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1 Summary

1.1 Synopsis

This document is part of the OSCAR project (Open ScienCe Aeronautic & Air Transport Research). The main aim of the OSCAR project is to pave the way for open science in the European Aeronautic and Air Transport (AAT) research landscape. For more information on the project, its workpackages, deliverables, and results please see the OSCAR project proposal or the other documents of the project available at the official website of the project: https://oscar-h2020.eu/.

This deliverable D4.4 presents an instruction on how EU projects can include open science principles into their daily project work by using the OSCAR open science code of conduct (henceforth often just called the OSCAR code).

This document has the following four main sections:

- Section 2 gives an overview over the OSCAR project, its main goals and its structure. The sub-section 2.4 is specifically dedicated to work package 4 (WP4) which is dealing with the development and implementation of the OSCAR open science code of conduct.
- Section 3 presents a theoretical background of codes of conduct, there purpose and interpretation.
- Section 4 deals with the theoretical background of open science and gives an overview about the main aspects of open science.
- Section 5 presents the open science code of conduct for the AAT sector developed so far (2020-11-24). See also deliverable D4.3. Furthermore, this section documents the development process of the OSCAR code of conduct, its man features and how it can be used in EU projects.

1.2 Objective and background

Due to changes during the project and the findings in previous tasks and deliverables, the objective of the deliverable 4.4 has changed (see detailed explanations in chapter 1.4).

The main objective of this document now is to give the AAT community context on open science and codes of conduct in general as well as an instruction on how to use the OSCAR open science code of conduct in EU projects.

1.3 Key results

- The OSCAR open science code will be about 15 pages short. The OSCAR open science code of conduct will be a hybrid rule-based, aspirational code of conduct with focus on simple principles. It is being developed in a hybrid button-up, top-down approach. It will contain about five simple open science principles including explanations and examples.

The OSCAR open science code of conduct will be easy to use and will contain practical implementation tips.

- The OSCAR open science code of conduct is tailored to the European AAT landscape.
- The OSCAR open science code of conduct is probably the first of its kind in Europe and most certainly the first of its kind of AAT sector.
- The use of the OSCAR open science code of conduct can improve European AAT research projects by accelerating innovation cycles and regain trust.
- This deliverable bases and documents the development of the OSCAR open science code of conduct.
- This deliverable contextualises the OSCAR open science code of conduct and gives important background information on codes of conduct and open science. It aims to enable the AAT community to better understand open science and codes of conduct. In particular, this deliverable aims to enable the AAT community to ethically and practically interpret and integrate not only the OSCAR open science code of conduct but open science and codes of conduct in general.

1.4 Changes to the deliverable at hand (D4.4)

At the beginning of the project, the initial plan was to integrate the OSCAR open science code of conduct into existing Consortium Agreement Models (CAM). During the project, this approach proved to be politically and organizationally unfeasible. The OSCAR team has de facto no or very little influence on the long-term orientation of the CAMs. Many different stakeholders influence the development of the usual CAMs such as IMG4, DESCA, etc. External political influence through a project like OSCAR is generally met with a negative attitude. Thus the OSCAR project chose an alternative approach which is more valuable for the AAT community and will support the process of integration of open science topics into the AAT landscape better, as well the implementation of the OSCAR open science code of conduct.

The surveys and interviews conducted during the OSCAR project showed that the AAT community needs guidance on how open science can be applied in AAT projects. See section *5.6 Benefits for the AAT community of doing open science, 5.7 Examples of open science applications* and *5.8 General step-by-step guide*. The project found that the term open science needs to be explained and contextualised. There are still some misconceptions about open science. See section *4.11 Common misconceptions about open science* and *5.9 FAQ*. In particular it is important showing the community, that open science does not only consist of open access but is a way of doing science consisting of many valuable principles and practices. See section *4 Theoretical background of open science*. Fraunhofer IRB also noted the need to discuss the concept of a code of conduct (henceforth often just called codes). See section *3 Theoretical background of codes of conduct* and *5 The OSCAR open science code of conduct*. There is also a need for clarification on how intellectual property rights (IPR) and open science relate to each other. Section *4.9 Open science and intellectual property rights (IPR)* and *4.10 Open science, privacy and security*.

To match the change of the content of task T4.4 and the linked deliverable D4.4., the title of the deliverable at hand changed accordingly from *"Modified Consortium Agreement models"* to: *"Recommendations for implementing the OSCAR open science code of conduct."*

The contents will be disseminated to the AAT community by the general OSCAR communication strategy in WP6.

2 Overview of the OSCAR project

2.1 Project description

The transport sector is a fast-growing sector of Europe and is associated with a wide range of economic and societal benefits – acting as a catalyst of technology transfer to many fields of mainly industrial application and vice versa taking up technologies from other sectors.

Today, the transport sector is confronted with diverse challenges: climate change, CO2 emissions, dependency from fossil fuels, evolving mobility demands, increasing global competition, emergence of new enabling technologies etc.

The transport sector as such is usually categorized by transport modes (car, road transport, rail, maritime, and aeronautics) and is characterised by the production and the operation of transport equipment. Additionally, both production and operation of transport infrastructure, as well as aspects of inter-modality of transport, need to be considered.

In this context, open science is considered as an important and promising opportunity to support the intended performance gain and innovations: "open science, open innovation and open to the world – the so-called 3 O's – are very likely to impact European innovation performance, growth and international competitiveness" (European Commission 2016b).

Traditional intellectual property rights (IPR) management focuses on keeping intellectual property under lock and key. The basic idea of traditional IPR management is to allow a company to use the advantages gained through secret i.e. non-disclosed research and innovation over its competitors in the market, via patents and licenses.

One of the basic principles of open science is to open up the scientific process as much as possible and thus to open up the intellectual property associated with the same scientific process. The basic idea of open science is to make knowledge and other intellectual assets freely available to the scientific community and society for reasons of fairness, good scientific practice, reusability and responsibility. It is important to note that even if you share your knowledge freely with the scientific community or with society, you are *not* giving up your copyrights to a creation. The creator retains all their rights to their creation in any case, even if they share it freely with others, for example by placing it under a free license such as a Creative Commons license (Creative Commons 2020).

It is fair to say, that conventional IPR management and open science are in a state of tension. If traditional IPR management and open science principles are described in generic terms, one could assume or perceive that open science and conventional IPR management contradict each other. Yet, it is important to note that open science and conventional IPR do *not* contradict each other, because they are completely distinct categories. In fact, open science and conventional IPR management can be well harmonized because there are *no logical or conceptual barriers* to this.

For example, "[…] while open access to research data […] becomes applicable by default in Horizon 2020, the Commission also recognises that there are good reasons to keep some or even all research data generated in a project closed." (European Commission 2020c)

The European Commission endorses the principle *as open as possible, as closed as necessary* "[…] and focuses on encouraging sound data management as an essential part of research best practice." (European Commission 2020c)

European AAT research covers the scale of technology readiness level (TRL) from level 1 to level 6 (Mai 2015; NASA 2020b; EARTO 2014). Arguably, the TRLs within a project are important factors that might influence how much research can be opened up. See also section *5.8 General step-by-step guide*. The more fundamental research is done, the more this research can be opened up. The more applied industry-related research is done, the less the research process can be opened up. Therefore, for the implementation of open science all aspects of the nature of each individual project need to be considered.

When implementing open science in European AAT research in general, reasonable compromises between closing and opening the respective project contents must be found. In doing so, special attention must be paid to the TRL of the respective project because TLRs could provide a good tool to decide where, how, and when assets can be opened. See also section *5.8 General step-by-step guide*.

The OSCAR project aims to contribute to resolving this perceived tension between open science and traditional IPR management in the AAT research sector and to harmoniously integrate both approaches. OSCAR addresses the issue of the current perception, acceptance, and implementation of open science in the field of European AAT research.

The main goal of the OSCAR project is to initiate and deliver optimized open science opt-in, opt-out or hybrid models for the European AAT research landscape. This requires an in-depth understanding of open science (principles, application, and benefits) as well as the structure of the European AAT landscape. It also requires convincing stakeholders of open science and guiding them through the integration of open science in their daily research work beyond single European projects.

2.2 Project structure

In order to realize the main goal and the related sub-goals of OSCAR, it is necessary to (1) have a detailed understanding of the level of awareness and acceptance of open science in AAT research, (2) develop and adapt implementation approaches for open science and (3) evaluate those approaches. While these three objectives provide tools and practical information to implement open science in AAT research projects it is also necessary to raise the motivation to implement open science within the AAT research community. This will be achieved with the following objectives:

- **Objective 1, WP2, WP3**: An assessment of the development of open science in European AAT projects since the beginning of the framework programme 7 (FP7), i.e. FP7 and Horizon 2020. Projects which relate at least partly to core AAT research, have been considered. These include JTIs Clean Sky and SESAR. . The assessment shall have been based on:

- a statistical analysis of estimated 1500+ collaborative research CSA projects. It should have revealed factors facilitating hampering the acceptance of open science approaches;
- an intense consultation phase with researchers and administrative or legal staff from industry (IND) including SME, research organisations (REC), universities, and academia research (HES) to gather comprehensive first-hand experience about awareness of open science as such, perceived benefits and drawbacks of the idea and potentially concrete examples.
- However, during the implementation of OSCAR legal constraints prevented accessing the needed EU eCORDA database, thus the statistical analysis had to be replaced by other means in order to identify suitable target projects.

- **Objective 2, WP4**: Develop an open science code of conduct that is tailored to the needs of the European AAT research landscape. This includes analysing current legal constraints and opportunities as well as implementing approaches of open science into the European AAT research landscape.
- **Objective 3, WP5**: Test the (interim) results in the course of WP4, to finalise recommendations targeting legal aspects and to validate the related open science code of conduct by simulating the application of the code of conduct in pilot project cases.
- **Objective 4, WP6**: Objectives 1 to 3 will contribute to increasing the implementation of open science in the European AAT research landscape. However, to achieve the ambitious goal of OSCAR, the acceptance of the idea as such, as well as the open science code of conduct is crucial. Different complementary communication measures will be conducted to maximise the intended acceptance of and support for open science in AAT research landscape.

2.3 Project steps

OSCAR achieves its goals in three consecutive steps:

2.3.1 Step 1: Information and opinion gathering

As a first step, the OSCAR consortium analysed the European AAT research landscape with respect to the awareness and the perception of open science. We have focused on collaborative research projects (FP7: Level 1 and Level 2, Horizon 2020: Research and Innovation Actions, Innovation Actions) and Coordination and Support Actions as most common instruments in AAT research. As mentioned before, the intended statistical analysis could not be performed thus another approach based on the professional experiences of the consortium members had to be developed.

In AAT, most research consortia consist of:

- Industry (IND incl. SME; from OEMs and the whole supply chain, represented by the IMG4 group);
- Research establishments (REC, represented by EREA);

- Academia research (HES, represented by EASN);
- In some cases, other types of partners as e.g. public bodies (PUB).

Some project consortia allow to distinguish between more research driven and more application driven projects, although there will be a level of uncertainty. There is also some tendency to associate lower TRL with the Framework Programmes and being driven by REC and/or HES. Vice versa higher TRL may be associated with some projects in Clean Sky with more emphasize in the role of IND, which might affect the degree of openness. See also section *5.8 General step-by-step guide*.

One main concern about open science and open access in particular is less the concept itself and more the way it is implemented by the European Commission through the Rules for Participation (RfP). First, in HORIZON 2020 there is no differentiation of the IPR and open access rules, for example with reference to the TRL (See section *5.8 General step-by-step guide*) or the nature of projects.There are also no specific rules applicable to public or private partnerships and it will probably remain so in HORIZON EUROPE. Currently, there is one single regime that applies to all situations, even where the difficulty of conciliate openness and projects with industrial partners is greatest. The objective is, nevertheless, a higher acceptance and understanding of the open science approach. To achieve this, it would be necessary to be able to apply slightly different and adapted or flexible open science rules, depending on the type of project and its contents. Secondly, rules applicable to open data are unclear, especially about the types of tools or platforms to manage and share research content openly and freely. This creates uncertainty and reluctance to share data.

One of the aims of OSCAR is to offer suggestions for more exact and diversified guidelines on how to implement IPR rules in coherence with open science.

The taxonomy of ACARE mentions 12 technical fields in total, such as Flight Physics, Aero-structures, Propulsion, etc., all with different needs that have to be considerend in order to achieve the FlightPath 2050 goals. During FP7 the European Commission introduced the first elements of open science – namely open access and later the open data pilot. Open access became mandatory in Horizon 2020, while open data remains a pre-set option, but consortia may opt out.

Since the beginning of FP7 and Clean Sky respectively an estimate of 1500+ AAT research projects have been started. Considering the publication of calls and the usual project duration there are likely up to 100 to 200 collaborative projects running in parallel. One can expect that clustering of projects by technical field and by other indicators provide sub-groups of sufficient size for a statistical analysis regarding the acceptance of open science. The primary focus was on the timely evolution open science by cluster, which turned out to be not feasible.

WP3 uses the services of WP6 (Networking, Dissemination & Exploitation) in order to spread publishable results to the research community and to attract project consortia for cooperation with OSCAR. The OSCAR consortium will select about 20 target projects, which agree to contribute to OSCAR within the framework of a non-disclosure agreement (NDA). Consortia will be interviewed on their experience with and expectations of open science in general, and how to implement open science in concrete projects. Practical hands-on experience will reveal opportunities and drawbacks. In addition, projects dealing with other transport modes, inter-modality and projects affecting indirectly AAT research shall be considered. WP3 will both address researchers executing these projects and administrative staff, i.e. representatives of the legal and the financial departments. Practical experience confirms – especially in medium and large organisations – the different points of view of researchers and administrative staff.

2.3.2 Step 2: Development of a preliminary code of conduct and considerations of legal constraints

WP4 mainly deals with the development of the OSCAR open science code of conduct. In this second step, the project is iteratively developing the methodology and conceptual framework for the open science code of conduct as well as the open science code of conduct itself. Step 1 so far (2020-07-13) gave insights into the level of understanding and acceptance of open science, its potential perceived conflicts with IPR within the AAT research projects. Step 1 also showed some important aspects of the open science community, i.e. plurality of platforms, data formats, practices, its dynamic development, etc. These early outcomes are a good base for the further development of our open science code of conduct.

One early outcome of WP4 will be an overview of the legal and contractual framework regarding open science and IPR in European AAT research projects. This overview will address rights and obligations related to open science in conjunction with aspects of IPR protection and competitiveness. Current grant agreement (GA) and CAMs deal – amongst other – with IPR protection issues. Thus, a practical implementation of open science should address those CAMs and should demonstrate compatibility of open science and conventional contracts in the project context. It shall be emphasized that the OSCAR consortium is *not* mandated to change these models. The OSCAR team may provide recommendations only on how open science and the open science code of conduct can be harmonised with conventional contractual practices within the European AAT research landscape. The remaining calls in Horizon 2020 and the preparation of FP9 together with the time schedule of OSCAR indicate that efforts should be spent on FP9.

The main goal of WP4 is to arrive at a short, clear and easy to use open science code of conduct for the European AAT research community. This open science code of conduct will be tailored for the implementation in European AAT research projects by addressing the specific requirements of the AAT field.

In **WP2** current CAMs regarding their compatibility with open science have been systematically analysed. The analysis showed that CAMs are indeed compatible with open science. For more information on this analysis, please refer to deliverable D2.3.

OSCAR is developing the first open science of conduct in the field of AAT research. The code of conduct aims to be short, clear and easy to use with all European AAT research projects. It should help researchers and engineers to integrate open science in their daily work. Furthermore, recommendations and guidelines on how to implement open science when reasonable shall be developed.

2.3.3 Step 3: Demonstration and validation

WP5 dealing with **Demonstration and Validation of the OSCAR open science code of conduct in Pilot Projects** is closely interacting with WP4 in order to feedback first experiences with interim WP4 results gathered in pilot projects. The iterative process will start with H2020 projects running at that time in which the application of the draft open science code of conduct will be simulated. OSCAR aims to answer the questions: Which impact of both the deliberation on the legal framework and on the code of conduct will be expected? Which suggestions will seem to be acceptable, which objections – be it regarding contractual aspects or regarding practical application – will come up? WP5 provides these answers to WP4 in order to develop more mature versions of the code of conduct and a set of recommendations for future CAMs. Once the partners agree on an acceptable level of maturity, OSCAR aims at a test implementation in at least one suitable project, ideally in one of each category of RIA, IA, and CSA. To achieve this ambitious goal the support of the European Commission will likely be needed, i.e. to identify such project(s) at an early stage of preparation.

2.4 Objectives and tasks of OSCAR WP4, legal and contractual constraints and the OSCAR code of conduct

The focus of WP4 is the development of the OSCAR open science code of conduct for the European AAT research projects and its implementation into legal frameworks in the EU project landscape. WP4 consists of five tasks and corresponding deliverables.

2.4.1 T4.1 Analysis of WP2 and WP3 results to identify state of the art, challenges, legal and contractual constraints and opportunities for implementing Open Science in AAT research (TL Fraunhofer IRB, M6 – M10)

In work packages WP2 and WP3 preliminary information on existing practices of and opinions on the application of open science in the European AAT research was systematically collected. In this task T4.1, the OSCAR consortium analysed the results of WP2 and WP3 as of 2020-07-13 with focus on the following aspects:

- Legal and contractual constraints for implementing open science in European AAT research landscape;
- Challenges for implementing open science in the European AAT research landscape;
- Opportunities for implementing open science in European AAT research landscape.

