UNIVERSITEIT VAN AMSTERDAM

Guidelines for Research Data Management (RDM) Swammerdam Institute for Life Sciences

version 1.0

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Contents

Guidelines for Research Data Management (RDM) SILS (version 1.0)

1. Preamble

Research data management (RDM) concerns the organization of data, from its entry into the research cycle through to the analysis of the data, the dissemination of the results and the archiving of the necessary and sufficient information by which these results were achieved. If set up in an intelligible fashion, it can help to make the research process more efficient. RDM is an integral part of the research process, and aims to meet expectations and requirements of the university, research funders, and legislation.

The purpose of a RDM policy is to preserve research data, to make scientific research traceable, to facilitate the reuse of research data and to allow for corroboration of research results through re-analysis of research data[1].

2. Introduction

2.1. Background

Research Data can be defined as *"The recorded factual material commonly accepted in the scientific community as necessary to validate research findings"* (OMB Circular 110).
In life-sciences research, there are in essence three types of primary data: raw data, processed data, and analyzed data, as well as metadata describing each type of data (Figure 1).

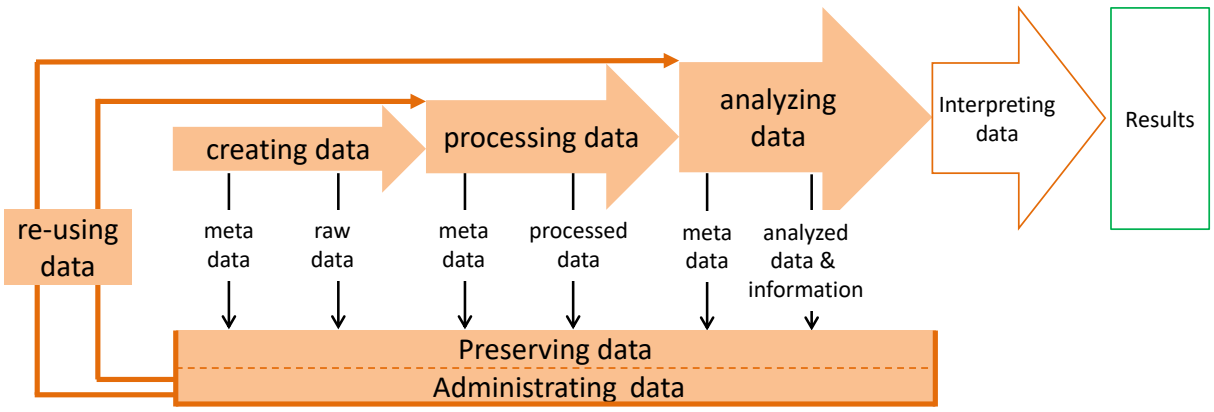

Figure 1. *Research data cycle*

More and more funders of academic research (including NWO and Horizon 2020) require researchers to manage their research data during and after their research. Also the UvA has formulated a policy for RDM[1] and at FNWI a 'Werkgroep Research Data Storage & Retrieval' has reported[2] on RDM. The way RDM is organized depends of course on the type of research and the RDM objective.

The four main objectives of RDM are[1]:

- Preservation: archiving research data in such a way that data can be retrieved.
- Traceability: allow others to retrieve the procedure plus the underlying data that form the basis for a scientific result.
- Reuse: allow reuse of research data in new analyses and/or in combination with other data.
- Corroboration of results via preserved data that can be traced and re-used.

At FNWI other often mentioned purposes for RDM were either postponed to address in a later phase of RDM ('Open-access data' and, closely related, 'protection of IP and/or privacy-sensitive data') or were deemed to be less applicable in the FNWI context ('reproducibility' because in sensu stricto this is in most life-sciences cases impossible and 'anti-fraud' because scientific fraud can be made more difficult through good traceability of research data but RDM in itself cannot prevent fraud).

2.2. Scope

SILS research is very diverse and it is impossible and undesirable to define a set of rules for RDM during your research. Hence, this *Guidelines* does not prescribe specific software applications for RDM that all research groups in SILS must use. It does not even demand that all research information is stored in a computer. Rather this *Guidelines* tries to convince you that you have at least to incorporate some basic form of RDM in your research, formulates a high-level policy of SILS towards RDM, and provides practical RDM handles.
As such it:

- describes in which research projects and activities research data must be managed;
- describes which research data must be managed
- covers the three different phases in any research project (starting up, execution and archiving, Figure 2) for which RDM must be set up properly. It gives recommendations on RDM in these specific phases.
- it highlights some of the solutions for RDM that via SILS or via the University Library are available to researchers.

