and Proceedings of the JuliaCon Conferences



Journal of Open Source Software (JOSS)

- JOSS papers archived, have DOIs, increasingly indexed
- First paper submitted 4 May 2016
- 31 May 2017: 111 accepted papers, 56 under review and pre-review
- 18 Dec 2023: 2261 accepted papers, 271 under review and pre-review
- Current publication rate: ~1.1 paper/day (& slowly increasing)
- Editors:
 - 1 editor-in-chief and 11 editors at launch;
 - 1 EiC, 7 associate/track EiCs, 69 editors, 35 emeritus editors today



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JOSS as a community

- Culture changes based on rules and incentives
- JOSS practices have influenced reviewers and developers in terms of what's good and what's minimally acceptable
 - Similar to rOpenSci's influence in the R community
 - Minimum criteria for successful review change over time as community best practices develop
 - E.g., packaging, testing/Cl, documentation
- JOSS applies open source software practices to reviews: openness & collaboration
- JOSS provides rules, and at a high-level, tries to nudge incentives
 - Accepted software = accepted paper
- If software was cited directly, JOSS papers wouldn't be needed, but JOSS reviews and JOSS community would still have great value

Software prizes

- Starting to appear
- France: <u>National Research Software Award</u>
 - Under Minister of Higher Education and Research's National Plan for Open Science
 - Awards in multiple categories made in 2022 and 2023
 - Article about the process of creating and running it: <u>https://doi.org/10.12688/openreseurope.16069.1</u>
- Germany: <u>Helmholtz Incubator Software Award</u>
 - Awards in multiple categories to be made in 2024, limited to Helmholtz Association work
- Australia: Eureka Prize for Excellence in Research Software
 - Award made in 2023
 - Plus discipline-specific awards:
 - Award for New Developers of Open Source Software in Ecology (first awarded 2022)
 - Venables Award for New Developers of Open Source Software for Data Analytics (first awarded 2022)
 - <u>"Torsten Seemann" Outstanding Bioinformatics Software Developer Award</u> (first awarded 2022)
 - Outstanding Bioinformatics Software Maintainer Award (first awarded 2022)
 - Emerging Leaders in Astronomy Software Development Prize (first awarded 2023)
 - All sponsored by ARDC, in collaboration with various societies

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#2: Career Paths





Who develops research software?

- Significant fraction developed by researchers
- But
- Researchers (faculty) generally don't know good software practices
- Software engineers generally don't understand research context
- Students & postdocs generally don't know good software practices and don't stick around
- Some postdocs do stay, join staff (perhaps unofficially)
- Leads to having some staff with both research understanding and software engineering skills

The craftsperson and the scholar

- Scholar: archetypical researcher driven to understand things to their fullest capability
 - Find intellectually-demanding problems
 - Curiosity-driven, work on a topic until understanding has been acquired, pass on that understanding through teaching
- Craftsperson: driven to create and leave behind an artifact that reifies their efforts in a field
 - Feels pain when things they make are fragile or ugly
 - Prefer to make things that explain themselves
 - Work requires patience, and pride in doing a job well
- Research software requires individuals who combine the best of both roles



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http://www.software.ac.uk/blog/2012-11-09-craftsperson-and-scholar

What is a Research Software Engineer?



https://danielskatzblog.wordpress.com/2019/07/12/super-rses-combining-research-and-service-in-three-dimensions-of-research-software-engineering/



Collaborations Workshop 2012

- Lots of people already doing this work
- No common title
 - ✓ Research Software Engineer (RSE)
- No community
 - ✓ Associations/societies
- Not a profession
 - \checkmark Career paths, structure