Based on the results of the analysis done in this task, the project derived measures to (a) implement open science in in the European AAT research landscape in general and (b) to tailor the development of the open science code of conduct in particular.

Deliverable D4.1 aggregates the results of D2.1, D2.3, D3.1 and D3.2 and derives key challenges, key opportunities as well as key actions for the implementation of open science in general and the open science code of conduct in particular.

The analysis performed in D4.1 supports and informs about the roadmap delivered with D4.2. The task T4.1 and the corresponding deliverable D4.1 strongly depended on the results of WP2 and WP3. The results from WP2 and WP3 were available later than planned. For more information on the delays, please see the documents of WP2 and WP3. Due to these delays, the activities in task T4.1 took place not only from month 6 to month 10 as planned but from month 6 to month 19. Because of these delays, the Deliverables D4.1 could also only be completed with a delay. Please see section 5 *Quality* in D4.1 for more information.

2.4.2 T4.2 Methodology & framework for the OSCAR code of conduct (TL Fraunhofer IRB, M8 – M11)

Based on

1. the analysis from T4.1,
2. the roadmapping workshop in Paris in November 2019 with Fraunhofer IRB, ONERA and SAFRAN on the legal and contractual constraints and opportunities and
3. on a literature research on the theory and development of codes of conduct,

the OSCAR consortium developed a road map and conceptual framework for the OSCAR open science code of conduct. This roadmap includes a detailed work breakdown structure, a Gantt chart and a maintenance and update pattern for the code of conduct (see D4.2).

The finalisation of deliverable D4.2 depended on the finalisation of deliverable D4.1 that was delayed due to delays in WP2 and WP3. Please see section 2.4.1 *Analysis of WP2 and WP3* above and section 5 *Quality* in D4.2.

An early initial draft version of the code of conduct was created by December 2019. This early draft of the code of conduct was given to the whole OSCAR consortium to give feedback and improve it.

The results of this task are delivered with deliverable *D4.2: Roadmap to Code of Conduct (including a maintenance workflow).*

2.4.3 T4.3 Iterative preparation of the OSCAR Code of Conduct and simulated application in pilot cases (TL Fraunhofer IRB, M12 – M18)

Based on T4.1 and T4.2 the first version of the code of conduct was available at the end of July 2020. The OSCAR consortium understands this code of conduct as a living document and this first version will be continuously and iteratively improved in the further course of the project together with all project partners. Fraunhofer IRB will incorporate new information and insights generated during the project into new versions of the code of conduct. The development of additional information material will be considered, such as

- Specifics of knowledge generation and research projects in the AAT sector;
- Development of auxiliary information to enable the AAT community to implement open science and its advantages (like faster innovation cycles) in their research projects.

It is planned to simulate the application of the open science code of conduct in selected pilot case projects (see WP5). The simulation process envisaged consists of adapting existing documents stemming from the project context on a trial basis so that they contain or reference the open science code of conduct. Alternatively, the OSCAR team tries to obtain the relevant information via a short survey. These findings will be used to further optimise the code of conduct.

The final version of the code of conduct, which will be available towards the end of the project, will be a tailored open science code of conduct that is short, clear and easy to use.

To communicate our open science code of conduct appropriate measurement like input to the general communication strategy and a dissemination plan (see WP6) will be developed along the way in close cooperation with activities in WP5 and WP6.

Some early results of this task will be delivered with deliverable *D4.3: First version of the Oscar Code of Conduct*.

2.4.4 T4.4 Instruction for implementing the open science code of conduct (TL Fraunhofer IRB, M14 – M16)

Consortium agreements (CAs) are legally binding contracts between all members of the consortium that are essential in all European projects. These documents regulate the mutual work and exchange between the project partners with focus on confidentiality, protection of background and foreground IP in a given project. CAs concretizes the more generic rules of the respective GA. WP4.4 demonstrates exemplary how CA models may take the code of conduct into account grant agreement. Consortium agreement models (CAMs) are contract templates that a project consortium can use to simplify the contract preparation.

At the time the OSCAR project proposal was written, it was planned to incorporate the open science code of conduct into existing CAMs. Initially the following two subtasks were planned:

- ST4.4.1 Selection of pilot cases (RIA, IA, CSA): here adequate pilot case agreement models should have been selected by comprehensible criteria.
- ST4.4.2 draft modification of CA models: The CA should have been modified. The adopted agreement models should have been tested and reviewed by members of the forum.

See section *1.4 Changes to the deliverable D4.4* for the change of this deliverable.

While the approach addresses European policy issues, the second activity works on the level of concrete projects.

The OSCAR project partners see it more feasible to create an instruction on how the OSCAR open science code of conduct can be implemented by future EU projects, especially from the view of the AAT sector. WP2 and WP3, as well as deliverable D4.1 describe the actual situation in the AAT community and the main concerns of the AAT sector to use open science. This task will address these concerns in detail and identify solutions for them.

The results of this task will be delivered with deliverable *D4.4: Instruction for implementing the open science code of conduct*.

2.4.5 T4.5 Finalization of the OSCAR Code of Conduct V.1.0 and the modified Consortium Agreement models on basis of WP5 results (TL Fraunhofer IRB, M24 – M28)

By incorporating the feedback and insights from all the other activities within the OSCAR project, including legal advice, the final version of the open science code of conduct will be prepared by Fraunhofer IRB. The code of conduct will then be communicated and disseminated according to our general communication strategy developed in WP6. The results of this task will be presented in deliverable *D4.5: Final version of the Oscar Code of Conduct.*

The result of D4.5 represents the main objective of the work package to provide an applicable open science code of conduct for future European research projects in the AAT sector.

2.5 Relevance and contribution of this deliverable to the objectives of OSCAR

The purpose of this deliverable is to give the AAT community an overview about actual definitions and requirements of the European Commission regarding open science in EU research projects. It is highly needed and an important groundwork to have a similar understanding about open science and its potentials, specifically for the AAT sector. In the next step this deliverable shows possible paths how the open science requirements can be matched with confidentiality restrictions of the AAT sector. During the interviews and talks, this emerged as a major concern from the AAT community. Many members, especially the industry, do not know exactly how they should interpret or implement the requirements for open science into their work.

3 Theoretical background of codes of conduct

In this section, we briefly discuss the theoretical background of codes of conduct. The theoretical background outlined here provides a basic understanding of the nature and function of codes of conduct. The concepts of normativity, morality and the science of morality i.e. ethics are essential. Codes of conduct are particularly interesting, because they lie at the intersection of morality, ethics and law; see section *3.4 Code of conducts*. The following sections will examine and explain these concepts briefly.

3.1 Normativity

When dealing with codes of conduct it is important to understand normativity, one of the most fundamental concepts.

If an airplane flies at 600 km/h, then the statement (D) "The airplane flies at 600 km/h." is a (true) *descriptive* statement because it describes what the case is. Besides descriptive statements, there are also *normative* statements. An example of a normative statement is: (N) "The airplane should be flying at 700 km/h". The difference between descriptive and normative statements can be easily seen by the so-called *direction of fit* (Anscombe 2000; Searle 1975). Descriptive statements like (D) have a truth-value that depends on what is the case. However, normative statements like (N) require the world to adapt in order to fulfil the conviction expressed in them. Normativity in general is a difficult concept and to address its deeper meaning and the philosophical discussion on normativity is beyond the scope of the report at hand. In the context of the present report, the following approximation is sufficient: Something has normativity if it entails that something ought to be (Darwall 2016).

Normativity is closely related to imperatives, prohibitions, duties, good and bad, right and wrong values, principles and norms. If we say that something should (or ought to) be so, or that something is required or prohibited, then we are dealing with normativity. For example, we believe that an aircraft *ought* to have an emergency chute. We firmly believe for example that it is *forbidden* to open the aircraft door during the flight. We think that the pilot of a helicopter *should* have passed a pilot's exam before taking off with passengers. However, we could ask the question: how do we know that a pilot should have passed a pilot's exam before flying with passengers? Of course, it is reasonable to believe that a pilot *should* have passed their pilot's exam; because otherwise the plane will likely crash and the passengers will likely die. Why is it imperative that the passengers do *not* die? Here we have reached the ground of normative reflection, because *the protection of human life is a fundamental normative premise*. If we make a normative statement, it must be based on such normative premises.

When dealing with normativity, in other words dealing with what is *ought to be* or demanded respectively not demanded or prohibited, it is important *avoiding* the *naturalistic fallacy* (Moor 1903a; Hurka 2015). The naturalistic fallacy is an error in logical reasoning, in which the conclusion is erroneously drawn from *being* to what *should be*. Just because an airplane has no wings does not mean that it should not have wings. Just because a pilot can crash, the aircraft does not mean that they should crash the aircraft. On the contrary, it is a pilot's duty to do everything possible to ensure that the plane does not crash. Furthermore, we can use Moor's *open-question argument* schema (Moor 1903b) to see that *we cannot deduce a normative property from a non-normative property*. For instance, only a few pilots are female, but is it right that only a few pilots are female? Just because it is the case that many pilots are male does not mean that many pilots should be male. Regardless of the true sources of normativity, which is still the subject of scientific research today (Korsgaard and O'Neill 1996), in our everyday lives we must first of all agree on common normative premises in order to be able to draw further normative conclusions. We must negotiate in a social discourse (Habermas 2001) what is demanded and what is permitted. We abide by the rules to which we as a society commit ourselves because we believe in their higher normative power.

3.2 Morality

The word "moral" has some positive and some negative connotations, depending on the socio-cultural or religious conditioning or background. In the scientific debate on morals (see the next section *3.3 Ethics*), however, the concept of morality is completely *neutral*. Morality can be seen as the totality of the normative rules, customs and practices of a society. However, it is important to note that the term "morality" could be used in two different ways (Gert and Gert 2020):

1. "descriptively to refer to certain codes of conduct put forward by a society or a group (such as a religion), or accepted by an individual for her own behavior, or
2. normatively to refer to a code of conduct that, given specified conditions, would be put forward by all rational persons." (Gert and Gert 2020)

In both cases, morality has something to do with norms in a more specific sense, namely with norms that have a specific normative (see section *3.1 Normativity*) or categorical character (Kant 2003).

At this point, it is important to distinguish between *law* and *morality*. Some things that are morally right are also legal, some things that are legal are also morally right. Yet, not everything that is morally right is also legal and not everything that is legal is morally right. For example, parking in the wrong place is forbidden by law but in some cases it is *not* morally wrong to park in the (legally) wrong place. On the other hand, medical animal testing is legally allowed but some would say that animal testing, at least in some cases, is morally wrong. In some states, the legal death penalty still exists today. However, many consider the death penalty to be morally wrong.

Fortunately, in the present context, we do not have to deal with such stark examples. Nevertheless, these points made earlier are important to get a sense of normativity, morality and our moral cognitive apparatus. A rough understanding of normativity, morality and ethics is a prerequisite for understanding what a code of conduct is. Ethics can help classify and systematise the complex moral and normative issues such as outlined above.

3.3 Ethics

Ethics or moral philosophy is the science of morality and includes the scientific investigation of normativity and its sources, analysing morally relevant actions and concepts, deriving normative value systems “systematizing, defending, and recommending concepts of right and wrong behavior“ (Fieser 2020). *Morality is the object of ethics; ethics is the science of morality.*

Sometimes, in colloquial language the term “ethical” and the term “moral” are used synonymously. Yet, strictly speaking, the term “moral“, as described in the section before, and the term “ethics”, as described here, have different distinct meaning. In colloquial language, the words “ethical” and “moral” are not only often synonymous, but also often have diverse negative and positive connotations, depending on the socio-cultural or religious context. In ethics, however, ethics and morality are completely neutral notions. In order to soften the connotations our readers might have, we deliberately choose the word “ethics” instead of “moral” in many places, but we mean “moral” in the according contexts.

Ethics can be divided into three main disciplines: (a) normative ethics, (b) applied ethics and (c) metaethics. Metaethics deals with the metaphysical, epistemic, and semantic status of moral concepts, conclusions, statements or actions. Normative ethics deals with the endeavour to derive concrete normative codes of conduct and moral standards. Applied ethics deals with the application of ethical analysis to actual cases.

Normative ethics and especially applied ethics can be used as the foundation in the development of a specific, concrete code of conduct. For the development of a code of conduct, one of the sub-disciplines of applied ethics is particularly important, namely business ethics. (Moriarty 2017)

3.4 Codes of conduct

Equipped with the appropriate theoretical foundations, codes of conduct can now be briefly determined.

3.4.1 Definition

A code of conduct is an explicit codification of implicit morally relevant values. It also is a set of rules or ideals of behaviour that govern the internal and collaborative work of an organisation, a group or a project. A code of conduct also often governs good professional practices and responsibilities. (Wikipedia 2020b)[1]

A code of conduct is an explicit voluntary commitment by an organisation, company, group or project to specific rules or ideals. This means that the rules declared in the code of conduct or the described ideals to be aspired are not in itself legally enforceable or binding (Wikipedia 2020b; Jenkins 2015). However, a code of conduct can in principle be part of a compliance management (Wikipedia 2020d) or *part of a contract* (Jenkins 2015; Koh and McConnell 2018) and thus can become legally binding.

Codes of conduct codify implicitly existing morally relevant values, and have, in principle, no legally enforceable basis in itself. The following two points are therefore of the utmost importance for the successful implementation of a code of conduct:

1. A code of conduct should be embedded in an implementation process. (Nijhof et al. 2003).
2. A code of conduct should, if possible, be incorporated into contracts.

See also section *3.4.3 Success factors and components of a code of conduct*.

A prominent example of a code of conduct is the code of conduct of Alphabet Inc. (the holding company of Google). In an earlier version of the code of conduct prior to Google's restructuring to become Alphabet Inc., the motto of the code of conduct was the phrase "Don't be evil" (Wikipedia 2020c). However, Google has been criticised time and time again for the hypocrisy of this motto (Cringely 2014). Please note that the code of conduct cited here is mentioned solely because it is

[1] Throughout this deliverable, from time to time we quote Wikipedia. Whether Wikipedia is citable is still under discussion. (Wikipedia 2020h; Casebourne et al. 2020; Harvard University 2020) We have carefully reviewed all our sources and checked for quality and correctness. We have paid particular attention to our Wikipedia sources. We have decided to cite Wikipedia in some cases as a source if and only if the entry in question was good enough and there was no other better quality source. Wikipedia was often a high quality source, especially in case such as open science, open source, computer science or cryptography. Where possible, necessary or sensible, we have always consulted alternative or complementary quality sources to the Wikipedia source.

among the relatively well-known codes of conduct and *not* because we particularly support this code of conduct or the company behind it. It just serves as a prominent example. For a list of interesting codes of conduct, see also section *3.4.4 Examples of codes of conduct.*

3.4.2 Approaches and types

In general there are two main types of codes of conduct (Whitton 2009; Laine 2018):

1. *Aspirational* codes of conduct and
2. *Rule-based* codes of conduct.

In an aspirational code of conduct, generally, higher ideals are formulated and these ideals should be striven for. An aspirational code of conduct refers to general values, norms or standards. Such a code of conduct is abstract and generic by nature. The disadvantage of an aspirational code of conduct is that the target group must (a) have more background understanding and (b) invest more work in deriving specific instructions for action. The advantage of an aspirational code of conduct is that the target group enjoys greater flexibility and freedom.

In contrast, a rule-based code of conduct, formulates specific rules which are to be followed. The disadvantage of a rule-based code of conduct is that the target group does not have as much flexibility and freedom and may find the rules restrictive. The advantage of a rule-based code of conduct is that the target group does not need (a) a general background understanding and (b) to invest work on its own to interpret and implement the rules.

Furthermore, there are two styles to develop a code of conduct (Whitton 2009; Laine 2018):

1. The *top-down* (leadership, authoritative) approach or
2. The *bottom-up* (community driven, peer-regulated) approach.

In a top-down approach, the employer or the organisation's leaders initiates the development of a code of conduct and determines the values and standards.

With a bottom-up approach, the community or peer group initiates the development of the code of conduct and sets the values and standards themselves.

Both the two types and the two styles of codes of conduct of code of conduct development have pros and cons. An aspirational code of conduct developed in a bottom-up approach is liberal yet vague and difficult to develop. A rule-based code of conduct developed in a bottom-up approach is restrictive yet clear and difficult to implement. An aspirational code of conduct developed in a top-down approach is liberal yet vague and easy to develop. A rule-based code of conduct developed in a top-down approach is restrictive yet clear and easy to implement. The trade-off between the two development styles and the two development approaches can be seen in Table 1.

	Aspirational	Rule-based
Bottom-up	• Liberal • Hard to develop	• Restrictive • Hard to develop
Top-down	• Liberal • Easy to develop	• Restrictive • Easy to develop

Table 1: Trade-off of different code of conduct types

3.4.3 Criteria, success factors and components of a code of conduct

It is not entirely clear whether or how codes of conduct work. There is evidence that codes of conduct have only a limited influence on the (ethical) behaviour of individuals. (Cleek and Leonard 1998) However, regardless of the question of their effectiveness, there are good reasons to have a code of conduct (see section *3.4.1 Definition*). For a code of conduct to fulfil its purpose, i.e. to influence people to behave in accordance with certain ethical values, there are a few basic conditions.