3. RDM Policy SILS

3.1. Which research must have RDM

All research intended to generate results that will be or can be used in the scientific process and hence in the scientific community, must have a proper RDM in place. This means that all research, whether funded by University, 2nd geldstroom or 3rd geldstroom are subjected to RDM. The same holds for student internships and PhD research.
RDM can be implemented at the level of an experiment, a group of experiments or a coherent piece of research (= project). At which level you implement RDM is completely up to you and can be different for each part of your scientific research.

3.2. Which research data must be managed

The minimum set of metadata on biological input materials, laboratory protocols, metadata on experiment design, raw (measurement) data, processed data, analyzed data, computer scripts and software that form the basis for a scientific result and that is sufficient to allow others to retrace the experiment and the analyses that led to the mentioned scientific result.

3.3. When should RDM be applied

Research data should be managed throughout your research. Whenever research results are shared with the outside world a proper research data management is mandatory. In other words, RDM should be well-organized in all research leading to any of the activities below:
Do keep in mind that publishing entails:

- A publication
- A PhD thesis
- An oral presentation at a conference
- A published conference abstract
- An official progress report
- A patent description
- A report on a student internship

3.4. Who is responsible for RDM?

Each researcher in SILS is responsible for a proper RDM during his or her research. The overall responsibility on RDM lies with the Principle Investigator, which is typically the professor.
The (to be appointed) SILS Data Steward can assist and advice throughout all phases of RDM (drawing up Data Management Plans, metadata files, setting up archives).

- *Procedure for people leaving the project and/or SILS*

If a researcher leaves the study and/or SILS, the PI will appoint a researcher that will inherit the responsibility for the management of the research data that was produced by the departing researcher.

All relevant research data + the metadata belonging to this research data should be stored for at least 10 years after the date the research is presented (Note: this is a new SILS rule). This means that after publication, after the presentation of a report of a student internship, after the defense of a dissertation the research data + metadata has to be curated, and moved from the environment in which the ongoing research is performed to a data archive.

3.5. Phases of Research Data Management

RDM activities can be tightly linked to the life cycle of a research project itself (Figure 1). Below these RDM activities are described for the three different RDM phases (Figure 2).

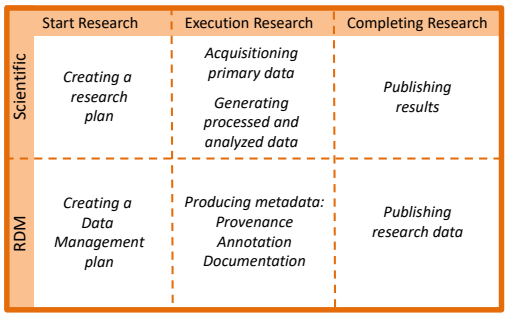

Figure 2. *RDM phasing parallels the usual phasing in scientific research*

3.6. Execution of RDM

3.6.1.Data Management Plan

At the start of each research within SILS, a Data Management Plan should be created. The format of the Data Management Plan is free, but it should contain the following information:

- information on the research (e.g. involved researcher(s), title, link to project proposal)
- estimation which data and metadata will be archived at the time of publication;
- the anticipated location(s) where data, protocols, scripts etc. will be archived;
- the anticipated locations(s) where the descriptions of data, protocols, etc. will be archived;
- the anticipated locations(s) where publications and supplemental information will be archived;
- if applicable an indication on any storage period other than 10 years;
- if applicable an indication of anticipated restrictions on data access;
- if applicable an indication of anticipated conditions on which the data might be shared.

Funding agencies such as NWO might impose a more detailed Data Management Plan than the above described minimum requirements. The Data Management Plan can be adapted during the research.

- *Responsibilities*
  - the Data Management Plan can be written by any researcher involved in the project, but must be approved by the PI;
  - the PI maintains a list that contains all approved Data Management Plans of current research in his/her group;
  - each researcher is responsible for adherence to the Data Management Plan and for changes to the plan if necessary. When changes to the Data Management Plan are approved by the PI, the list of approved Data Management Plans is updated accordingly.

A template for a Data Management Plan can be found here:
http://rdm.uva.nl/binaries/content/assets/subsites/research-data-management/datamanagementplan/uva_dmptemplateeng_v1_1.docx?2871507654245
A number of templates (including NSF, MRC, ZonMW and Horizon 2020) are available via:
https://dmponline.dcc.ac.uk/.