Casebooks Project Editor (Research Assistant/Associate) Climate Researcher (Research Associate) Clinical Study Programmer CoMPLEX Research Associate Computational Biologist / Bioinformatician Computational Scientist Computational Scientist in Computational Fluid Dynamics & Industrial Applications Computational Scientist in Structural Mechanics and Industrial Applications Computer Scientist Computer Vision Researcher Content Developer/Programmer Control Engineer-IMG - 3 posts CREATe Data Specialist Data Analyst Data Integration Coordinator Data Manager x3 Database and Software Engineer Database Manager/Researcher Database Programmer Digital Media Technician E-Learning Portal Manager (KTP Associate) e-Learning Systems Development Analyst e-Learning Systems Development Analyst (Moodle, SQL) E-Learning Web Developer E-Portfolio Learning Technologist Embedded Systems Engineer Engineering Technician Environmental Scientist EPSRC Studentship on Algorithmic Construction of Finsler-Lyapunov Functions Experimental Officer in Bioinformatics Experimental Psychologist Finance Assistant Gaia Alerts Software Developer Gaia Software Developer (Gaia UK Team) GIS Applications Specialist Graduate Programmer / Software Developer Graphics Programmer Health Data Manager / Scientist High Throughput Bioinformatician High roughput Sequencing Bioinformatician (Two ests) (IIVE Marager / Al Va Co-ordinator HIVE Senior Researcher and Technical Lead Hydro-informatics Scientific Software Developer (male / alysis Conager or Targing Information Systems Developer Instrumentation ingineer Investigator Statistician IT Developer (1) (The state of the state Throughput Sequencing Bioinformatician (Two Engineer Investigator Statistician IT Deve Windows Systems) Knowledge Transfer Associate - Software Developer KTP Associate - Robot Vision Scientist (Research Fellow) KTP Associate (Fixed Term Contract for 24 months) KTP Associate (Precision Agriculture Data Analyst) KTP Associate â€" Graduate Web Developer KTP Associate: Electronics / Robotics Engineer Learning Technologist Leicester Respiratory BRUIT Developer Linguist / Psycholinguist Maker Space Technician Marie Curie Early Stage Researcher Marie Curie Early Stage Researcher in Rader Rader Rader for Margarad Water On lity Modelling Marine Earth Observation Scientists Medical Statistician Medical Statistician / Senior Medical Statistician Marcrogg Hegmes Mobile Application Developer NASC IT Support -Programmer and Systems Administrator (Fived tory) Nativ Research Markets Science 2007 Researcher Marie Curie Early Stage Researcher in Rade Surveillance Planning Officer Policy Modeller 2010 Post - Doctoral Research Assistant INSTRON Post Doctoral Research Worker Post Doctoral Researcher in the application of Digital Technology Post-Doctoral Research Assistant in Simulation and Visualization Post-Doctoral Research Associate Post-Doctoral Research Associate (Pathogen Genomics) Post-Doctoral Research Fellow Postdoctoral Fellow - population genetics / evolutionary genetic Postdoctoral Fellow in Bioinformatics Postdoctoral Fellow in Cancer Therapeutics Postdoctoral Research Assistant Postdoctoral Research Associate Postdoctoral Research Fellow Postdoctoral Research Scientist Postdoctoral Researcher in Declarative (Logic and Functional) Programming Postdoctoral Researcher Postdoctoral Scientist Postdoctoral statistician Postdoctoral Training Fellow - Statistical and Computational Genetics of Autism Principal / Senior Bioinformatician Principal Bioinformatician Product Development Engineer (Rail) Publishing Portal Web Developer Radio Frequency Engineer Reader in Computer Science Reporting Analyst Research (Software) Engineer Research Assistant Research Associate Research Fellow Research Image Data Manager, Biomedical Engineering Research Officer Research Officer â€" Social Protection Research postgraduate Research Programmer Research Scientist Research Scientist / Senior Research Scientist Research Scientist in Machine Learning and Computer Vision Research Software Developer Research Software Developer for the Herchel Smith Professor of Organic Chemistry Research Software Engineer Research Studentship Research Worker Researcher SAP Trainee Technical Analyst Scientific Officer with Michela Garofalo Scientist SEAHA Studentship: Extracting epidemiological data from collections SEEG Data Archive Manager Senior / Research Associate in Clinical Integration and Image Analysis for Fetal Surgery Senior Analyst Programmer (Business Analysis) Senior Analyst/Programmer Senior Bioinformatician Senior Bioinformatician / Bioinformatician Senior Computational Statistician -Spatial Models Senior Data Acquisition Scientist / Data Acquisition Scientist Senior Data Manager Senior Database Administrator Senior IT Developer Analyst Senior Mathematical Modeller Senior Media Developer Senior Postdoctoral Researcher - Evolutionary and Computational Analysis of Infectious Disease (Phylodynamics) Senior Research Assistant Senior Research Associate Senior Research Associate â€" Molecular Modelling & Simmulation Senior Research Associate in Quantitative Clinical MRI Senior Research Fellow Senior Research Fellow/Research Fellow in Vibration Diagnostics and Prognostics/Digital Signal Processing Senior Research Laboratory Technician Senior Research Technician Senior Software Developer in Bioinformatics Senior Software Engineer / Software Engineer Senior Statistical Epidemiologist Senior Systems

Credit: Simon Hettrick

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11 years of RSEs

- Movement and term: Born in the UK
 - Late 2013 UKRSE Association forms with ~50 members
 - Now society, ~700 dues-paying members, ~4600-member community
- Also: Belgium, Germany, Netherlands, Society of Research Software Engineering (UK Nordic, Australia/New Zealand
- And US-RSE (https://us-rse.org), ~2200 members across universities, national labs, industry
- New associations now forming
 - Africa & Asia
- Associations work on local issues collectively, and can coordinate



Image credit: Ian Cosden

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But also, in France...





National network of Research Software Engineers created in 2011

15 local networks (sometimes older)

Current challenge: Join French and English RSE worlds!

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Research software ecosystem





Research software ecosystem

- Many organizations working in this area
 - Research-performing organizations (e.g., universities, centers, laboratories, industry)
 - RSE organizations
 - Disciplines/societies (US: AAS, AGU, IEEE, ACM, ...)
 - Organizations focusing on software and sustainability/stewardship (SSI in UK, URSSI in US, EVERSE in Europe, ...)
 - Research funders (public and private)
 - Publishers, librarians, archivists, scholars
- Where can they communicate and coordinate?