Ethical competence

Codes of conduct are not just documents that have an intrinsic effectiveness. Nor are the principles and values codified in codes of conduct self-fulfilling. Codes of conduct must be interpreted and implemented. This interpretation and implementation requires a certain minimum *ability to make ethical considerations*, make ethical decisions and behave morally. (Whitton 2009) See also *section 3.1 Normativity, 3.2 Morality* and *3.3. Ethics*. For a code of conduct to fulfil its purpose, the persons to whom it applies must be *ethically competent*. (Whitton 2009) In case of doubt, this ethical competence must first be learned. In order to develop the ethical competence of adults, Whitton (2009) suggests that the code of conduct should be accompanied by additional training materials such as introductory videos, realistic ethical dilemmas and moral scenarios.

Adam and Rachman-Moore (2004) argue similarly to Whitton (2009). Informal organisational values and personal examples are more important than formal implementation methods of a code of conduct. (Adam and Rachman-Moore 2004)

Implementation process

For the code of conduct to be effective, it is important that there is a well-planned and methodologically sound *implementation process* in addition to the mere document. (Nijhof et al. 2003) In order to methodically accompany this implementation process, Nijhof et al. (2003) propose an assessment method based on the European Foundation for Quality Management (EFQM) model. The method proposed by Nijhof et al. (2003) consists of 10 steps of organisational self-assessment and includes planning activities, questionnaires and meetings.

Legal framework

Kenneth Hayne argues that it is important making codes legally binding. (Koh and McConnell 2018) At least two jurisdictions in the context of banking show that the legally binding nature of codes works in principle. (Koh and McConnell 2018) According to Kenneth Hayne, simplicity of the code is key because otherwise it is too hard to know and follow the rules. (Bant and Paterson 2019)

Important components

A study by Lidner (2004, 2) on codes of conduct in open source projects shows that successful codes of conduct share common components. Important "elements of successful implementation" of a code of conduct are:

1. "a participatory development process",
2. "strong leadership",
3. "ensuring the code is embedded in a wider integrity management framework",
4. "structures and mechanisms for guidance, monitoring, review and enforcement",
5. "dissemination",
6. "building capacity",
7. "creating incentives for compliance".

Tourani, Adams, and Serebrenik (2017, 28) identify five components of successful codes of conduct:

1. purpose,
2. honourable behaviour,
3. unacceptable behaviour,
4. enforcement and
5. scope.

(Tourani, Adams, and Serebrenik 2017, 28)

In summary, our analysis allows us to identify the following criteria for a successful code of conduct:

1. The rules or ideals are morally relevant and legally sound.
2. The rules or ideals are clear and unambiguous.
3. The rules or ideals are realistic and can be easily implemented.
4. The code of conduct is easy to use.
5. The code of conduct contains good examples of application depending on concrete scenarios.
6. The code of conduct is visually and content-wise appealing and overall gives the recipient group a good user experience.
7. The code of conduct motivates (inceptives) the recipient group to follow the rules or strive for the ideals.
8. The code of conduct contains clear indications of the possible consequences of not following the rules or ideals and values good behaviour.

9. The code has a clear purpose and scope.
10. The code of conduct is part of a bigger legal or compliance framework.

These criteria were taken into account in the creation and development of the OSCAR code.

3.4.4 Examples of codes of conduct

It is a good idea not to reinvent the wheel and learn from the mistakes and successes of existing codes. Therefore, against the background of the outlined criteria (in section *3.4.3 Success factors and components of a code of conduct*) for a successful code of conduct, we have reviewed some existing codes and identified the following four examples.

DFG Guideline for Safeguarding Good Research Practice

An interesting example of a scientific code of conduct is the Deutsche Forschungsgesellschaft (DFG) *Guideline for Safeguarding Good Research Practice*. (DFG 2020) This code of conduct is developed as rule-based and predominantly top-down. It is widely adopted, as all major scientific organisations in Germany are members of the DFG.

Contributor Covenant

Another example is the *Contributor Covenant.* (Ehmke 2020) This aspirational type code of conduct mainly addresses open source software projects. “The Contributor Covenant was created by Coraline Ada Ehmke in 2014 and is released under the CC BY 4.0 License.” (Ehmke 2020) Everybody can contribute to its further development. This means that it is a predominantly bottom-up developed code of conduct.

European code of conduct for research integrity

For the OSCAR code of conduct the E*uropean code of conduct for research integrity* from the institution ALLEA was a good reference. (ALLEA 2017) It addresses the principles of research integrity on a European level. The principles of good scientific work are the fundament for the open science principles and includes them.

Ethical Principles of Psychologists and Code of Conduct

Yet, another interesting code of conduct worth mentioning is the *Ethical Principles of Psychologists and Code of Conduct* (American Psychological Association and reserved 2020). This code is relatively comprehensive and deals a lot with interpersonal aspects.

Both, the *DFG Guideline for Safeguarding Good Research Practice* (DFG 2020) as well as the *Contributor Covenant* (Ehmke 2020), form the basis for the of the OSCAR code (see section *5 The OSCAR open science code of conduct*) in content, structure and style. Fraunhofer IRB choose those two codes of conduct as a basis for the OSCAR code of conduct because they match the criteria described in section *3.4.3 Criteria, success factors and components of a code of conduct* and are supported and used by many organisations and projects.

4 Theoretical background of open science

In this section, we briefly describe the theoretical background of open science. The aim of this section is to give an overview of the basic concepts, principles and practices of open science. The theoretical background of open science outlines aims to help understand its complex relationships with other areas. It also aims to help clarify frequent misconceptions regarding open science.

4.1 Defining open science

Open science is a way of doing science. Open science can be understood as a specific way of conducting research. One of the main goals of open science is to make the entire scientific process—including its inputs, outputs and intermediate results such as hypotheses, data, publications, peer reviews, methods etc.—as open as possible for as many as possible. (Bezjak et al. 2018; Fecher and Friesike 2014; FOSTER 2020b; Wikipedia 2020a)

It is important to note that there is currently no generally accepted single definition of open science. The definition given here is the result of a careful compilation of different definitions from different sources. The lack of a consensus on what open science actually is can be interpreted as an expression of the fact that the open science phenomenon is still quite young and is developing organically.

Nielsen (2011) gives the following definition of open science:

> “Open science is the idea that scientific knowledge of all kinds should be openly shared as early as is practical in the discovery process.” (Nielsen 2011) See also Gezelter (2011).

The Open Science Training Handbook (Bezjak et al. 2018) gives the following definition of open science:

> “Open Science is the practice of science in such a way that others can collaborate and contribute, where research data, lab notes and other research processes are freely available, under terms that enable reuse, redistribution and reproduction of the research and its underlying data and methods.” (Bezjak et al. 2018)

Watson (2015) defines open science as “the practice of making everything in the discovery process fully and openly available, creating transparency and driving further discovery by allowing others to build on existing work.” (Watson 2015)

Vicente-Saez and Martinez-Fuentes (2018) conducted a systematic literature review and derived the following definition: “Open Science is transparent and accessible knowledge that is shared and developed through collaborative networks” (Vicente-Saez and Martinez-Fuentes 2018, 6–7)

On the one hand, these examples show how different the definitions of open science are in their wording yet, on the other hand how similar they are in their meaning. We cannot provide an exhaustive conceptual analysis here. We are convinced that the above definition is sufficient for the purposes of the present deliverables. For further information on open science, its definitions and key concepts see (Bezjak et al. 2018; Masuzzo and Martens 2017; European Commission 2016; 2017b; Fecher and Friesike 2014; Watson 2015; FOSTER 2020a; Vicente-Saez and Martinez-Fuentes 2018).

4.2 Main principles and characteristics of open science

As outlined above, there is no generally accepted single definition of open science. The aforementioned definition of open science as a way of conducting science in which as much of the content of the research lifecycle as possible is opened up to as many as possible includes various concrete forms of doing open science. Just as with the general definition of open science, there is no agreement on the more specific instances or forms that constitutes open science.

One approach to further determine open science is to classify it according to certain principles, practices, characteristics and indicators. This methodological approach is quite salient yet usually implicit in the relevant literature. We give here only a few examples of such classifications.

Wikipedia (2020a) for example lists the following principles of open science:

- Open source,
- Open data,
- Open access,
- Open methodology,
- Open peer review and
- Open educational resources.

AIMS (2020) classifies open science by characteristics and indicators. According to AIMS (2020) some characteristics of open science are:

- Open scholar communication,
- Open research data and
- Open access publications.

Some indicators of open science according to AIMS (2020) are for example:

- Open peer review,
- Researcher attitude towards open access,
- Researcher attitude towards sharing and
- Research and data repositories.

FOSTER (2020b) offers a taxonomy of open science with the following items on top level (see also Figure 1):

- Open access,
- Open data,
- Open reproducible research,
- Open science evaluation,
- Open science policies and
- Open science tools.

Bezjak et al. (2018) subsumes the following practices and areas under open science "open access to publications, open research data, open source software/tools, open workflows, citizen science, open educational resources, and alternative methods for research evaluation including open peer review". (Bezjak et al. 2018)

Another way to determine open science more specifically are the five schools of open science, proposed by Fecher and Friesike. (2014). See section *4.4 Five schools of open science*.

4.3 Best practices and indicators of open science

In this deliverable, we assume that open science includes the following practices, each of which can also be expressed by a rule of thumb (principle):

- **Open access**
  The rule of thumb of this practice is to make scientific publications freely available. (Suber 2012; 2020; Wikipedia 2020q) There are different strategies for publishing according to the open access practice, three of them are (Suber 2012; 2020; Wikipedia 2020q; Schmeja 2018):

  - Diamond open access
    Diamond or platinum open access means that the publication is published in an open access journal. The publisher does not require article processing charges (APC) nor do they ask the readers to pay. Therefore, these journals or publishers are often financed by third-party funds and donations.

  - Gold open access
    Gold open access means that publications of scientific work are directly published in an open access journal or an open access monography. There exist different ways of how the publications are financed. The most common way is the article processing charges (APCs). These APCs are also charged to the author for conventional, closed publications. Other financing options can be sponsoring, sale of printed versions, support from communities, institutions or organisations (open-access.net 2020). In the case of EU research projects, the European Commission offers to reimburse costs for open access publication (see the H2020 Annotated Model Grant Agreement V5.2 Article 6.2.D.3 "Cost of other goods and services".

The cost must be mentioned when submitting the proposal. For more information see also the H2020 Online Manual) (European Commission 2019c).
(Schmeja 2018; Fuchs and Sandoval 2013).

- Green open access
  Green open access is the additional publication of scientific work on an institutional repository (open-access.net 2020) like *arXive.org* (2021) or a private website, also known as self-archiving. To be compliant with the H2020 requirements each publication stemming from a research project funded by the EU has to be published as an open access publication within a period of 6 months. With the help of SHERPA/RoMEO (https://v2.sherpa.ac.uk/romeo/), individual publishers and journals can be compared in terms of their different open access policies and publishing conditions.**Fehler! Linkreferenz ungültig.** (Sherpa Romeo 2020; open-access.net 2020; European Commission 2020h)

- **Open data**
  The rule of thumb of this practice is to make your research *data* freely available. (Wikipedia 2020o) In the narrower sense, data means the concrete data records on which the published works are based on. See, for example, the important FAIR Data principles (Findable, Accessible, Interoperable, Reusable). (GO FAIR 2019)

- **Open source**
  Open source software is software whose source code is openly accessible. In the context of scientific work, this means that software that is created and used during the research process, should be openly available, modifiable, distributable and re-useable by other researchers. (Open Source Initiative 2021; Wikipedia 2020v) Among many other things, open source enables the verification of research results and minimizes redundant software developments, which can lead to savings of research funds.

- **Open notebooks**
  Open (research) notebooks create transparency about scientific primary record of research by not only summarizing the overall results in an article but also providing early insights and documentation into how the research progressed in detail. It can contain diaries, workbooks, laboratory research records, journals etc. (Wikipedia 2020f; Salvagno 2012; FOSTER 2020d)

- **Open peer review**
  In principle, the peer review process increases the quality of scientific publications. Up until now, peer review often took place behind closed doors. A closed peer review is prone to errors and such a closed process can be exploited to push through certain subjective interests unnoticed. An open peer review ensures neutrality and foster open and fair communication between the parties. An open peer review also increases the recognition of the reviewer's work. Examples for open peer review journals are: GigaScience (http://www.gigasciencejournal.com/), PeerJ (https://peerj.com/) and F1000 Research (http://f1000research.com/) (Ross-Hellauer 2017; Wikipedia 2020u; AG Open Science 2020) F1000Research has recently received funding from the European Commission to develop a platform where scientists can publish easily and at no additional cost. (European Commission 2020c)

- **Open educational resources**
  Open educational resources is the practice where teaching or training materials such as books, videos or transcripts are made freely available. It contributes to ensure equal opportunities for education worldwide and it promotes the mega trend towards the knowledge society and lifelong learning. (Wikipedia 2020j; UNESCO 2020b)

- **Open methodology**
  The rule of thumb of this practice is to document your scientific methodology and methods and make it freely available. (Open Science AG 2020)

- **Citizen science**
  Citizen science is science that is carried out with both professional scientists and non-professional scientists. The rule of thumb in citizen science is to open your research to people who are not full-time or professional scientists. Citizen science is all about being inclusive and about the integration and engagement of the civil society in research project to make the research life cycle more accessible, transparent, inclusive and understandable. (Gura 2013; Wikipedia 2020t) The *European Citizen Science Association* formulated a detailed explanation of the different variation and characteristics of citizen science, see Haklay et al. (2020).

- **Open infrastructure**
  The rule of thumb of this practice is to make the infrastructure of your research freely available and reusable. (Fecher and Friesike 2014)

- **Open metrics**
  The rule of thumb of this practice is to make the metrics with which you measure the scientific impact freely available. (Fecher and Friesike 2014; FOSTER 2020c)

An overview over the wide range of open science practices and categories can be seen in the open science taxonomy developed by the EU project FOSTER (2020b), see Figure 1.

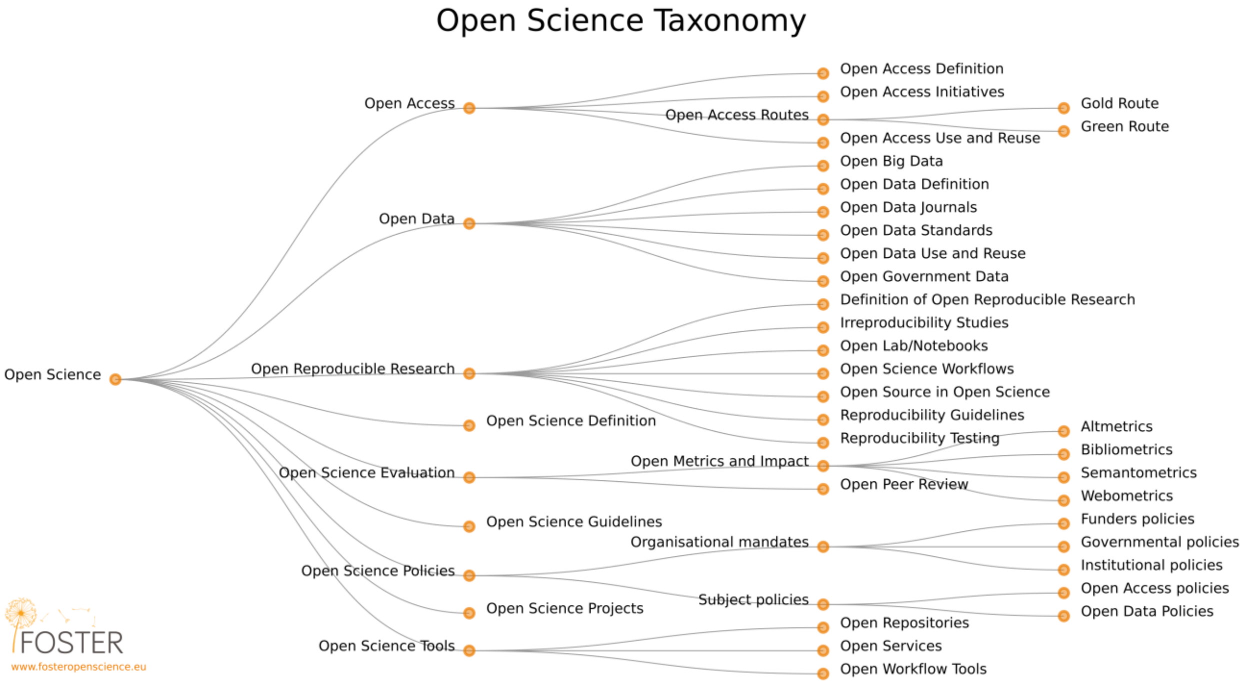

Figure 1: Open Science Taxonomy from the EU project FOSTER

4.4 Five schools of open science

Open science is a pluralistic, rapidly and dynamically evolving field, driven by the mega trend of digitalisation. Hence, it is difficult to give an adequate classification of open science. Open science can be interpreted in a narrow sense and in a broader sense. The section *4.1 Open science definition* describes open science in a narrow sense: open science as a certain way of doing science.

In contrast to that, open science in a broader sense can be understood not only as a specific way of doing science but as a *scientific-political movement* or five *schools of thought* (Fecher and Friesike 2014). These five schools of thought have certain, slightly different agendas (Fecher and Friesike 2014). Fecher and Friesike (2014) propose the following five schools of thoughts:

- *The democratic* school of thought aims to make *knowledge* accessible to as many people as possible.
- *The pragmatic* school of thought aims to open up the *process* of knowledge production.
- *The infrastructural school:* The goal of this school of thought is to develop *platforms*, tools and services that are freely available.
- *Public aim:* The goal of this school of thought is to make science freely available to *citizens*.
- *Measurement:* The aim of this school of thought is to develop freely available *metrics*.