3.6.2.*RDM during research*

During research in many cases many files, scripts and (intermediate) data are produced that eventually are not used when the conclusions of the research project are drawn up. At the time of publishing your results you have to archive all *relevant* research data. Hence, what to keep and what to throw away.

To facilitate the process of research data archiving, it is wise to have a form of research data management *during* your research, otherwise it can be extremely hard to retrace everything after (long) studies. You could see it as an extended form of the familiar lab journal. Everyone in experimental sciences knows the value and necessity of lab journals for wet-lab activities, and these considerations equally apply to dry-lab activities related to your studies.

You need to have a system in place that traces and describes your research as it develops. This could be done via a simple file-folder system, provided you conscientiously maintain the development of metadata and the storage of data and information.

3.6.3.RDM after the research has finished: archiving.

Archiving means that you have to decide what data and metadata you need and want to store for at least 10 years in order to comply with the objectives of good RDM. Archiving means making inventory and throwing irrelevant data and metadata away.

- *Activities: linking result to protocols, lab journals, scripts etc.*

Usually in the publication phase (Figure 3) of research a selection of data and metadata is made that encompasses all the research presented in the publication (see 3.3 for types of publication).
For wet lab experiments there can be (primary) data (including derived metadata such as quality metrics, and other machine output) and (electronic) lab journals and/or files from notes software (e.g. OneNote). For dry lab experiments & analyses this can be analyzed data, a directory with scripts or workflows, an (electronic) lab journal and/or files from notes software (e.g. OneNote).
At the times when results are made public it is necessary to state *all relevant information* that relates to how the presented result(s) were obtained, such as:

- which samples were used
- which lab protocols were used
- which primary data was generated
- which processing protocols/scripts were used
- which processed data was generated
- which analysis protocols/scripts were used
- which analyzed data was generated

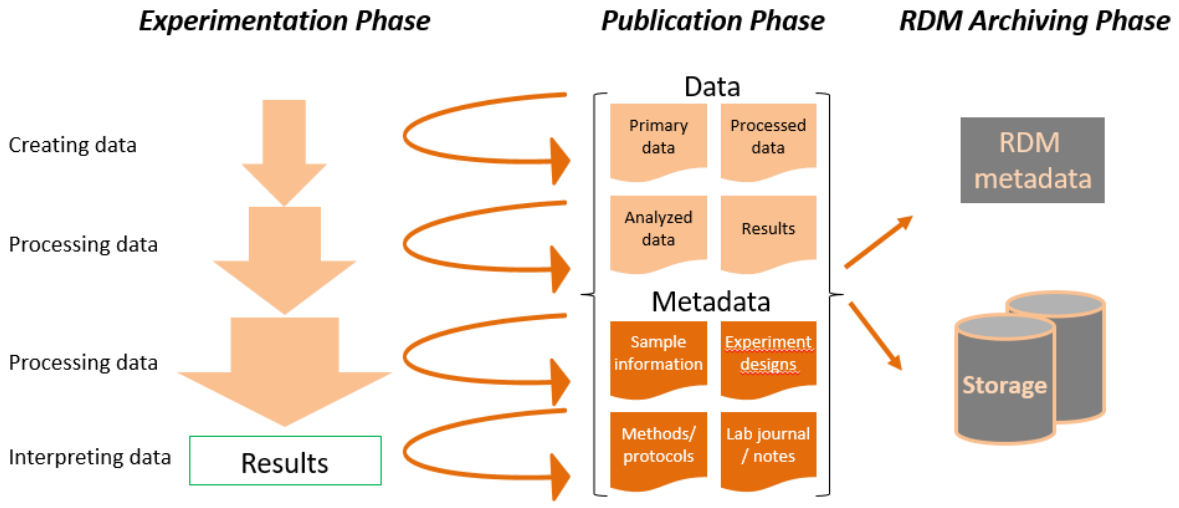

Figure 3. *Experimental phases and RDM*

It could be that a lab journal together with the M&M section of a manuscript is already sufficient to this ends. However, in many cases it is necessary to specify metadata (Figure 3, RDM metadata) to link to the lab journal and/or record the file names of the data, protocols and scripts used to the presented result.