Research Software Alliance (ReSA)



- Vision: Research software and those who develop and maintain it are recognized and valued as fundamental and vital to research worldwide
- Mission: to advance the research software ecosystem by collaborating with key influencers and decision makers
- Founded in 2019, fiscally sponsored by Code for Science & Society
- ReSA has recently
 - Co-developed the FAIR for research software principles
 - Shared diversity, equity, and inclusion best practices at — Vive la difference - research software engineers workshop
 - Expanded its global mapping of the international research software _ community landscape
 - Gathered global research software funders to set the agenda for sustainable research software
 - Leading to ADORE.software (Amsterdam Declaration on Funding) Research Software Sustainability)
 - Collaborated in task forces on specific issues affecting the global research software community

- Individual Participation
 - Receive our newsletter
 - Join the ReSA Slack
 - Add to our funding call database
 - Join task forces focused on specific activities

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https://www.researchsoft.org

ADORE.software



- When ReSA formed, research software funding was an immediate topic
- Funders wanted to exchange experience and identify ways to have a greater impact on research software
- ReSA Funders Forum discussions and other concurrent discussions brought together to create "<u>International Funders Workshop: The Future of Research</u> <u>Software</u>" in Amsterdam in Nov 2022, with 45 funding organizations represented
- Discussed initial draft declaration, provided feedback
- Now have version 1.0, also via <u>ADORE.software</u>
- A stewardship group, comprising representatives of the signatories and supported by the ADORE.software secretariat, is responsible for overseeing and promoting the endorsement process, which is now starting

ADORE.software recommendations



Research Practice

- 1. Funders should stimulate 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 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 to ensure research software sustainability.
- 5. Funders should share information about their investments and work in a coordinated manner to cross institutional and national boundaries.
- 6. Funders should ensure that funding instruments are fit for purpose so that research software is both maintained & developed for the longer term.

People and Research Software

- 7. Funders should stimulate training, hiring, funding of professional research & technical staff to reuse, develop, maintain sustainable research software.
- 8. Funders should facilitate appropriate reward & recognition measures that enable career progression in creation & maintenance of research software.
- 9. Funders should require citation practices for research software that recognize substantial contributors to all aspects of the software.

Research Software Ethics

- 10. Funders should encourage the responsible use of appropriate indicators to assess the degree of permanence, reusability, impact of research software.
- 11. Funders should explicitly consider the environmental and social impact of the use of research software.
- 12. Funders should explicitly recognize that diversity, equity and inclusivity are significant factors in making research software sustainable.

Recommendations paraphrased, see ADORE.software for full version

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ADORE.software status

- V1.0 released in September 2023
- Also includes toolkit (<u>https://ADORE.software/toolkit</u>); provides additional definitions, details and examples to help adoption and implementation of the ADORE recommendations
 - Definition of research software, research software infrastructure, funders
 - Examples of funder programs, policies, resources, strategies, guidelines, recommendations, and networking opportunities
 - A living document, to be updated regularly, and with your suggestions
- Signatures starting to come in; please consider if your organization can
 - Become a signatory of the declaration (for research software funders)
 - Endorse the adoption of the recommendations; aim to implement them in your organization
 - Update other signatories and the community on your progress to implementing the recommendations
 - Become a supporter of the declaration (for everyone else)







We are here

- Research software is increasingly important to research
 - Organizations coming together to promote it and associated people
- Recognition increasing
 - Software citation starting to become accepted, w/ uptake from researchers, publishers, librarians, etc.
 - Software papers are partially a placeholder for software citation, but also have an important community function
 - Prizes appearing
- Research Software Engineers (RSEs)
 - Recently recognized as a role, but a long history
 - Now building community & making case for formal career paths
- People & organizations concerned with research software working together in ReSA

What you can do

- Promote software sharing and credit
 - When you are an author, cite the software you use
 - When you develop software, make it easy to cite
 - When you review, demand software be cited
- Support RSEs
 - Support software developers and maintainers
 - Consider how your organization does this, and if you can change it
 - See <u>http://us-rse.org</u> or <u>https://society-rse.org</u>
- Work to make sure software work is included in hiring and promotion for everyone
- Overall, raise awareness of research software as a key element of research
 - Understand that research software is not business software, w/ different goals, incentives, methods, practices, workforce, education
 - Join ReSA
 - Sign <u>ADORE.software</u>

Credits

- Thanks to Arfon Smith and Kyle Niemeyer for co-leadership in FORCE11 Software Citation WG
- And Arfon Smith for JOSS leadership
- And Neil Chue Hong & Martin Fenner for co-leadership in FORCE11 Software Citation Implementation WG
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- And colleagues Gabrielle Allen, C. Titus Brown, Kyle Chard, Ian Foster, Melissa Haendel, Christie Koehler, Bill Miller, Tom Honeyman, Anna-Lena Lamprecht, Michelle Barker
- And to the BSSw project (<u>http://bssw.io</u>) for a fellowship to pursue some parts of the citation work
- More of Dan's thinking
 - Blog: <u>http://danielskatzblog.wordpress.com</u>
 - Mastodon: @danielskatz@fosstodon.org