4.5 Open science and related fields

Open science is a pluralistic and dynamic phenomenon with many facets. It relies on general ethical values, principles and practices that are deeply rooted in society and science. (Düwell 2019) Thus, it is not surprising that open science has many similarities with other fields, movements and initiatives like the responsible research and innovation (RRI) initiative. (European Commission 2021; FIT4RRI 2021)

Although open science has many overlaps and points of contact with other topics, it is important to clearly distinguish between them. This section provides a brief overview of how open science relates to other fields.

4.5.1 Open science and responsible research and innovation

There is a great thematic proximity between open science and RRI. This closeness can be seen, among other things, in the fact that open access is part of the principles of RRI. Furthermore, one of the main goals of RRI is to make science, research and innovation more responsible and inclusive. Responsibility in turn is one of the fundamental values not only of science but also of all society. This means that open science and RRI are closely linked and they reinforce each other.

4.5.2 Open science and sustainability

There is also a great thematic proximity between open science and sustainability in general. (Grahe et al. 2019) In particular, the thematic proximity can be seen, among other things, in the fact that the 17 sustainability goals of the United Nations includes “Quality Education” (goal 4), “Gender Equality” (goal 5), “Industry, Innovation and Infrastructure” (goal 9). (United Nations 2020) The goal of gender equality is part of RRI, which overlaps with open science. The goal of quality education is part of open educational resources, which is part of open science. The goal of inclusive and sustainable industrialisation and innovation overlaps with open innovation, which overlaps with open science.

4.6 Objectives of open science
4.6.1 Social responsibility

Science is facing global challenges such as the Covid-19 disease and climate change. In addition, science is facing denialism (Diethelm and McKee 2009) and its own internal challenges too, such as the replication crisis (Ioannidis 2005; Schooler 2014). Open science can help to overcome challenges like these by making scientific processes and results more accessible, transparent, understandable and overall more inclusive.

The principles and practices of open science overlap in many aspects with the *general* principles of *good scientific practice* (Laine 2018),moral values and ethics (Düwell 2019). For example, openness and transparency are the necessary conditions for the possibility of objectivity, reliability, reproducibility and verifiability in the first place. More specifically, all open science principles are also automatically part of the general principles of good scientific practice. In this way, open science supports good scientific practice and open science can be understood as the *gold standard of good scientific practice*. Of course, science in general encompasses not only open science as a particular way of doing science, but also many other different styles, practices and types of scientific activity. Science does not exist in a vacuum. On the contrary, science is a complex practice embedded in a broader cultural practice.

In particular, science is embedded in our socio-cultural systems and forms a constructive interdependent relationship with them. In society, we have moral values, principles rules, norms, standards and ideals that encompass economy, politics, science and other systems. Science, economy, politics and civil society are mutually dependent and reinforce each other.

It is up to science to take its responsibilities, fulfil its duties and obey moral norms, especially when it acts on behalf of society. *This is especially the case when the public finances a research project*. Open science can make a real contribution to better connecting itself with society, regain its trust and take responsibility by further improving the already present good scientific practices (see also section *3.1 Normativity 3.2 Morality* and *3.3 Ethics*).

In other words, open science is science that takes its social responsibility seriously and sees itself as what it is: part of a society.

4.6.2 Benefits of open science

In this section, we will give an overview on the general benefits of doing open science. For the *specific* benefits of doing open science for the AAT community, see section *5.6 Benefits for the AAT community of doing open science.*

Open science has many self-evident and a few rather hidden advantages over conventional closed science. The list of advantages of open science given here is not exhaustive.

Impact, visibility and citation rates

Heise (2018) identifies 12 positive effects that speak for open access: among those 12 effects are two, which directly affect the impact of scientific and scholarly publications. Open access leads (a) to higher citation and (b) to higher circulation rates. Heise's (2018) analysis is based on the results of other studies on this topic.

In 2017, three of the most cited journals were open access journals. (Annina Huhtala 2018) The latest figures indicate that open access publications have a greater overall impact than closed access publications.

A relatively new study by Piwowar et al. (2018) estimates the share of open access to at least 28% of scientific literature. On average, open access publications achieve an 18% higher citation rate than conventional publications. (Piwowar et al. 2018) This result is not an isolated case: according to the meta-study by Tennant et al. (Tennant et al. 2016), 46% of the studies analysed conclude that open access has a citation advantage. In addition to the positive correlation between open access and citation rates, other positive correlations can be observed.

An analysis of published articles on *Springer Nature* shows that "open access articles are more read, cited, and receive more attention than non-OA articles." (Springer Nature 2018) On average, open access articles are downloaded four times as frequently, cited 1.6 times more and receive 2.4 times more attention (according to *Altmetric* (Altmetric 2020)), than closed access articles. (Springer Nature 2018) There is also movement in the journals. In 2017, 16% of peer-reviewed articles were published in open access journals. (Scimago Journal & Country Rank 2020; August and Reply 2018) Within the last 3 years, open access journals were cited 7% more frequently than closed subscription journals. (August and Reply 2018) Four of the 20 most cited journals were Full Open Access journals. (August and Reply 2018)

Knowledge transfer and innovation

In markets with short innovation cycles, open innovation and in particular open defensive publications (prior art) can be a quick and cost-effective alternative to traditional patent protection. (ZIZ Karlsruhe 2020) Innovation performance of some companies can be improved under certain conditions through open innovation cycles. (Brüggemann et al. 2016) Companies can benefit from the simple and fast integration of new research results (open access publications and open data) into agile innovation processes. (Chesbrough 2015)

Arguably, the more complex a scientific or innovation problem is, the more important it is to share data and knowledge openly. In this sense, open forms of organisational governance can improve the solution search in context of complex, difficult or fundamental innovation problems. (Felin and Zenger 2014, 916–17)

Trust and partnership

As outlined above, open science can help increase the visibility of your research. It is reasonable, that greater visibility of your research and your research outcomes in turn could help form partnerships with other researchers, research organisations and industry partners. Especially young and small research organisations, companies and start-ups can benefit from a fast and easy flow of information within and between the partners. In this respect open science has great advantages for these companies, because they can find data and knowledge easily and form relevant partnerships early.

Furthermore, the open handling of information between all partners of a research project or company has a trust-building effect. The public also has more trust in a research project or company when it does open science, i.e. when it opens up its knowledge, its data, and its results as much as possible.

Academic research

As seen above one of the major advantages of open science is the greater visibility (for example through open access or open data) of the results and impact of your research. Greater visibility in turn also could lead to a better research network. Open science has the potential to generate innovative research ideas (Open Science and Research Initiative 2014) and more robust scientific findings (The Lisbon Council 2019). When doing open science, efficiency increases because research data, research results, methods and infrastructure are easily available without any paywalls. Open science can help avoid duplication of work. The European Commission could save 10.2 billion € per year using FAIR principles for storing data. (European Commission and PwC EU Services 2018) Another example from an analysis of the European Bioinformatics Institute showed that open research data for the global life science community saves 1.3 billion € per year. (OpenAIRE 2021) Transparency, an important principle of open science, contributes to ensure the quality of research results by making it more susceptible to scientific rigour. (Open Science and Research Initiative 2014, p.5) Furthermore, open science promotes a standardized modus operandi for worldwide co-operations on similar research topics and thus the scientific community can react faster to scientific misconduct. (Open Science and Research Initiative 2014)

Open science can help young researchers, non-professionals and citizens improve their scientific literacy by providing them free access to educational resources, research data and publications. Furthermore, a commitment to open standards in science can improve trust in science. Additionally, open science can help ensure that scientists receive the recognition they deserve for their work. (Open Science and Research Initiative 2014)

Government and society

The *social impact* of opening up science in general and research results in particular is tremendous. Openness promotes human rights and democracy. A better and trustworthy information base could lead to transparent and deliberate decisions in politics. It is logical that publicly funded research should be accessible to society, the funders of the research, as it may help solve key societal challenges (Picarra 2016, p.4) (see also section *4.5.1 Social responsibility*). Open science and citizen science in particular can help improve civil society and research processes as well. On the one hand, research can use citizen science to understand societal challenges and get well-grounded feedback, and on the other hand, citizens can build trust in research activities and participate in the process. (Open Science and Research Initiative 2014, p.3) For example, a study of Fraisl et al. shows that some Sustainable Development Goals (SDG) of the United Nations can be achieved via citizen science projects in such a way that each citizen can participate and create benefits for their own local society and take responsibility by their own. (Fraisl et al. 2020). See also section *4.8.2 Sustainability.* Figure 2 gives a nice overview of some of the main benefits of open science.

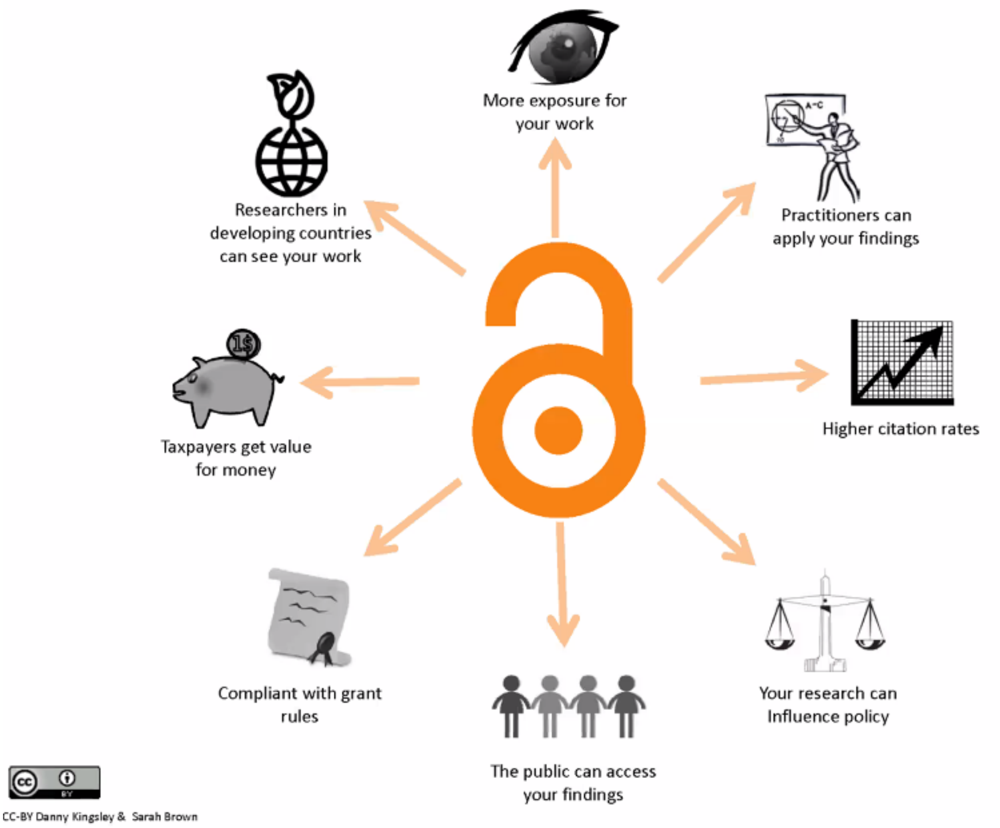

Figure 2: Benefits open science (McKiernan and McKiernan 2020)

4.7 Challenges in the context of open science

The implementation of open science, its according mind-set and technicalities is a long-term process. It is not sufficient simply providing free access to publications and data. Open science is a culture and it requires infrastructures, organisational commitments and good practices.

Challenges in academia research

Efforts to work according to the principles of open science are not yet sufficiently rewarded and hardly considered in research careers. (Open Science and Research Initiative 2014, 4) Despite this fact, however researchers working according to the open science principles, make a greater contribution to the community and have the benefits described above (section *4.5.2 Benefits of* *open science*). There are some national initiatives[2] to abolish old cultures like the *publish-and-perish* system. Ideas for alternative reward systems are already under development. In 2018, the European Commission published a report, which describes the *Open Science Career Assessment Matrix (OS-CAM)* (Open Science Career Assessment Matrix) as an alternative. (European Commission 2017a, 5 f.) Furthermore, *altmetrics* is an alternative method to calculate the impact factor like the Hirsch-Index (h-index) (Hirsch 2005) that is using different sources like citations or discussions on social media to measure the true outreach and impact of a publication. ('What Are Altmetrics?' 2015)

Although several studies have shown that open access publications are cited more often than closed publications, see section *4.5.2 Benefits of open science*) The lack of incentives and the continued dominance of performance indicators, such as the h-index or impact factors for journals, contribute to the slow adoption of the open culture by academic researchers. (Barbarossa et al. 2017, 4)

A further complication is that conducting research in accordance to open science principles is more labour-intensive—at least at the start— because data, for example, must be described in more detail and in a standardized way in order to comply with the FAIR principles for example. However, the positive long-term effects of course far outweigh the initial investment. If the initial efforts are not recognised ideally or financially, it is hard to commit to open science. In addition, open data is a challenge and source of insecurity, because by definition data *in general* is *not* covered by copyright protection. In connection with legal uncertainty, the question of an attractive data infrastructure for the controlled storage and long-term preservation of data has not been solved yet. The EC plans to address this issue with the *European Open Science Cloud* (EOSC) (European Commission 2020e). However, the technical design of the platform is still vague at the moment. (Barbarossa et al. 2017, 4; Picarra 2016, 7; Open Science and Research Initiative 2014, 4)

Challenges for politics and civil society

There is a need not only for standards in the description of data and the data itself, but also for consistent funding specifications. (Barbarossa et al. 2017) In Horizon Europe, the EC plans to use the experience gained from H2020 to unify wording, standards and simplify administrative procedures. (European Commission 2020g)

[2] For example, Austria with a first draft of their suggestion for a national open science strategy. It recommends an Integration of Open Science criteria into the evaluation system by research institutions.(OANA 2019, 16). Additionally, as well the Netherlands with their "national plan open science" in the year 2017. (van Wezenbeek et al. 2017, 10)

Challenges for business

The Industry is often critical towards the opening of in-house data and research results, especially with respect to non-European countries (e.g. like China in the field of microelectronics or aviation). However, it should be noted that confidentiality and patents do not prevent products from being copied or reverse engineered. There is a chance to counteract this copy culture with open science as a systematic countermeasure. Funders and politics need to ensure global reciprocity and an open science culture and policy between EU and third party countries. (European Commission 2020f, 26) Efforts are currently underway at the global level, as UNESCO is working on a global open science policy recommendation, which should be finished by the end of 2021. (UNESCO 2020a)

In its statement on the future of the open science policy of the EU, EARTO demands that the data owners should decide for themselves whether their data could be shared with whom and under what conditions. (EARTO 2020, 7) This is particularly important for sectors[3] dealing with security relevant technologies like the AAT sector. According to the information available on Horizon Europe (HEU), there will be no change in the exclusion of system-critical or confidential data to the open data default. This means that closed data is possible only in specific exceptional cases. In such cases it is necessary to justify why the data needs to be non-disclosed. (European Commission 2020g) Access models to EU repositories would give the project partners the freedom to open up to specific groups. A central repository, as planned by the EOSC (European Commission 2020e), could use metadata to make it transparent to everyone which data exists on a specific research topics. In a possible next step, a digital rights management could grant access to full datasets only to European partners for example.

Another challenge is to make the policymaking process more transparent. Industry partners, participating in EU funded research projects would like to see more involvement and transparency in the development of open science specifications in the Horizon Europe development process to counteract uncertainty and mistrust[4].

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[3] H2020 – Annotated Model Grant Agreement V5.2: Article 29 "DISSEMINATION OF RESULTS — OPEN ACCESS — VISIBILITY OF EU FUNDING ": "This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply."

[4] Valerie Hachette. 2020. SAFRAN presentation: Implementation of Open Science in Aviation. 10th EASN Virtual International Conference. 2-4 September 2020.

4.8 Open science and EU policies

There are only a few references to open science into applicable texts to the H2020 framework program. Nevertheless, open science is described in the *Rules for Participation and the Grant Agreement*. The Grant Agreement is the main contract between the European Commission and the project coordinator in representation for the project consortium.

Rules for Participation (EC Regulation n°1290/2013 of 11 December 2013)

The Rules for Participation do not mention open science explicitly. However, there are a few hints to the topic and a link to open access, which is a part of open science. In general, Article 4 describes that publicly funded results shall be made available to any member state of the European Union or associated country. Yet, there are limitations to this requirement in certain cases like in cases of security relevant information or information that is confidential (Article 3).

Article 18 describes recommendations for the grant agreement, where specifically in paragraph 5 the inclusion of the "principles of research integrity" and the "Recommendation on the management of intellectual property in knowledge transfer activities" are mentioned. Open access is mentioned explicitly in Article 43 about the exploitation and dissemination of results. Article 43 provides principles of open access to scientific publication but refers to the Grant Agreement in order to further implement the concept. Under Rules for Participation, open access of research data remained only an option for ERC frontier research and FET or other appropriate areas.

Grant Agreement (Article 29 – Dissemination of results – open access – visibility of funding)This article describes that results from European projects has to be disclosed as soon as possible for the public either through scientific publications or similar. There are exceptions to this rule if the results can be exploited by the project partners (Article 28) or the publication is restricted due to obligations that are described in the Article 27 (protection of results), Article36 (confidentiality obligations), Article 37 (security obligations) or Article 39 (protection of personal data). If a publication of a result is intended, all project partners have to be informed and has 45 days to object. Article 29.2 mentions explicit specifications, for the case results are published in scientific articles. Article 29.2 defines that provides the principle of open access to all peer-reviewed publications relating to the results. Each beneficiary shall make the peer-reviewed publication available as soon as possible on a free of charge and open repository (see description of green open access) besides a publication in a scientific journal. Ensure open access shall include access to bibliographic meta-data that identify the publications and also aim to deposit ideally in a repository research data needed to validate the deposited publication.