- *Activities 1: providing metadata*

Also, the presented data must be annotated and described in such a way that it is clear what the data is about and how the data was produced. This step is essential to allow traceability and reuse of the data. The metadata (Figure 3) is stored in a file in the same directory as the data.
If applicable the following items can be recorded:

- the author(s) of the data set
- the machine the data was produced with & data of production
- a description of the dataset
    - period of acquisition
    - what the data entails
    - how the data was produced (lab journal & protocol link outs)
    - geographic location of the origin of the data
    - data classifications
    - coding (ISO, IEEE, etc.)
    - taxonomies
    - etc.
- digital identifiers (PID / DOI / ePIC)
- ownership, copyright
- limitations to access (e.g. embargo)

Currently many standards for metadata are emerging that might be used in this process of which the *Dublin core* http://dublincore.org/metadata-basics/ is a de-facto standard.

- *Recommendations*

A convenient way to limit the RDM work is to structure a project as follows:

- a project folder (and subfolders) that can be used by all researchers on a study.
- each experiment in a study has a separate folder with *analysis,* a *data* and a *scratch* folder.
- lab journals, notes, and other project related files are organized on the study folder level.

During research the experiments are analyzed in the scratch folder. As soon as an analysis becomes final it is moved to the analysis folder.

- *Responsibilities*

- Each researcher is responsible to comply with the conventions set in the Data Management Plan.
- Each researcher is responsible to describe and annotate his/her research data in such a way that the data in principle can be understood by others, solely on the basis of this description.
- The study leader is responsible to provide, for the duration of the study, a safe a secure space for the study data. Safe and secure means that of the data a regular back up is made.

- *Activities 2: collecting all elements*

- all relevant data that has been used to arrive at the communicated results must be collected, together with the procedures, protocols and scripts used.
- the data management plan will be part of the archive.
- the data must be properly annotated (adding metadata and adding an RDM Table of Content)

3.7. RDM storage

NWO prefers research data & results to be deposited in national or international repositories over an institutional repository. The advantage of such repositories (such as the European Nucleotide Archive, http://www.ebi.ac.uk/ena or GEO, https://www.ncbi.nlm.nih.gov/geo/) is better visibility and availability in comparison with a local repository. Moreover, provision of metadata is enforced and standardized, which greatly improves reusability of the data. However, not for all types of research such repositories are available and it may be that these repositories do not offer enough flexibility to store all relevant information of a research project. SILS has decided to set up a the SILS Research Data Archive that meets the goals of RDM as set in the Introduction.
Because life sciences data can be very large, it will not be feasible to hold all data during 10 years on spinning disks. Therefore, the archiving takes will take place on tape. For this SILS provides the means and in the appendix 4.1 the archiving protocol is described.

In addition to paragraph 3.6.3:

- For each project that is archived (an archive item), a minimum metadata set as to be provided (the Identifier Form). This data will enable the SILS Research Data Archive to be searchable and will make archive items identifiable. The metadata set can also contain information on an embargo period or on confidentiality.

After the archive item has been generated, it can be found at:
http://sils-tape.science.uva.nl/archive.php.

- *Recommendations*

If RDM is set up along the lines of the recommendations in paragraph 3.6.3. the archiving step only entails the removal of the *scratch* directories and the production of the identifier form.

- *Data belonging to other parties*

In case you make use of data that are owned by organizations, other universities, or persons, who would object to storage of this data by us, make sure that this is documented in your metadata file.

- *Responsibilities*

- The archiving step will be the responsibility of the project leader of the research project, a task that can be delegated. All researchers (staff members, lead scientists, PhD students and post docs) are eligible to this task. Bachelor and Master students should be taught RDM, the final responsibility of archival lies with the supervisor.
- Experts that may be consulted for specific matters for advice:
    - *SILS* RDM steward
        - Wim de Leeuw
    - Coordinator RDM support library UvA/HvA
        - Mariëtte van Selm
        - Kasper Abcouwer
    - Technical coordination RDM at FNWI
        - Jeroen Roodhart
        - Boy Menist

- *Rules on access to data*

The copyright of the data is formulated in the Data Management Plan. In the Data Management Plan also possible restrictions on access of the data (e.g. embargo periods, confidentiality) are mentioned. If a request arrives for data of a research project, the holder of the copyright or, if nothing is defined in this, the PI decides about the disposition of the data to the third party. A request for retrieval of an archive item should be done by the PI. A disclaimer (see Appendix 2) should accompany the data when send to third parties.

4. Appendix

4.1. Archiving protocol

4.1.1.Outline of the SILS Research Data Archive.

The principal investigator (PI) or group leader is in ultimo responsible that all research projects that have been carried out in his or her group are submitted to the SILS Research Data Archive. The project leader of the research project will be responsible for the composition of the archive item, a task that can be delegated. All researchers (staff members, lead scientists, PhD students and post docs) are eligible to this task. BA and Master students should be taught RDM, the responsibility of archival lies with the supervisor.

The archive keeps a relevant record of information on each finished research project in SILS. In some research areas, international repositories are available to make your data and metadata available (e.g. Short Read Archive SRA and Gene Expression Omnibus GEO-NCBI). Such repositories, together with the publication or report in which the link-outs to the repository are included, might be sufficient as an archive for your research. If this is not the case, if additional data must be archived or if the disposal of a local archive is desired as well, an entry in the SILS Research Data Archive should be made.

The SILS Research Data Archive contains the following components (figure 4):

- The central SILS Research Data Archive;
- A distributed copy of the SILS Research Data Archive: each group owns a set of tapes containing all archive items that belong to this group;
- A database of archive meta information with:
    - A register of all SILS tape archive entries;
    - All supplied information on archive entries (Identifier Forms)

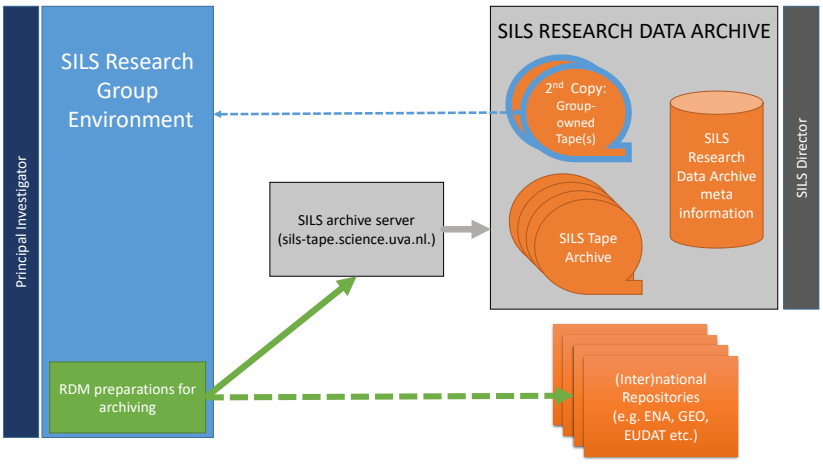

Figure 4. Archiving research project in SILS. Green: activities that must be taken by the researcher/submitter to the archive. Grey: activities taken by the SILS Data Steward. Orange: Archive elements. Blue dashed line: movements of distributed copy of SILS Research Data Archive.

4.1.2. Procedure

An outline of the procedure is given in Figure 5.

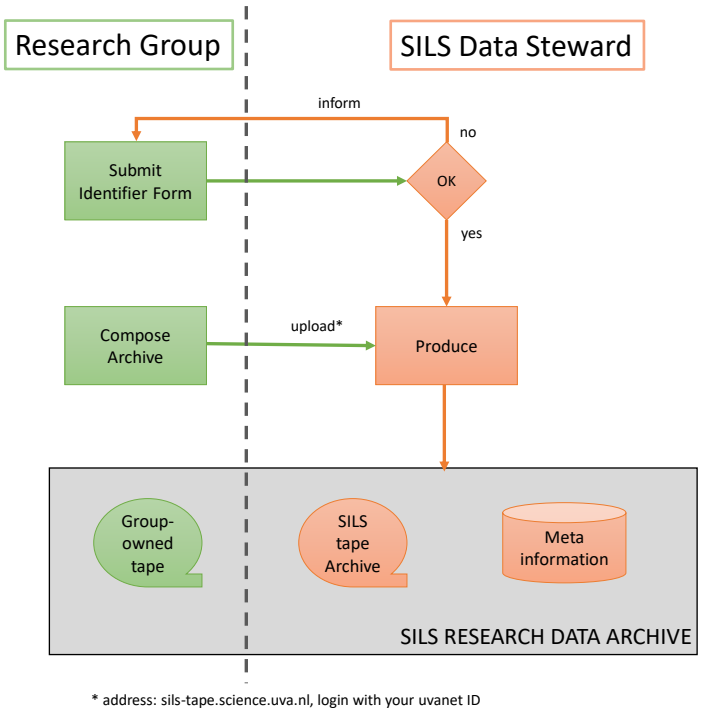

Figure 5. Workflow of the SILS Research Data archiving procedure. The three main steps in the procedure are indicated by numbers (see text)

- SILS archive: archive.rdm.sils@uva.nl

- Address to upload archive: sils-tape.science.uva.nl

upload using sftp or scp and login with your uvanet id.