Article 29.3 is an optional article for projects, which participate in the Research Data Pilot. It requires the storage of descriptive metadata and data that is needed to validate the published results. (European Commission 2019c, 245)

Due to the ongoing preparation of the upcoming funding program Horizon Europe, it remains to be seen what role open science will play. As far as we know from the common understanding of the Rules for Participation in the Framework Programme Horizon Europe, released on March 27th 2019, open science is defined in Article 2 *Definition* explicitly. Further details of the requirements are described in Article 10 of the Rules for Participation. The upcoming Rules for Participation most likely will again focus on the non-restricted access to scientific publications and research data. Research data management should follow the principle "as open as possible, as closed as necessary" (European Commission 2020a) as well as the FAIR principles (GO FAIR 2019). Paragraph three of article 10 leaves room for further implementation of additional open science practices in Horizon Europe calls. (General Secretariat of the Council 2019)

4.9 Open science and intellectual property rights (IPR)

As already mentioned in section *4.11 Common misconceptions about open science*, open science and the protection of intellectual property are *fully compatible*. This section will give a brief overview on intellectual property in the context of open science.

Intellectual property (IP) represents an intangible asset. IP is created actively by creative processes of the human intellect. Examples for intellectual property are: inventions, software, reports, design, music, books, videos, work of art etc. (IPR Helpdesk 2020) Intellectual property rights (IPR) are a juridical tool to protect the intangible nature of IP. The juridical structure expresses itself as patents, copyrights, industrial design rights, trademarks, trade secret, utility models or database rights. (IPR Helpdesk 2020)

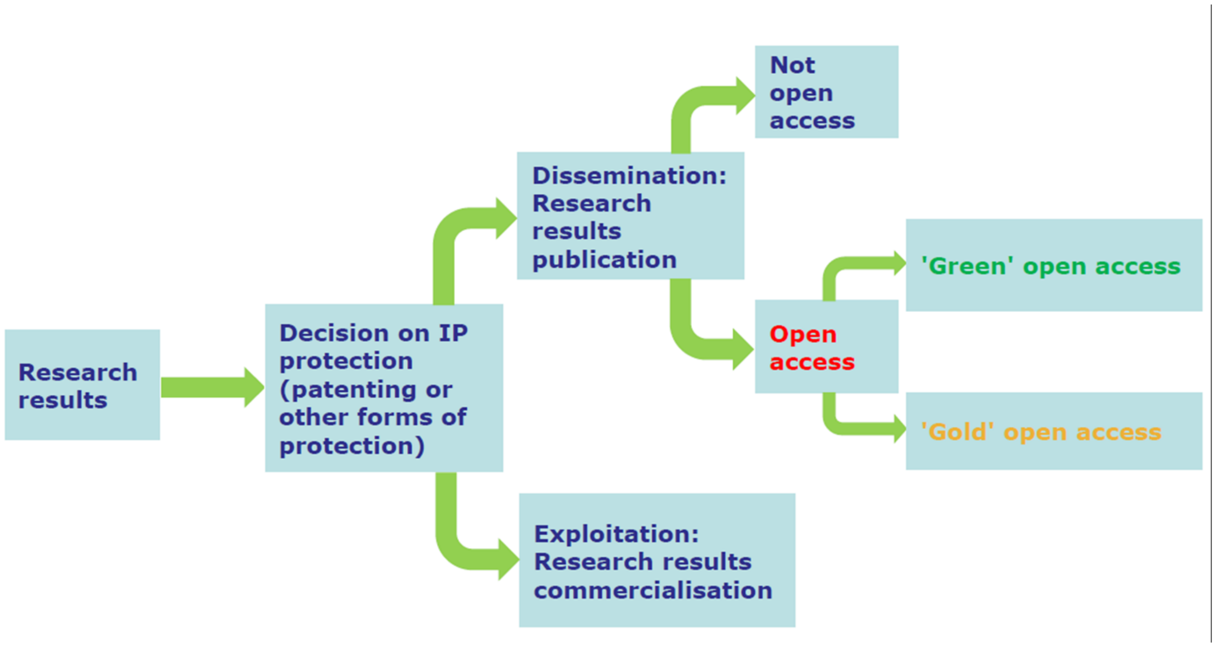
In many documents like the AMGA or Rules for Participation, the European Commission states that the protection of the project partners IP background and the generation and protection of new IP during European funded project have highest priority. The generation of new IP is important to improve society and grow the economy in Europe. The European Commission offers and funds the European *IP Helpdesk* (http://www.iprhelpdesk.eu/) to inform EU projects since 1998. (European Commission 2020d) The European IP Helpdesk is a service that provides free-of-charge information on intellectual property issues.

Within certain limits, the European Commission gives projects freedom of decision on how the projects deal with their research output. The H2020 AMGA describes in detail opt-out possibilities for open access results and data. This will *not* change significantly in the upcoming program Horizon Europe, as far as we known. Yet, it is possible that open access will be the default option. If you want to opt-out you may need to justify this move. See section 4.8 *Open science and EU* policies. Topics like:

- Priority for exploitation actions;
- IPR management and non-disclosure agreements with project partners from the industry;
- The project goal is threatened by publication of project data;
- Personal data (due to GDPR restrictions);
- Confidentiality reasons like security aspects;
- No research data is generated at all,

will continue to exist. (European Commission 2019c, 251)

Open science is the intention to boost innovation activities and economy with a more transparent approach. (EARTO 2020, 7) In a workshop to IPR and open science in 2017, it was clearly stated that "[t]here are no incompatibilities between IPR and Open Science. On the contrary the IPR framework, if correctly defined from the onset, becomes an essential tool to regulate open science and ensure that the efforts from different contributors are correctly rewarded." (Barbarossa et al. 2017, 2) Open science and IPR are complementary. Open science and intellectual property (rights) management do not contradict each other at all and are part of a bigger strategy to choose the right protection tools by using different exploitation and dissemination paths. Even if a scientist publishes their results in an open access journal, they, of course remain the author of the publication, with all associated copyrights. (IPR Helpdesk 2017, 3).



Source: European IPR Helpdesk - Fact Sheet Open Access to scientific publications and research data in Horizon 2020: Frequently Asked Questions (FAQs), 2015, p.3

Figure 3: IP exploitation paths for research results (European Commission 2013, 1)

It is the responsibility of each organisation or project to have its own IP and dissemination strategy, independent from open science. Exploitation of project results does *not* exclude the possibility that project results are made available to the general public via open access, open data or open source at a later date (e.g. after a successful patent application). (IPR Helpdesk 2019) For example, data could be opened up after a certain period, after the project partners had time to use the data for themselves and it is no longer expected to generate added value[5]. The IP Helpdesk provides a good infographic on the possible exploitation paths of IP (see Figure 3).

4.10 Open science, privacy and security

Open science and security have *no* genuine or inherent connection. The issue of security is just as much connected or unconnected with open science as it is with science in general or many other subjects. However, the following link can be drawn between open science and security.

The basic principle of open science is openness, which includes the transparent handling of knowledge, data, methods etc. Open science shares this basic principle of openness with Kerckhoff's principle or Shannon's maxim, which plays an important role in the development of security and encryption systems. (Wikipedia 2020e; Petitcolas 2020; Savard 2020; Petitcolas 2011) See section *4.10.4* Openness and databases for a description of the Kerckhoff's principle. Modern security technologies primitives are designed in accordance with this principle and therefore the source codes of such systems like cryptographic primitives are always disclosed. Furthermore, open source, one important sub-category of open science, offers the possibility to find errors faster and easier. In this way, open science helps to improve the quality of security systems.

Similarly, open science and privacy have *no* genuine or inherent connection. The issue of privacy is just as much connected or unconnected with open science as it is with science in general or many other subjects. See section 4.10.3 Openness and privacy.

4.10.1 Privacy in general

The meaning of the term “privacy” has historical roots in philosophy, sociology, anthropology, politics and law, yet it has no single generally accepted meaning. (DeCew 2018) Privacy could be analysed as “control over information about oneself” (DeCew 2018) or as “the ability to determine for ourselves when, how, and to what extent information about us is communicated to others” (DeCew 2018). Privacy could also be described as a precondition for intimacy. (DeCew 2018) Moore (1998) defines privacy as a “culturally and species relative right to a level of control over access to bodies or places and information.” (Moore 1998; DeCew 2018).

In the context of the current scientific discourse within information and computer ethics, the concept of privacy is viewed in the light of digital media and infrastructures i.e. digital information and communication technologies (ICT). One of the core concepts in these discussions is

[5] To the present date (30.10.2020) the European Commission plans that data results which are not exploited after one year the project end, shall be published on a repository. (European Commission 2020g)

informational privacy also called *information privacy, data privacy* or *data protection.* (Wikipedia 2020p; Warren and Brandeis 1890) Some of the more recent theories on informational privacy, such as Floridi's (2005; 2006; 2013) account, are roughly consistent with Moore's (1998) analysis of privacy outlined above. Roughly speaking, informational privacy is at the core and in the nature of every person according to Floridi (2005; 2006). In Floridi's framework, a person can be understood as an agent in a digital world, generating, holding and exchanging information. (Floridi 2005; 2006) Having and exchanging information is a core characteristic of being a person in Floridi's (2006) framework: "informational privacy is also a matter of construction of one's own informational identity." (Floridi 2006, 112) Against this background, it should be clear that privacy is an important good that needs to be protected.

4.10.2 Privacy and databases

One phenomenon of the digital era is the aggressive, ubiquitous collection, storage, analysis and marketing of outrageously large amounts of data (big data) and sometimes this includes very private, personal or intimate data of individuals and groups (Taylor, Floridi, and Sloot 2017). The data age provokes questions about the security of private data, which, as we have seen, is fundamentally worth protecting.

Databases are systematically stored collections of data that are systematically accessible (Wikipedia 2020k) and can conveniently be handled by using database management systems (DBMS) that enable basic operations on them like create, read, update and delete (CRUD) (Wikipedia 2020r). (For the sake of simplicity, from now on we will only speak of databases and referring to DBMS because only DBMS are of relevance in the context of this report.) This means that databases are *by definition* designed to make collections of data systematically accessible. This in turn means that the design of databases is inherently linked to the design of security systems, encryption methods, rights management and access control. Designing and managing databases in such a way that they are secure, especially with regard to private data, is a non-trivial task. From the very beginning, databases are subject to a tension between accuracy or usability and security. This is especially true for the storage and handling of *private data*.

A recent data loss case in the UK, where private COVID-19 patient data was stored in Microsoft Excel sheets, shows how important it is to deal with the storage and handling of private data from the very outset and to follow generally accepted principles of data management and data security. (Landler and Mueller 2020) Excel sheets are not secure for the use with private data and they are not a database in the first place.

In contrast to this example of bad practise, there are already good paradigms, practices, databases and cryptographic protocols that guarantee anonymity or inaccessibility of private data. One example of a privacy-preserving protocol is the open Decentralized Privacy-Preserving Proximity Tracing (DP-3T) protocol. (Wikipedia 2020n) This protocol is currently used in contact tracing apps to fight against the COVID-19 pandemic by tracing infected persons. (Wikipedia 2020n) The fact that this contract tracing app is open source recently enabled a security researcher to discover a security gap that could be fixed shortly afterwards. (t3n 2020)

However, in general it is impossible to guarantee complete security for private data. The *database reconstruction theorem* by Dinur and Nissim (2003) shows that security of private data is *not* just an apparent problem or a problem that can be solved somehow. The database reconstruction theorem is a fundamental result, showing the impossibility of protecting private data in the general case. (Dinur and Nissim 2003; Abowd 2019; Wikipedia 2020l) Roughly speaking, the database reconstruction theorem states that if a statistical database is accurate enough, then individual input data can be reconstructed. (Dinur and Nissim 2003; Abowd 2019; Wikipedia 2020l) This shows a fundamental limit of informational privacy on the level of statistical database containing aggregated data of individuals. This limit of the security of private data is of a *general* nature and applies to *all* areas where statistical data is handled *without exception*.

Differential privacy (Wikipedia 2020l) was developed to circumvent this fundamental limitation of the security of private data. Differential privacy is a method to protect private data in a statistical database by injecting noise into the statistical database. (Dinur and Nissim 2003; Abowd 2019; Wikipedia 2020l) Only if enough noise is injected, private data can no longer be reconstructed. (Dinur and Nissim 2003; Abowd 2019; Wikipedia 2020l) However, the injection of noise into statistical databases in turn makes the data less accurate and therefore less informative. (Dinur and Nissim 2003; Abowd 2019; Wikipedia 2020l) This means that there is a fundamental trade-off between the protection of private data and the informative value of the data. (Abowd 2019)

These results show that handling private data or data in general is non-trivial and fully protecting it is even *not possible in the general case*. These results in turn also mean that great caution is needed when handling private data or data *in general*.

4.10.3 Openness and privacy

There is *no* direct or special connection between open science and privacy. Privacy and open science are two different categories that do *not* have an inherent overlap.

As outlined above in section *4.9.1 Privacy in general,* privacy means having a certain degree of control over one's own corporate or individual information.

In contrast, openness in the context of open science simply means that the scientific process is designed to be as open as possible, for as many people as possible. (Bezjak et al. 2018; Fecher and Friesike 2014; FOSTER 2020b; Wikipedia 2020a) In this context, openness means, on the one hand, being as transparent as possible with one's research and, on the other hand, being receptive to the scientific critique of scientists, to improvements, etc. (Bezjak et al. 2018; Fecher and Friesike 2014; FOSTER 2020b; Wikipedia 2020a)

It is important to note, that having privacy does *not* mean that you cannot conduct open science. Similarly, conducting open science does *not* mean that you do not have any privacy. Openness and privacy are simply disjoint concepts.

In general terms however, openness *may* be associated with privacy. Those who associate openness with privacy may think that more openness goes hand in hand with less privacy, because one has to reveal more of herself when one is more open. *This, however, is a false* *conclusion*. As the definitions of privacy given above shows, privacy is the control over what information or data flows when, how and where to whom. By definition, having control over your own data also means that you can decide what to do with your data. Of course, high security standards must be applied when handling one's own data or the private data of others (see database reconstruction theorem in section *4.1.2 Privacy and databases*) *regardless* of whether you are doing open science or traditional science. In principle, one can always *decide* at any time which data to open and which to keep closed. One can have a high degree of privacy *and at the same time* be open.

In other words, being open is a decision-making process in which one chooses to disclose certain information and keep private others. Privacy is the control over this decision-making process.

4.10.4 Openness and databases

As outlined in section 4*.9.2 Privacy and databases* the database reconstruction theorem shows that there are restrictions on the storage and handling of private data in the general case. (Dinur and Nissim 2003; Abowd 2019; Wikipedia 2020l)

When dealing with private data, especially when storing private data in a statistical database, strict security measures must be taken in all cases, regardless of whether the research is conducted in the manner of open science or in the manner of normal science.

As outlined in the sections *4.9.3 Openness and privacy*, under normal circumstances, it can be freely chosen which information in a database is disclosed and which is not. This means that openness and privacy are *not* contradictory here either. A database can make certain content openly available and keep other content under lock and key at the same time.

It is very important to distinguish between (a) the *contents* and (b) the *methods* of a database. While *content* such as private data or company secrets *can* be kept secret or *can* opened consciously and decisively, however *methods* such as cryptographic protocols or security systems *should* always be open. At first glance, this may seem counterintuitive.

In the context of databases, openness may involve opening the data itself or the database management system as such, i.e. the software (algorithms, encryption, etc.). While the database management system should be open source, making data publicly accessible, however, is a significant political and ethical decision. *Personal data are particularly worthy of protection, as we have seen, and should never be made available without the explicit consent of the person to whom the data belongs.* In addition to the ethical foundation of data protection, there are also in accordance, generally legally binding rules for the protection of personal data in Europe, in particular the General Data Protection Regulation (GDPR). (European Commission 2020b) The processing of personal data is also regulated in the Model Grant Agreement, ARTICLE 39. (European Commission 2019)

Security is sometimes *erroneously* associated with obscurity or secrecy. Security through obscurity as the main method of providing security (of data) has been rejected for a long time and since then has been replaced by way more successful paradigms like Kerckhoffs's principle or Shannon's maxim. (Wikipedia 2020e; Petitcolas 2020; Savard 2020; Petitcolas 2011) Roughly speaking, Shannon's maxim is that a security system (such as a cryptographic primitive or an encryption algorithm for a database) should work even if everyone is fully informed of how the system works. (Wikipedia 2020e; Petitcolas 2020; Savard 2020; Petitcolas 2011) For logical reasons, such an open (source) system is *in principle* more secure than a system relying on the secrecy of its operation. Note that Shannon's maxim does *not* concern the content, but the *methods* of protecting the content. Shannon's maxim is completely consistent with the open source principle, which is an integral part of open science. In practice, open source means that the source code of a program or software is made freely available, editable and distributable. (Wikipedia 2020v; Open Source Initiative 2021)

In addition to the fundamental superiority of open security systems outlined above, there are also other advantages of open systems over closed systems. The fact that other security researchers can examine the system means that security vulnerabilities can be discovered more quickly and more often. This in turn leads to the system becoming more secure over time. Since open systems can, in principle, be analysed by more people than closed systems, open systems are also superior in this respect. For more information on security engineering see Anderson (2008).