1. ***The Identifier Form***

   Fill out and submit the identifier form (1, http://sils-tape.science.uva.nl/requestform.php) that contains the minimal information on the archive, and that includes:

   1. all information necessary to uniquely identify the archive item.
   2. last author or researcher responsible for the project and if applicable: first author.
   3. institutions involved
   4. funding agencies, stake holders,
   5. confidentiality and embargo's
   6. preservation period
   7. other remarks

   Once the identifier form meets the requirements, you will receive an email with the location to which you can upload your archive folder. All information in this form will be published (http://sils-tape.science.uva.nl/archive.php), unless you indicate an embargo and/or confidentiality. In that case, only the first six form-items will be published.

2. ***Composition of the archive***

   Next, create a folder on your local computer environment, which contains all data of the research project that needs to be archived. A zipped template folder structure can be downloaded here: http://genseq-h0.science.uva.nl/download/RDM/archive-template.zip (Windows and Mac). In the template, the optional *SILS Data Disclaimer (Appendix 4.3)* is included.

The following archive structure is recommended:

I. Publication or report
- manuscript and supporting information

Remark: it is possible that there is more than one publication belonging to this project.

II. Data Management Plan
- a copy of the Data Management Plan is archived

III. Project Information
- the Project Proposal
- Progress reports
- (Electronic) lab journals / note-taking software files
    - if lab journals are not digitally available a file describing the location of the lab journals is provided.

IV Experiments
- This folder contains subfolders with all experiments done in this project
- Each experiment subfolder contains:

IVa. Model/methods/materials
Anything relevant that is not in publication, and applicable:
- a link to the lab journals that concern this experiment
- specification of used materials
- specification of employed methods
- specification of apparatus
- specification of software

IVb. Data
Anything relevant that is not in publication or in (inter)national data repositories, and applicable:
- data
- meta data file

IVc. Data analysis
Anything relevant that is not in publication, and applicable:
- a link to the lab journals that concern this analysis
- specification of software / scripts used for the analysis
- specification of apparatus used to analyze data
- processed data presented in publication

V. Ethics (optional)
- Ethics Protocol and Approval (PDF exported from EC site)
- Information brochure, materials and debriefing brochure (as uploaded in the EC submission).

3. Archiving

You have received an email with the location to which you can upload your archive folder:

1. Upload the archive to this folder on the SILS archive server sils-tape.science.uva.nl using an sFTP client (e.g. FileZilla https://filezilla-project.org/ or Cyberduck https://cyberduck.io/?l=en). Connect to the archive server: sils-tape.science.uva.nl. Username and password are your uvanet.id and your uvanet.password. Upload your archive to the folder indicated in the email.
    - An example of this procedure using Cyberduck is shown in Figure 6. If you have any question regarding this step, please contact the rdm-archive.sils@uva.nl / tel. 020-525.7201.
    - If the archive exceeds 1TB: contact the Data Steward: an alternative way to transfer the archive to the SILS tape archive will be offered.
2. Once the archiving on the central SILS archive is ready, you will receive an email with the request to bring your group-owned tape. If you have not yet received such a tape or the tapes that you own are full, a new tape will be provided.
    - A second copy is written to the group-owned tape after which you are asked to collect the group-owned tape.
    - After both tapes are written the copy of your archive folder on the SILS archive server will be removed.

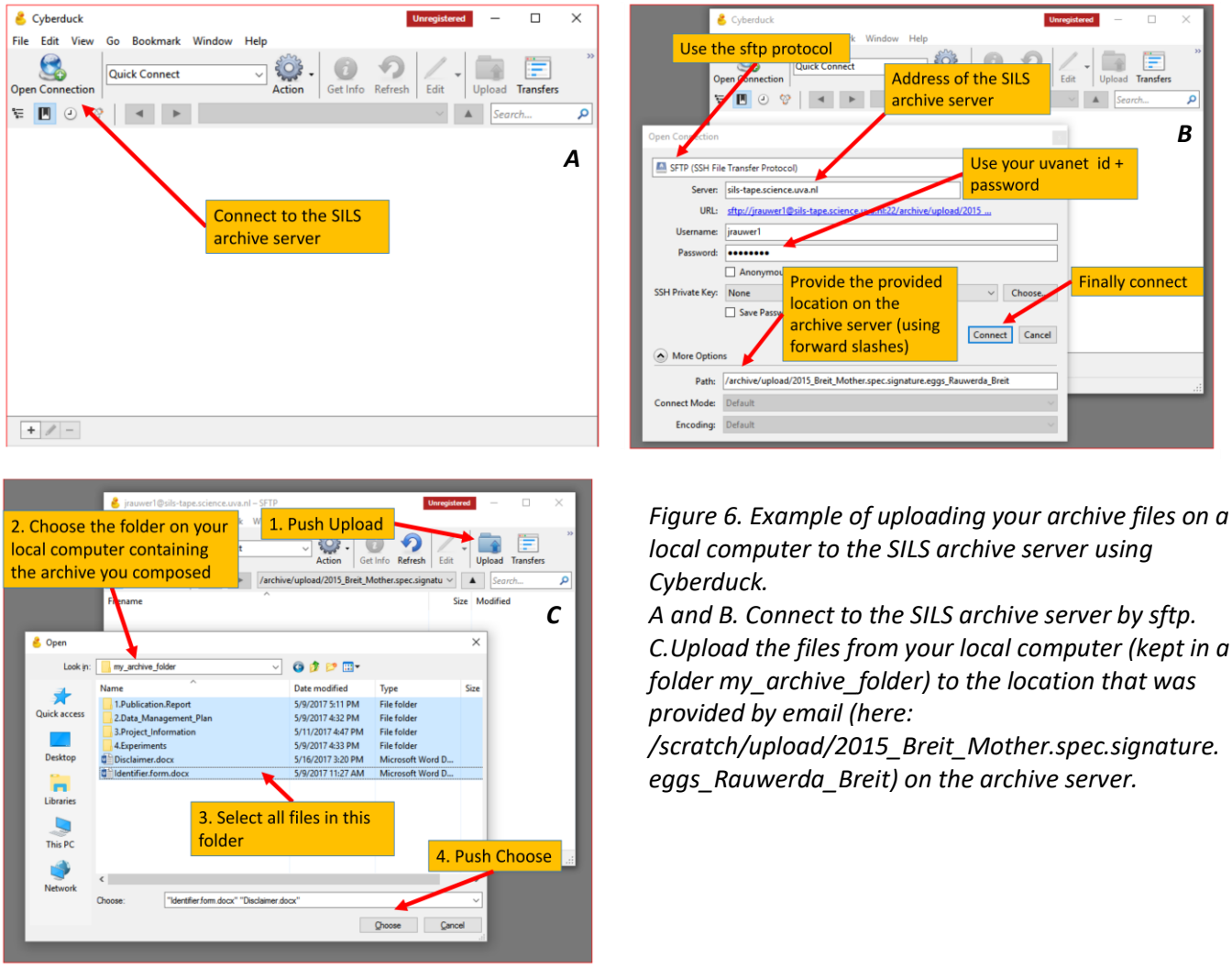

Figure 6. Example of uploading your archive files on a local computer to the SILS archive server using Cyberduck.
A and B. Connect to the SILS archive server by sftp.
C.Upload the files from your local computer (kept in a folder my_archive_folder) to the location that was provided by email (here: /scratch/upload/2015_Breit_Mother.spec.signature.eggs_Rauwerda_Breit) on the archive server.

What if you forgot something or want to correct a mistake?
After a project has been archived, mistakes can only be corrected by submitting a new version of the project to the archive. Once the corrected version is put on the SILS archive server this new version will be archived and registered. Older versions of the archives will not be destroyed.

The archive index
The contents of the SILS Research Data Archive can be found at http://sils-tape.science.uva.nl/archive.php.

Retrieving an archive item
A request for archive retrieval can only be done by the PI or group leader. An archive item will be provided for download from the SILS archive server via a procedure similar to the one described in 4.1.2.3.1.

4.2. Example RDM paragraph in research proposals

Below is an example of the questions used in the format of a recent NWO Vici call. In Italic remarks from the UvA Library on these questions are given, that may help you formulating texts. In future we may formulate some standard FNWI/*SILS* formulations one can use.