4.10.5 Open source and data protection

As outlined in the sections *4.9.4 Openness and databases*, open science—open databases specifically—and privacy are two disjoint categories. Yet, both categories are *not* mutually exclusive; on the contrary, openness is an essential principle of database security systems. Only open security systems or methods can provide the maximum possible protection for sensitive content such as private data.

The internet with its (security) infrastructure as we know it today is probably only possible because there are open source, open standards and open practices. For example, the internet relies among other thing on the open Transmission Control Protocol (TCP) and the Internet Protocol (IP) also known as TCP/IP protocol. All internet protocols especially security protocols like OpenSSH (Wikipedia 2020i) or cryptographic primitives like SHA-3 (Wikipedia 2020g) are open source. (Wikipedia 2020s)

Furthermore, Linux an open source operating system runs on about 96% of the top one million websites worldwide. (Price 2018) Android has a Linux kernel and is running on about 70% of all smartphones worldwide. Among the top 10 most used databases are 7 open source databases. (Stack Overflow 2020)

When it comes to protecting sensitive data, using well-established, open source software is probably the best choice.

4.10.6 Open data and privacy

Open data is one of the open science practice whereby data is disclosed whenever possible. Especially in the context of open science, open data goes hand in hand with other practices like open access. The open data practice means that data that can be disclosed, should be disclosed as far as possible. See also the FAIR data principles (GO FAIR 2021).

In the scientific context, this means that those data sets are published which form the basis for a scientific result. It is especially a good practice to publish data that were used for a corresponding publication. The publication of such data can take place via data repositories like *zenodo* (zenodo 2020) or institutional repositories like *Fordatis* (Fraunhofer 2020) or the European Open Science Cloud (European Commission 2020e).

However, the open data practice is explicitly *not* about simply making *all* kinds of data publicly available. Only (a) data that is necessary and (b) data that is not private, not sensitive or not unethical should be made publically available.

It is very important to note that personal data, as described in the previous sections, is particularly worthy of protection. The processing of personal data is also regulated in the Model Grant Agreement, ARTICLE 39. (European Commission 2019b) There are also generally legally binding rules for the protection of personal data in Europe, in particular the General Data Protection Regulation (GDPR). (European Commission 2020b) Therefore, private data is of course *not* covered by the open data principle. *Personal data should never be made available without the explicit consent of the person to whom the data belongs—regardless of the open data principle.*

In an organisation or during a project it is therefore very important to have clear guidelines for the handling of private data from the very beginning and to follow them without exception. It must be clearly defined from the outset which data can be published and which must be protected.

Open data is *not* a special case here. Open data is affected by the generally applicable ethically and legally binding rules for the protection of private data *just like any other non-open practice*.

4.11 Common misconceptions about open science

This chapter will give an overview about the most common misconceptions on open science and its respective clarifications.

4.11.1 Open science and open access

Myth: Open access and open science are the same.

Fact: Open access can be described as a sub-category or practice of open science. Open access focuses on the free and unhindered access to information like scientific publications or research data. For a detailed discussion of open science and open access, see section *4.2 Main principles and characteristics of open science* and *4.3 Best practices and indicators of open science.* Open access was one of the first practices that came up in the context of the journals crisis in the late 90ies where many public libraries could no longer pay the rising charges for journals subscription.

In 2002 the Budapest declaration (BOAI 2015) and in 2003 the Berlin declaration (MPG 2021) were signed by major science organisations and universities. Furthermore, open access was the first practice of open science the European Commission included in their program. Yet, it is very important *not* reducing open science just to open access.

4.11.2 Open access and copyright

Myth: Open access means that I will have no intellectual property right on my publications.

Fact: Open access means that you publish your publication so that it is available easily and free of charge on the internet. *All your copyrights will remain fully intact*. In Horizon 2020, open access is defined as the online access to scientific publications, at no charge to the end-user. Open access only aims at making your work as widely accessible to the public as possible. Open access does mean that you put your publications in the public domain, nor to allow the public to change or redistribute your work without your consent.

4.11.3 Open science and intellectual property

Myth: Open science contradicts the protection of intellectual property.

Fact: Open science and intellectual property are fully compatible. The fact that you are conducting open science instead of just normal science has *no* effect on your intellectual property. For a detailed explanation see also chapter *4.9 Open science and intellectual property rights (IPR)*.

4.11.4 Open science and European projects

Myth: Projects funded by the European Union must necessarily open up all their research.

Fact: The European Commission's Horizon Europe scientific framework programme will probably give funded projects the freedom to open up their research. However, the opening of research will probably be the default in the near future. Projects that do not wish to open up their research (opt-out) must justify this. Furthermore, it is allowed to make non-disclosure or confidentiality agreements.

4.11.5 Open science and quality

Myth: Open science leads to a loss of quality in science.

Fact: Open science leads to more quality in science. (Brüggemann et al. 2016; Stracke 2020) Open science is a way of doing science, that emphasis good scientific practice. The core principles of open science, such as openness and transparency are fundamental requirements of science in the first place. Those principles and best practices are at the core of high quality research.

The prejudice that open science and especially open access leads to a reduction in quality is partly due to so-called *predatory journals*. Predatory journals are *fake* journals that have no peer review, no review board and no quality control. In addition, predatory journals demand horrendous prices from authors and publish every paid submission without any quality control or editorial work within a very short time (sometimes within a few days). *Predatory journals have nothing to do with open science or open access.* Unfortunately, however, many predatory journals advertise with the open access as a quality seal to fool scientists. Please consult the website *Stop Predatory Journals*: https://predatoryjournals.com/ for more information on that topic. (Stop Predatory Journals 2020)

5 The OSCAR open science code of conduct

In section *3 Theoretical background of codes of conduct,* we discussed what codes of conduct are and why they are important. In section *4 Theoretical background of open science,* we discussed what open science is and why it is important.

In the current section, we will discuss what the OSCAR open science code of conduct is, why it is important and why you should use it.

5.1 Overview

In short, the OSCAR open science code of conduct is tailor-made for the AAT community; it is concise and facilitates to follow the open science principles. Furthermore, the OSCAR code is the first of its kind: as far as we know, it is the first *open science* code of conduct in Europe to date (2020-11-24) in general and for the AAT sector in particular.

At this date (2020-11-24) the OSCAR open science code of conduct is a work in progress. However, the first version of the OSCAR open science code of conduct was already finished in July 2020. Figure 4 gives you an impression of how the code looks like in this stage.

The OSCAR open science code of conduct focuses on common and important open science principles and practices. All the principles listed in our code will be illustrated by concrete examples. Additionally, the OSCAR code will provide information on other European codes of conduct with focus on research integrity, good scientific practice and open source.

The OSCAR open science code of conduct will be rule-based and it is developed in a hybrid bottom-up, top-down approach (see the following sections and the previous section *3.4 Codes of conduct*).

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2 Principles of open science

2.1 Principle 1: OPENNESS AND OPEN COMMUNICATION

Our research and scientific practice is characterized by openness and open communication. By openness we mean the habits of thought and action that emphasizes the plurality of perspectives, inclusiveness and free sharing. In the pursuit of our activities as scientists and researchers, we commit ourselves to be as open as possible.

A good example for openness is: Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

2.2 Principle 2: TRANSPARENCY

Our research and scientific practice is characterized by transparency. By transparency we mean the behaviour of being explicit at all levels of communication with the aim of traceability and comprehensibility. In the pursuit of our activities as scientists and researchers, we commit ourselves to be as transparent as possible.

A good example for transparency is: Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

2.3 Principle 3: REUSABILITY AND INCLUSIVENESS

Our research and scientific practice is characterized by reusability and inclusiveness. By inclusiveness we mean the behaviour of including equally a plurality of different people and their social background and worldviews into our social and professional practices. By reusability, we mean one outcome of being inclusive. In the pursuit of our activities as scientists and researchers, we commit ourselves to be as inclusive as possible and make our research as reusable as possible.

A good example for reusability and inclusiveness is: Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

2.4 Principle 4: REPRODUCIBILITY AND ROBUSTNESS

Our research and scientific practice is characterized by reproducibility and robustness. By robustness we mean the quality of our actions, methods and results of withstanding pertubations and stresses over time. By reproducibility we mean one outcome of doing robust research. In the pursuit of our activities as scientists and researchers, we commit ourselves to thrive for reproducibility and robustness.

A good example for reproducibility and robustness is: Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

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Figure 4: Impression on the current version of the OSCAR code of conduct

5.2 Development process

In this section, we outline the development process of the OSCAR open science code of conduct.

5.2.1 Literature analysis

Our literature analysis covered (a) existing codes of conduct and (b) literature on codes of conduct, their implementation and effectiveness and (c) the necessary theoretical background for codes of conduct like ethics and morality (see section *3 Theoretical background of codes of conduct*). All literature found in our literature analysis were fed into a literature database. The results of this literature analysis can be found in section *3 Theoretical background of codes of conduct.*

During the initial search, Fraunhofer IRB found about 25 articles on codes of conduct. The review of the articles on this topic reduced the number of relevant texts to 10:

- Adam, Avshalom M., and Dalia Rachman-Moore. 2004. ‘The Methods Used to Implement an Ethical Code of Conduct and Employee Attitudes’. *Journal of Business Ethics*, no. 54: 225–244.
- Bant, Elise, and Jeannie Marie Paterson. 2019. ‘Understanding Hayne. Why Less Is More’. The Conversation. 2019. http://theconversation.com/understanding-hayne-why-less-is-more-110509.
- Cleek, Margaret Anne, and Sherry Lynn Leonard. 1998. ‘Can Corporate Codes of Ethics Influence Behavior?’ *Journal of Business Ethics*, no. 17: 619–630.
- Jenkins, Matthew. 2015. *Codes of Conduct Topic Guide*. Edited by Transparency International. Berlin: Anti-Corruption Helpdesk.
- Koh, Benjamin, and Pat McConnell. 2018. ‘Bank Codes of Conduct: Add Bars to the Window Dressing and Make Them Legally Binding’. The Conversation. 2018. http://theconversation.com/bank-codes-of-conduct-add-bars-to-the-window-dressing-and-make-them-legally-binding-105391.
- Laine, Heidi. 2018. ‘Open Science and Codes of Conduct on Research Integrity’. *Informaatiotutkimus* 37 (4). https://doi.org/10.23978/inf.77414.
- Lidner, Samira. 2004. *Implementing Codes of Conduct in Public Institutions*. Edited by Transparency International. Berlin: Anti-Corruption Helpdesk.
- Nijhof, Andre, Stephan Cludts, Olaf Fisscher, and Albertus Laan. 2003. ‘Measuring the Implementation of Codes of Conduct. An Assessment Method Based on a Process Approach of the Responsible Organisation’. *Journal of Business Ethics*, no. 45: 65–78.
- Tourani, Parastou, Bram Adams, and Alexander Serebrenik. 2017. ‘Code of Conduct in Open Source Projects’. In *SANER 2017*, edited by Martin Pinzger, Gabriele Bavota, and Andrian Marcus, 24–33. Piscataway, NJ: IEEE. https://doi.org/10.1109/SANER.2017.7884606.
- Whitton, Howard. 2009. *Developing the `Ethical Competence’ of Public Officials - A Capacity-Building Approach*. Edited by OECD Integrety Forum.

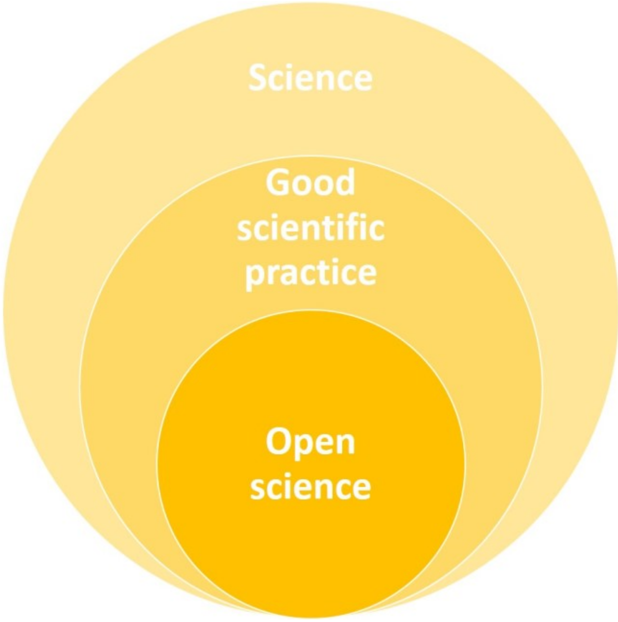

Figure 6: Venn diagram sketch of the inclusion relation of individual concepts of science in general and open science in particular

During the initial search, Fraunhofer IRB found about 10 relevant codes of conduct. A further review reduced the number of relevant example codes to four of which two then formed the basis for the OSCAR open science code of conduct:

- *DFG Guideline for Safeguarding Good Research Practice*. (DFG 2020)
- *Contributor Covenant* (Ehmke 2020)

See section *3.4.4 Examples of codes of conduct* for more details.

5.2.2 Hybrid development approach: bottom-up, top-down

The literature analysis showed (see section *5.2.1 Literature analysis*, section *3 Theoretical background of codes of conduct*) that it is favourable for the OSCAR project to develop the OSCAR code in a hybrid top-down, bottom-up approach (see section *3.4.2 Codes of conduct, approaches and types* and Table 1). This hybrid approach was confirmed by a small internal survey regarding the OSCAR open science code of conduct in the AAT community. The complete results of this survey can be seen in the appendix.

The advantage of this hybrid development approach is that the top-down approach keeps transaction costs low and the bottom-up approach allows content to be developed relatively close to the community (see also Table 1), which is the AAT community in this case. The bottom-up approach is particularly reflected in the fact that the values and principles found in the OSCAR internal survey are incorporated into the OSCAR code (see section 5.4 Principles).

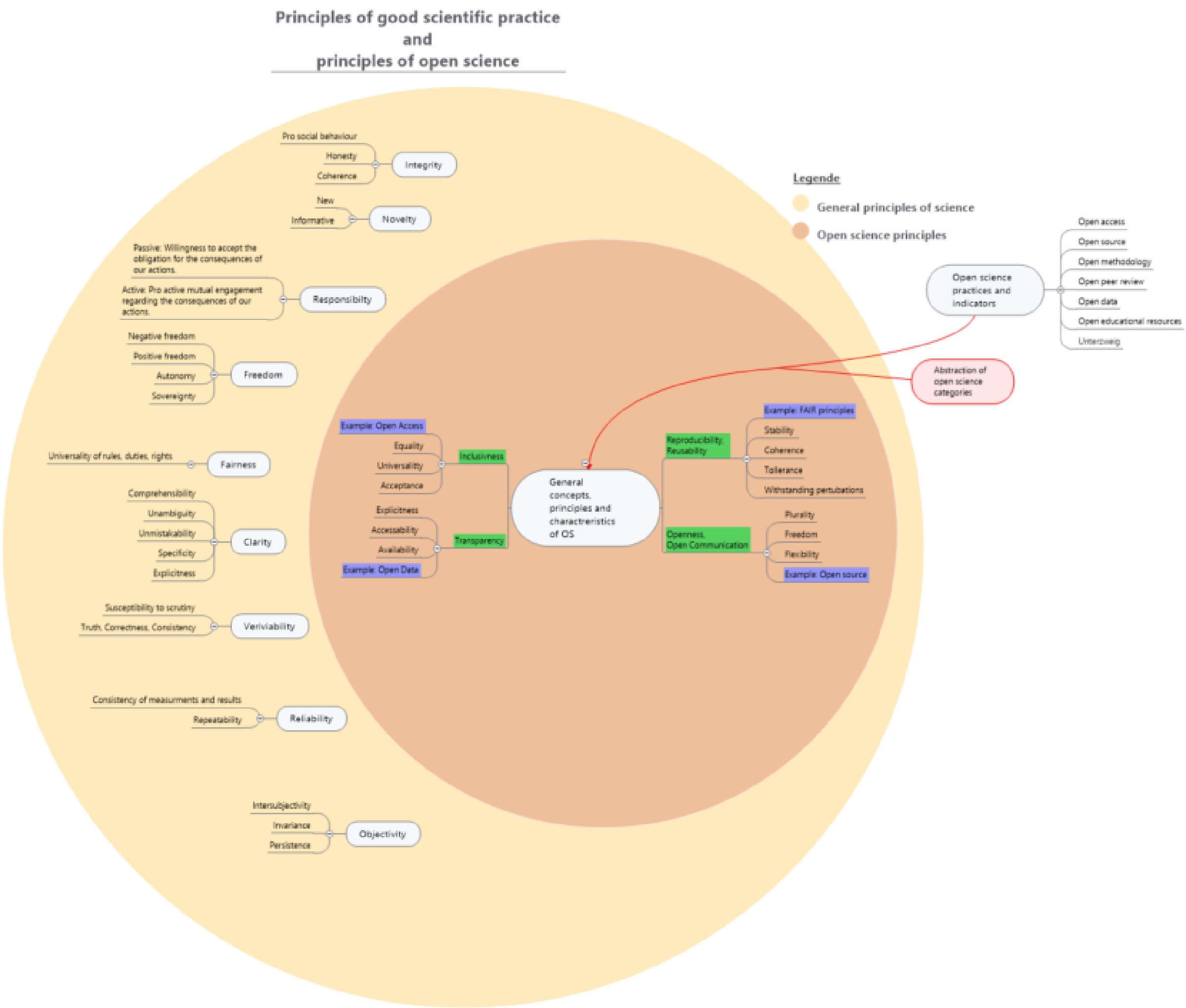

Figure 5: Venn diagram sketch of the inclusion relation of good scientific practices in general and open science practices in particular

5.2.3 Rule-based type

The literature analysis showed (see section *5.2.1 Literature analysis*, section *3 Theoretical background of codes of conduct*) that it is favourable for the OSCAR project to develop the OSCAR code as a rule-based code (see section *3.4.2 Codes of conduct, approaches and types* and Table 1).

Rule-based codes have the advantage that they are short and easy to implement. The AAT community can benefit from the simplicity of rule-based codes of conduct. However, as the AAT community benefits also from more background information on open science, the OSCAR team has decided to add an aspirational-style preamble and an appendix with background information.

5.2.4 Handling the concepts

The aim of developing the OSCAR code of conduct is to have a set of consistent rules or principles, that is as comprehensive as possible, but at the same time as simple and concise as possible.

To achieve this, various concepts must be harmonised and ordered. This task is conceptually non-trivial. Figure 5 gives you an impression on the complexity of the task of identifying and organising the main components of the OSCAR code of conduct. A particularly difficult task is to incorporate all major concepts of open science and good scientific practice in general, while keeping the code short and concise. Furthermore, many principles and practices of open science overlap with general principles and practices of science (see section *4 Theoretical background of open science*). See the general inclusion relation of good scientific practises and open science practices in the Venn diagram sketch in Figure 6. All open science principles and practices are also automatically good scientific practices in general. However, not all practices of science are necessarily open science practices. Transparency for example is a key principle of open science as well as a key principle of science in general. Transparency is the foundation on which reproducibility is possible in the first place. See the Venn diagram in Figure 7 for the inclusion relation on the level of individual concepts of science and open science.

In order to classify the relevant concepts, Fraunhofer IRB has proceeded in three steps. First, Fraunhofer IRB identified all major relevant principles of good scientific practice with their standard definitions. Second, Fraunhofer IRB abstracted the main concepts around open science to get a short list of principle that are similar to the principles for good scientific practise in general. Third, Fraunhofer IRB used the inclusion relationship of the concepts to reduce the total number of concepts used.

Some of the more common principles, methods or values of good scientific practice in general are (Sciences (US) and Research 1992; Andersen and Hepburn 2020):

- Integrity,
- Novelty,
- Reproducibility,
- Clarity,
- Verifiability,

- Reproducibility,
- Reliability,
- Fairness,
- Objectivity and
- Freedom.

Of course, the list of principles given here does not claim to be complete. It should be noted that we cannot, of course, go into the complex background discussion in philosophy of science on the principles, values or methods of science. It should also be noted that there is no agreement on whether there are general principles in science, and if so, which ones. For more information on the topic of the scientific method, principles or values see for example Gauch (2002) or Andersen and Hepburn (2020).

This selection of principles was then mapped against the most common open science principles Fraunhofer IRB found in the literature analysis (see section *4 Theoretical background of open science).*

5.3 Principles

To arrive at the principles for the OSCAR open science code of conduct, Fraunhofer IRB conducted three major steps.

In the first step, Fraunhofer IRB identified the main principles and practices of open science (see section *4 Theoretical background of open science* and *5.2.2 Concepts*. Additionally, in an OSCAR internal workshop on the development of the OSCAR code, the OSCAR consortium decided to only list open science principles not principles of good scientific practice in general (like in the DFG code (DFG 2020)). See also the fourth step below.

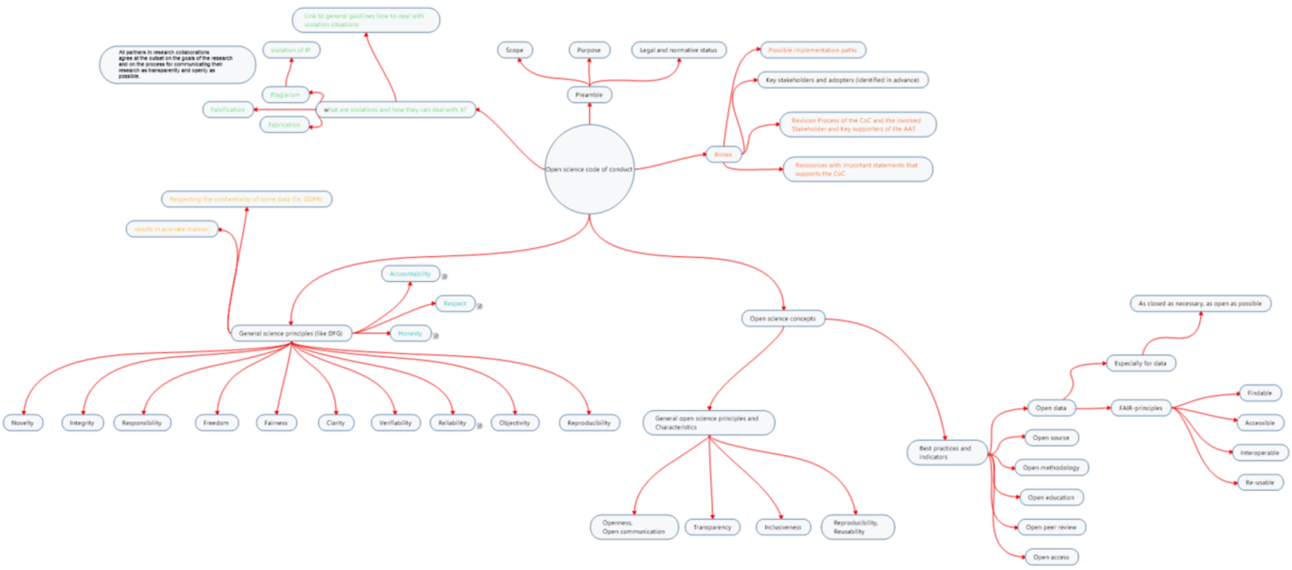

Figure 7: Concept map of the main components of the OSCAR open science code of conduct

In the second step, Fraunhofer IRB combined the different concepts by using abstraction and their inclusion relation (see section *5.2.2 Concepts*).

In the third step, Fraunhofer IRB set out the basic structure and the basic components of the OSCAR code (see section *5.4 Main components*).

In the fourth step, Fraunhofer IRB conducted a small consortium-internal survey (with LimeSurvey (2020)) asking the OSCAR partners from the AAT sector what values and principles are significant or important in the everyday business of the AAT community.

The results of the internal survey show that the most important values and principles in the AAT community are the following (see also Figure 8):

- Sharing,
- Openness,
- Trust,
- Collaboration,
- Scientific excellence,
- Integrity,
- Responsibility,
- Professionalism,
- Communication and
- Innovation.

Only ethical or morally relevant values, principles, norms and standards are relevant for a code of conduct (see section 3.1 Normativity, 3.2 Morality, 3.3 Ethics and 3.4 Codes of conduct). Therefore, Fraunhofer IRB reduced this list to a list containing only ethical or moral relevant items:

- Sharing,
- Openness,
- Trust,
- Integrity and
- Responsibility.

Those principles coincide well with the general principles of good scientific practice. As outlined in section *5.2.2 Concepts*, open science principles are a part of any good scientific practices and principles of science in general. All open science principles and practices are also automatically good scientific practices in general. However, not all practices of good science are necessarily open science practices. It is therefore important—and difficult—to draw a clear line as to which principles and values can be attributed exclusively to open science. Only by highlighting the principles and values that are specific to open science can the code of conduct remain lean.

Figure 8: Word cloud generated from the results of the OSCAR internal survey regarding the most important values and principles in the AAT community

Thus, Fraunhofer IRB filtered and merged the principles and values found in the internal OSCAR survey with the general principles of open science (see section *4 Theoretical background of open science* and *5.2.2 Concepts*) and arrived at the following five *preliminary* principles:

- Openness and open communication,
- Transparency,
- Reusability along with inclusiveness,
- Reproducibility along with robustness and
- Fairness along with responsibility.

These five principles for the OSCAR open science code of conduct represent only a first preliminary approximation and will probably change in the coming iteration steps.

In the following five short sections, we will elaborate briefly, on what we mean by those principles.

5.3.1 Openness and open communication

Our research and scientific practice is characterized by openness and open communication. By openness, we mean the habits of thought and action that emphasize the plurality of perspectives, inclusiveness and free sharing. In the pursuit of our activities as scientists and researchers, we commit ourselves to be as open as possible.

5.3.2 Transparency

Our research and scientific practice is characterized by transparency. By transparency, we mean the behaviour of being explicit at all levels of communication with the aim of traceability and comprehensibility. In the pursuit of our activities as scientists and researchers, we commit ourselves to be as transparent as possible.

5.3.3 Reusability and inclusiveness

Our research and scientific practice is characterized by reusability and inclusiveness. By inclusiveness we mean the behaviour of including equally a plurality of different people and their social background and worldviews into our social and professional practices. By reusability, we mean one outcome of being inclusive. In the pursuit of our activities as scientists and researchers, we commit ourselves to be as inclusive as possible and make our research as reusable as possible.

5.3.4 Reproducibility and robustness

Our research and scientific practice is characterized by reproducibility and robustness. By robustness we mean the quality of our actions, methods and results of withstanding perturbations and stresses over time. By reproducibility, we mean one outcome of doing robust research. In the pursuit of our activities as scientists and researchers, we commit ourselves to thrive for reproducibility and robustness.

5.3.5 Fairness and responsibility

Our research and scientific practice is characterized by fairness and responsibility. By fairness, we mean the general validity of rules, duties and rights for all individuals in the same manner. By responsibility, we mean the behaviour of accepting the consequences of someone's owns actions and acting accordingly. In the pursuit of our activities as scientists and researchers, we commit ourselves to proactively exercising fair and responsible behaviour.

5.4 Main components

The literature analysis (see section *5.2.1 Literature analysis*, section *3 Theoretical background of codes of conduct*) and especially the resulting criteria for a good code of conduct (see also section *3.6 Criteria for a good code of conduct*) showed that the OSCAR code should consist of the following four main parts (see also Figure 9).

1. **The introduction**

   The introduction part will give necessary background information and guidance on what the OSCAR code of conduct is and how to use it.

2. **The principles**

   This part will consist of a list of about five open science principles. Each principle will be defined in simple terms and it will come with tangible examples.

3. **Enforcement**

   This part will describe how the code can be enforced and what concrete actions should be taken in the case of misconduct.

4. **Appendix including user stories or use cases**

   This part consists of some example user stories or user cases formulated in a natural language to guide users. This will improve the usability of the OSCAR code of conduct by helping different individuals with different background and roles to implement the code.

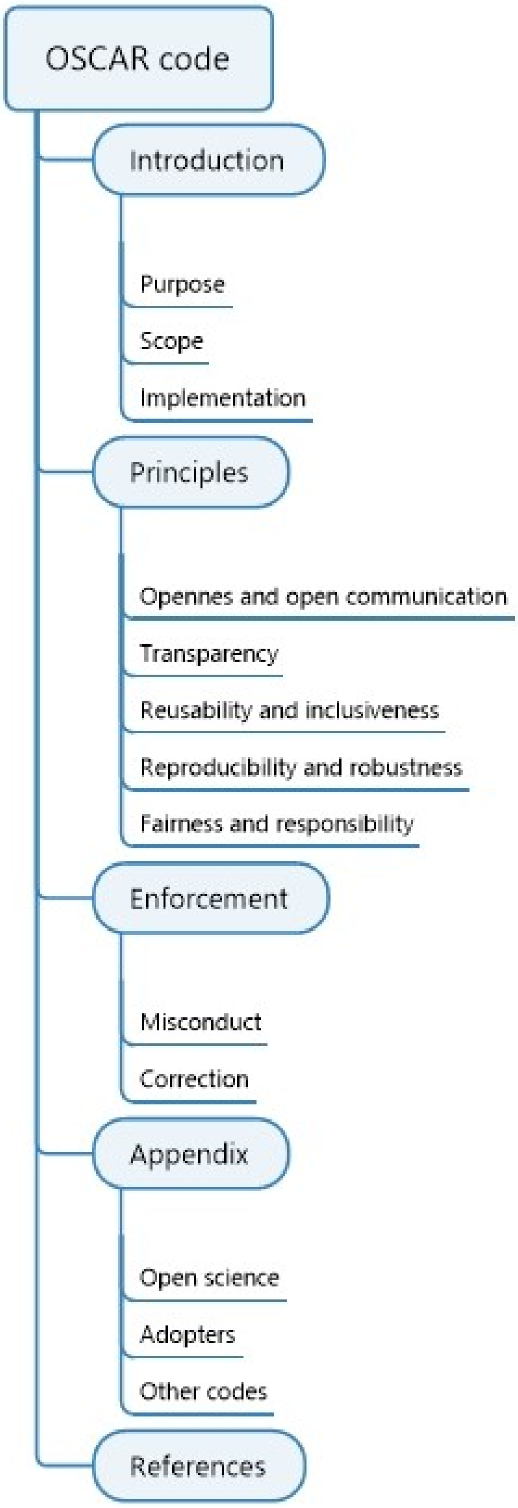

Figure 9: The main components of the OSCAR open science code of conduct

5.5 Current concerns of AAT community regarding open science

In order to better understand the opinions of the AAT community regarding open science, the OSCAR project has interviewed people from the industrial environment. In these interviews, frequently asked questions were about the upcoming new Horizon Europe regulations. In particular, one frequent question was about how (open) data must be handled in the upcoming framework program. Until now "Horizon Europe will require research data to be FAIR and open by default (with exceptions notably for commercial purposes)" (European Commission 2019d, 2) (see also section *4.8 Open science and EU policies*). Yet, the EC mentions that there is the possibility of opt-out options like commercial purpose for data. (European Commission 2020g) However, these statements unsettle some stakeholders, because from now on the project partners have to justify a non-disclosure of data. Data is a new important asset for companies in the digital age. Generally data does *not* have the necessary threshold of originality and therefore data are not automatically protected by the copyright law (Barbarossa et al. 2017, 8). However, databases *are* protected by copyright if they are structured or organized in a new or original way. (European Parliament and Council of the European Union 1996) Hence, the IPR Helpdesk suggests developing a new database and incorporating your data into this new database. (European IP Helpdesk 2020a; 2020b) For the AAT sector, data protection is significant because of security issues and competitive advantages. The strong competition between Europe, China and the US in this sector also plays a big role. It is comprehensible that metadata of datasets should be made openly accessible according to the FAIR principles to reflect the existence of such data. Another idea is to have access control for specific data, which would be feasible and useful as a concept for the European Open Science Cloud. One solution could be to make uncritical (no confidential) data openly accessible after a defined embargo period from the project partners.

5.6 Benefits for the AAT community of doing open science

All general benefits of open science outlined in section *4.5.2 Benefits of open science* are of course also benefits for the AAT community. In this section, we would like to outline those benefits of open science that are particularly relevant to the AAT community. The short list of benefits for the AAT community given here is not exhaustive.

Complexity, responsibility, research and innovation

Due to climate change and the COVID-19 pandemic, AAT and AAT research is currently and in the near future facing considerable challenges. Global warming is not only a challenge for aviation but aviation itself is partly the cause for global warming. It is estimated that aviation accounts for 3.5% of global warming. (Ritchie 2020) In this respect, climate change is especially significant for the AAT research sector. First, because the AAT sector is confronted with the consequences of climate change. Second, because the AAT sector is partly to blame and thus partly responsible for stopping climate change. Addressing climate change and its consequences is an incredibly complex and difficult task. To make matters worse, we have very little time left to take effective measures to stop climate change. The European Union and its member states already committed themselves to undertake efforts limiting the global temperature rise to 2.5 degree, which is the agreed goal of the *Paris Agreement* (United Nations 2015). The AAT research and innovation community is facing enormous challenges that have to be overcome in a short time. New forms of aviation must be invented, researched, developed and brought to the market within a short time.

As outlined in section *4.5.2 Benefits of open science* in paragraph *Knowledge transfer and innovation* open science can help find solutions if the research or innovation problem is complex or difficult. Especially in research fields that have a low TRL and respectively deal with a high level of complexity it could be beneficial to conduct open science. Furthermore, in research fields with fast innovation cycles, open science can help achieve better results in a shorter time. To meet these challenges, the industry needs transdisciplinary cooperation to reduce internal risks.

There are already very ambitious projects such as the hydrogen-powered concept aircraft from Airbus, which is scheduled to enter service by 2035. (Airbus 2020) However, this is a very ambitious goal and we need much more of these approaches—and such aircrafts must be in regular operation by around 2035. Open science can help to significantly improve and speed up the necessary research and development processes.

Trust and security

Besides the big challenge to handle the growing complexity in science and the ever-faster innovation cycles, the AAT sectors has to deal with a significant trust issue. The Boeing 737 max crashes gives a glimpse for an image damaging case for the AAT sector. (Gelles 2019) The crashes were due to incorrect or faulty program code in the MCAS software (Travis 2019). Perhaps those tragic accidents potentially could have been prevented by more open communication, transparency and open standards in the design and testing processes. See also section *4.9 Open science, privacy and security.* Additionally, being open leads to more trust among passengers, funders, research partners and the public.