In this stage of the funding request process NWO would like you to answer four questions with regard to data management. The referees and the assessment committee can give advice on your answers, but this section of your application is not included in the decision about the awarding of the funding. If the funding is awarded, you'll be asked to submit a data management plan in which you describe in more detail how you will manage your data. For now, you can be brief; the main message you want to get across is that you're aware of the importance of good data management, already have put some thought into managing your data during the project you're asking funding for, and are willing to "help further science" by making your data available for reuse by other researchers after completion of your project.

1) Will data be collected or generated that are suitable for reuse?

Yes: Then answer questions 2 to 4
No: Then explain why the research will not result in reusable data or in data that cannot be stored or data that for other reasons are not relevant for reuse

It probably will not surprise you that the preferred answer to this question is 'yes', for a number of reasons. Data that can be reused by other researchers don't have to be generated or collected again, which could potentially save money (prevent funding from being spent on generating data that already have been generated). Creating or generating reusable data can also benefit you as a researcher: reuse of your data by colleagues, either in your own field of research or in other disciplines, reflects well on you. Moreover, by making your data available for other researchers, you demonstrate adherence to the Netherlands Code of Conduct for Academic Practice. However, there could be valid reasons to answer 'no', mostly to do with ethics and property rights. Datasets that contain personal data are harder to share with others, since leaving out personal data isn't always possible without making the data less usable for research, and if you use data from commercial partners you'll need their permission to make the data available for reuse

2) Where will the data be stored during the research?

In answering this question you'll want to demonstrate that you have thought about safety and security of your data: how are you going to prevent data loss (think computer crashes, backups et cetera) and how are you going to make sure that your data is inaccessible to people who shouldn't be able to access your data (especially important if you work with sensitive/personal data). A good place would be UvA network storage (H-drive): ICT Services regularly all files on the H-drive and can restore them if something should go amiss, and only you can access your part of the H-drive. However, if you work with very large datasets the H-drive may not be an option because you need more storage space than is available. In that case, the people at FEIOG (FNWI's own ICT Services) are best equipped to advise you, because of their technical expertise and knowledge of the FNWI technical infrastructure. You can reach them by email at feiog-science@uva.nl.
If you work with sequence data, the genseq environment maintained by Dr. Wim de Leeuw (w.c.deleeuw@uva.nl)@ MAD/RBAB might be an option for your data analysis & storage during research).

3) After the project has been completed, how will the data be stored for the long-term and made available for the use by third parties? To whom will the data be accessible?

After completion of your research project NWO wants you to deposit the data from your project in a repository (data archive). NWO prefers national or international repositories over an institutional

repository; since at UvA we do not yet have an institutional repository, you would have to choose a national or international repository anyway. Which repository that will be depends on what kind of data you want to deposit. In the Netherlands, we have two national repositories: DANS Easy, maintained by the KNAW-NWO institute DANS, and 3TU.Datacentre, maintained by the three Dutch technical universities. DANS Easy mostly contains data from Alfa and Gamma research, while 3TU.Datacentre is a more likely candidate for Beta research data. But you could also choose an international repository that caters to your field of research. To find out which repository would be best, you could ask around among colleagues, or we could dive into some registries of repositories to find a suitable candidate.
Choosing a data repository at this stage may seem a bit premature, but data repositories can have specific requirements: they only accept certain file formats, they only allow certain licenses on data sets, et cetera - those are things you don't want to discover at the end of your project, since fulfilling those requirements then could cost you a lot of time that you wouldn't have had to spend if you had known them in advance.

4) Which facilities (ICT, (secure) archive, refrigerators or legal expertise) do you expect will be needed for the storage of data during the research and after the research? Are these available?
The answer to this question of course highly depends on what kind of research you are planning and what kind of data you are going to generate or collect. This again is something you'll want to have the people at FEIOG advise on (see question 2); they also should be able to help you 'translate' the facilities you need into costs to put in your proposed budget. I hope this clarifies and gives you some direction. If you want me to go over your draft proposal, don't hesitate to send it to me, and feel free to ask any follow-up questions!

4.3. SILS Data Disclaimer for Open Access

[OPTIONAL. To be stored with the data.]
With respect to the datasets provided by the *SILS* of the University of Amsterdam, neither *SILS* nor any of its employees, makes any warranty, express or implied, including the warranties of fitness for a particular purpose, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information (either isolated or in the aggregate) contained, or represents that its use would not infringe privately owned rights.
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1. UvA. *Beleid voor Research Data Management aan de Universiteit van Amsterdam en Hogeschool van Amsterdam*. (2014).

2. RDM FNWI werkgroep. *Verkenning FNWI Research Data Management*. (2015)