5.7 Examples of successful open science applications

There are many interesting cases that demonstrate the benefits and positive impacts we described in section *4.5.2 Benefits of open science*. Every science has its own specifics. This also applies to AAT, of course. However, the results from other areas are easily transferable to others, because open science is not about content, but about a way of doing science. This way of doing science can be transferred to all disciplines. In this respect, the open science successes from one area are very well transferable to another area. Insofar, the AAT community can learn from the open science successes of other sciences.

5.7.1 Life sciences

An interesting example from the biomedical sector is the *PISTOIA Alliance*. According to a *Tufts Center* publication from 2015, the cost of drug development has doubled over the last decade. (European Commission et al. 2018) As a result, more and more institutions were joining forces for joint pre-competitive research to divide the risk and costs of research and development activities. The PISTOIA Alliance is one example of an industry-driven collaboration between academia and large pharmaceutical companies like Pfizer or Novartis. Together the partners share, aggregate and provide access to data, which is needed for innovation. A further effect is that redundant activities between the institutes are reduced. The savings at the beginning of the research cycle allow participants to spend more money on innovation and development of new products. One goal of the alliance is the development of technological standards, infrastructure and novel scientific methods. The alliance is financed by a membership model, which enables a fair participation possibility for small and large partners. For further information, please see the [Pistoia alliance open science monitor case study](). (European Commission et al. 2018)

Another example from the life sciences is the *Open Target* project, “an innovative, large-scale, public-private collaboration on pre-competitive research that provides comprehensive and up to date data for drug target identification and prioritization”. (European Commission 2019a) Among other things, this project developed open source tools that improve the productivity of all stakeholders. Furthermore,

> “[a]ccelerating scientific knowledge in life sciences, reducing duplication efforts by putting together stakeholders that shared common interests in R&D, catalysing drug discovery and uncovering new opportunities for drug development for rare diseases are just some of the benefits that the partnership and its platform offer to society”. (European Commission 2019a, 17)

The authors of a study regarding chemical and clinical probes supporting drug discovery came to a similar conclusion. (Edwards et al. 2009) In their abstract, they write:

> “Drug discovery resources in academia and industry are not used efficiently, to the detriment of industry and society. Duplication could be reduced, and productivity could be increased, by performing basic biology and clinical proofs of concept within open access industry-academia partnerships.” (Edwards et al. 2009)

5.7.2 NASA

Another interesting case is the NASA's *Artemis Accords.* (NASA 2020a) In section "SECTION 8 - RELEASE OF SCIENTIFIC DATA" (NASA 2020a, 4) the open sharing of data is mandatory:

> “1. The Signatories retain the right to communicate and release information to the public regarding their own activities. The Signatories intend to coordinate with each other in advance regarding the public release of information that relates to the other Signatories’ activities under these Accords in order to provide appropriate protection for any proprietary and/or export-controlled information.
>
> 2. The Signatories are committed to the open sharing of scientific data. The Signatories plan to make the scientific results obtained from cooperative activities under these Accords available to the public and the international scientific community, as appropriate, in a timely manner.

3. The commitment to openly share scientific data is not intended to apply to private sector operations unless such operations are being conducted on behalf of a Signatory to the Accords." (NASA 2020a, 4)

The meaning and wording of this section can be seen as a model for the European AAT research landscape. *It is very important to note, though that large parts of the Artemis Accords are highly questionable, because the probably violate international law. Only the section on the release of scientific data, mentioned above, can be considered as a model.*

5.7.3 Mozilla

Mozilla Firefox is a free and open source web browser with a usage share of about 8.17% in 2020 and a peek usages share of 32.21% in 2009. (Wikipedia 2020m) The Firefox web browser is designed to secure personal privacy and to respect the rights of its users. Firefox is openly developed by the Mozilla Foundation, a non-profit organisation (Wikipedia 2020m; Mozilla 2020a). The source code of the browser is freely available and can be changed and redistributed by everybody. (Mozilla 2020b) Mozilla is a great instance of the vast open source software ecosystem we are all using and relying on today. See also *4.10.5 Open source and data protection*. Mozilla is an excellent example of a successful open source business model, that generates added value for society. Enterprises such as Mozilla can serve as a role model and model for the AAT industry as well.

5.8 General step-by-step guide

The OSCAR open science code of conduct is not only the first of its kind, but with its thematic focus on open science, it is also especially innovative for the AAT community. It is therefore important to show by example how the OSCAR code can be used. For this purpose, the OSCAR team has prepared an outline for possible implementation steps.

Step 1: At the very beginning of the project (preferably before submitting the proposal), have a workshop with all partners on the topics:

1. Intellectual property (foreground and background IP),
2. Data management (including repositories) and
3. Publication management and publication strategy (including predicted costs).

In this step, it is important that all partners agree on a common general strategy and commit to the negotiated general contents and rules.

Step 2: At the very beginning of the project (preferably before submitting the proposal), have a second workshop or meeting with all partners on the details of the contents and project results regarding the following questions:

1. Which contents and results of your project will have which technology readiness level (TRL)? In this step, you can use a tool like Table 2 (see also Table 2 and Figure 10).
2. Which contents and results of your project need to be confidential?
3. Which contents and results of your project need to be non-disclosed?
4. Which contents and results of your project can be open?

Step 3: At the very beginning of the project (preferably before submitting the proposal), consult the annotated version of the OSCAR code of conduct and try to answer the following questions:

1. Can you commit to the general theme and the general ideas of the OSCAR code of conduct?
2. Do you want to make the code part of your contract?

Step 4: If step 3 was positive, then proceed by incorporating the OSCAR code of conduct by:

1. Explicitly referencing your main contract(s) within the OSCAR code of conduct or by
2. Explicitly referencing the OSCAR code of conduct within your main contract(s).

Step 5: During the project you can follow the motto "as open as possible, as closed as necessary" (European Commission 2020a). See also Table 2 and Figure 10.

In principle, the younger the field of research or innovation is, the more complex i.e. challenging the research or innovation problems are. For example, the problems in foundational research are generally more complex than those in applied research. Technology readiness levels (TRL) offer a good classification of maturity levels from foundational research to the finished product. (Mai 2015; NASA 2020b; EARTO 2014) In this sense, TRL can also offer a great indicator to assess the complexity level of a phase in a research project.

		Open science practices								
		Open access	Open data	Open model	Open source	Open methodology	Open (lab)notebook	Open standards	Open policies	Citizen science
TRL	1-3									
	4-6									
	7-9									

Table 2: Assessment of the applicability of open science practices with the help of the TRL of an item

		Open Science Principles									
		Open Access	Open Data	Open Model	Open Tool	Open Source	Open Methodology	Open Content	Open Standards	Open Policies	Citizen Science
Possible contribution		Reports & publications	Data collection	Computational reference models	Software (application)	Software code	Reports, example applications	Other project material	Descriptions, definitions		Collaborative platform
Examples		Conference paper at ResearchGate	ONERA-M wInd tunnel test data	Generic AGILE BWB configuration	OpenVSP (aircraft design tool)	OpenFOAM (CFD solver)	Krieging interpolation method	Pictures, videos, website content	CPACS aircraft modelling data standard		
TRL	1-3		x					x			
	4-6	x		x	x	x					
	7-9										

Legend: x — Topic is being addressed in project at this level
(yellow) — Open Science contribution will be made at this level

Explanation: The example project is a typical RIA research activity. (Complete fiction - no actual proposal used.)

Objective: Assessment of the environmental benefits of powering an a/c turbine by LH2.
Research activities: deriving an LH2-powered engine from an existing design, estimating performance & costs, forcasting the emissions, assessing the env. impact of a fleet of LH2 a/c.
Overall TRL of the project is 4-6 (technology development).

The project will:
(1) OA: publish project results at conferences (activity and OS contribution at TRL4-6)
(2) OD: create a first draft of a global emission inventory for LH2 and make it public (activity and OS contrib. at TRL1-3)
(3) OM: create computational models of LH2 engines - (a) high-fidelity for the project (TRL4-6), (b) generic „rubber engine“ with basic properties for OS research (TRL1-3)
(4) OT: adapt existing engine design tool to use LH2 and make it available on demand (TRL 4-6 - regulated access to Open Tool)
(5) OSrc: develop code for the analysis tool (TRL4-6), confidential
(6) OC: share pictures/artist impressions and animations of a LH2 concept aircraft for free use (TRL1-3)

Figure 10: Example assessment of the applicability of open science practices with the help of the TRL of an item

5.9 FAQ

Is open source and free software the same?

No, open source and free software is not the same. Open source is a way of developing software were the source code is publically available, changeable and redistributable under a licence like the MIT license. Free (as in freedom *not* as in free beer) software is software that is open source and additionally respecting the rights and freedoms of persons. (Scott K. Peterson 2017)

How can I make my research open to public?

To publish your research results as open access publications, you have three main options:

First, you can publish in a gold open access journal, second in a hybrid open access journal or third, you publish your work on your own websites or a preprint server like arXive.org. Here is a list of gold open access journals in the aeronautics research area:

- Chinese Journal of Aeronautics (Press of Acta Aeronautica et Astronautica Sinica)
- Propulsion and Power Research (Elsevier)
- Curved and Layered Structures (deGruyter)
- Aerospace (Multidisciplinary Digital Publishing Institute (MDPI))
- Aviation (Vilnius Gediminas Technical University)

- International Journal of Micro Air Vehicles (SAGE)
- Latin American Journal of Solids and Structures (Argentinean Association of Computational Mechanics)
- Theoretical and Applied Mechanics Letters (Elsevier)
- International Journal of Aerospace Engineering (Hindawi)
- Metal Powder Report (Elsevier)
- Journal of Aerospace Technology and Management (Instituto de Aeronautica e Espaco(IAE))
- Open Engineering (de Gruyter)
- Cailiao Gongcheng - Journal of Materials Engineering (Beijing Hangkong Cailian Yanjiuyuan-Beijing Institute of Aeronautical Meterials)
- Hangkong Cailiao Xuebao - Journal of Aeronautical Materials (Chinese Society of Aeronautics and Astronautics)
- International Journal of Aeronautical and Space Sciences (The Korean Society for Aeronautical & Space Sciences)
- INCAS Bulletin (INCAS - National Institute for Aerospace Research Elie Carafoli)
- Advances in Military Technology (University of Defence)
- International Journal of Aviation, Aeronautics, and Aerospace (Embry-Riddle Aeronautical University)
- Fatigue of Aircraft Structures (de Gruyter)

To publish your research data you can use open repositories like:

- Zenodo (https://zenodo.org/)
- Skybrary (https://www.skybrary.aero/index.php/Main_Page#operational-issues)
- GitHub (https://github.com/)
- IEEE DataPort (https://ieee-dataport.org/)
- GitLab (https://about.gitlab.com/)

What is a DOI?

A Digital Object Identifier (DOI) is a unique identifier for a digital content. Any DOI is linked to its current digital address (its URL). DOI has been established by the International DOI Foundation (IDF), which is a non-profit organization. For more information, on DOIs visit: https://www.doi.org/.

What is ORCID?

ORCID is a unique and consistent alphanumeric code that identifies authors. ORCID is also the name of the non-profit organization that develops the ORCID infrastructure. Creating ORCID is free of charge. For more information on ORCID, visit: https://orcid.org/. You can freely register at https://orcid.org/register.

What does FAIR mean? Which are the FAIR principles?

"In 2016, the 'FAIR Guiding Principles for scientific data management and stewardship' were published in Scientific Data. The authors intended to provide guidelines to improve the Findability, Accessibility, Interoperability, and Reuse of digital assets. The principles emphasise machine-actionability […] because humans increasingly rely on computational support to deal with data as a result of the increase in volume, complexity, and creation speed of data." (GO FAIR 2021) The FAIR principles are (GO FAIR 2021):

- **Findable**
  "The first step in (re)using data is to find them. Metadata and data should be easy to find for both humans and computers. Machine-readable metadata are essential for automatic discovery of datasets and services, so this is an essential component of the FAIRification process." (GO FAIR 2021)
- **Accessible**
  "Once the user finds the required data, she/he needs to know how can they be accessed, possibly including authentication and authorisation." (GO FAIR 2021)
- **Interoperable**
  "The data usually need to be integrated with other data. In addition, the data need to interoperate with applications or workflows for analysis, storage, and processing." (GO FAIR 2021)
- **Reusable**
  "The ultimate goal of FAIR is to optimise the reuse of data. To achieve this, metadata and data should be well-described so that they can be replicated and/or combined in different settings." (GO FAIR 2021)

For more information on the FAIR principles visit: https://www.go-fair.org/.

6 Quality

6.1 Comparison of planned activities and performed work

The chapter *1.4 Changes to the deliverable at hand (D4.4)* has already discussed the reasons why this deliverable differs from the original proposal. Because of the mentioned reasons, the OSCAR project consortium decided to change the planed approach. Instead of integrating the open science code of conduct into a CAM, the goal was defined to promote the knowledge about open science, especially for the general set-up of the AAT community, and to explain the principle of a code of conduct. The most important basis for a successful implementation of a code of conduct in a project is not the integration in contractually binding documents but the acceptance of the mind-set and uniform understanding of the topic. This will be ensured by the deliverable D4.4. A possible inclusion of the code of conduct on a contractual level is shown in D4.3.

Fraunhofer IRB fosters the change process of deliverable D4.4 in collaboration with SAFRAN and Fraunhofer IFAM. In a virtual workshop in June 2020, the OSCAR consortium discussed use cases and questions from the AAT community, which emerged during the interviews from WP2 and WP3 and decided to change the focus of the deliverable. The open issues from the AAT community were analysed and the goal of the current deliverable was identified. During three ongoing virtual workshop with the OSCAR partners, led by the Fraunhofer IRB, the questions and ideas were detailed and elaborated. In addition, the Fraunhofer IRB conducted various research around the topic of open science in the EU project context.

6.2 Quality of the results

The deliverable contributes to a better understanding of open science and emphasises the importance of developing and disseminating a unified mindset via the open science code of conduct for the AAT community. The results were underpinned by an analysis of the literature on codes of conduct in general. The results of this contribution added value for the AAT community through an overview of information on open science in the context of EU projects. The step-by-step guide in the second part of the deliverable shows how open science could be implemented in future projects. The deliverable has, as far as possible, an application-oriented orientation, which will promote the acceptance of the topic open science and the OSCAR code of conduct in the community.

6.3 Comparison of objectives and achievements made

Since the goal of the deliverables has been realigned, no comparison can be made with the initial proposal. It should be noted that the reorientation will lead to greater added value for the community than the original goal, since integration into contractually binding documents only makes sense if a uniform understanding and the attitude of the addressed community is receptive to the topic. Already during the work on WP2 and WP3, deficits in uniform understanding and acceptance in the AAT community became apparent.

7 Conclusions
7.1 Summary

Content wise, this deliverable consists of three main parts. The contents of the first two parts: part *3 Theoretical background of codes of conduct* and part *4 Theoretical background of open science* are the result of an extensive literature and theoretical analysis of the relevant key concepts of codes of conduct and open science.

In the part *3 Theoretical background of codes of conduct,* we discussed the necessary theoretical background of codes of conduct. We outlined the meaning and significance of the relevant key concepts like normativity, morality and ethics. In section *3.4 Codes of conduct defined,* we defined the concept of a code of conduct, gave criteria, examples and a systematisation of code of conduct development approaches.

In section 4 *Theoretical background of open science*, we discussed the necessary theoretical background of open science. We defined open science and its main characteristics. We also discussed the main aspects of open science. Furthermore, we outlined some of the main benefits of open science in section *4.6.2 Benefits of open science*. We addressed open science, privacy and security in section *4.10 Open science, privacy and security*. Additionally, we addressed common misconceptions regarding open science in section *4.11 Common misconceptions about open science*.

In section *5 The OSCAR open science code of conduct*, we outlined the development process of the OSCAR open science code of conduct. We gave insights in the conceptual analysis work needed to arrive at the first version of the OSCAR code. We described the main components of the OSCAR code and outlined specific benefits of open science for the AAT community. We addressed some of the frequently ask questions regarding open science in section 5.9 FAQ. Finally, we outlined a short general step-by-step guide for the AAT community to use the OSCAR code of conduct and implement open science in their research projects in section *5.8 General step-by-step guide.*

7.2 Key results and findings

Open science is a way of doing science in which the research process (including hypothesis, results, publications, methods, source code, etc.) is made open as much as possible for as many as possible. A code of conduct is an explicit codification of implicit morally relevant norms, values or principles with the goal of improving the practices and behaviour of a group or organisation. An open science code of conduct is an explicit codification of implicitly morally relevant open science values or principles of open science to improve the scientific practices in research projects. The OSCAR open science code of conduct is an open science code of conduct tailor-made for the European AAT community.

Developing an open science code of conduct is conceptually and organisationally surprisingly hard. Yet, codes of conduct are an important and a helpful tool to improve and structure the practice and behaviour of an organisation or project. The OSCAR open science code of conduct is the first code of conduct of its kind. It is the first open science code of conduct as far as we know and it is most certainly it is the first of its kind in the AAT sector.

The OSCAR code will be about 15 pages long and will be concise and simple to use. The OSCAR code is being developed in a hybrid bottom-up, top-down approach and will be a hybrid rule-based, aspirational code. The OSCAR code will come with concrete examples and implementation practical hints.

The extensive literature and theoretical analysis performed by Fraunhofer IRB enabled us to contextualise the development of the OSCAR open science code of conduct. This deliverable gives important background information for the AAT community on open science and codes of conduct. The OSCAR open science code of conduct can help the AAT community to regain trust and accelerate their innovation cycles.

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