Case study report

Project ZOOOM - 3Os and IP Awareness raising for collaborative ecosystems

Grant Agreement No. 101007385

Funded by the
European Union

Document Control Information

Settings	Value
Document Title:	D2.2 – Case study report
Project:	ZOOOM
Document Version:	00
Dissemination Level:	PU
Date:	17/08/2023

Document Author(s)

Organisation	Name(s)
UNITN	Davide Serpico, Erica Santini
VTT	Jutta Suksi, Pasi Pussinen
JSI	Nataša Pibernik
UNIP	Elizabeta Zirnstein
INNOSBG	Florian Dürager
EITM	Giulia Marenghi

Table of Content

www.zooom4u.eu

List of Abbreviations

Acronym	Explanation
3Os	Free and open source software, open hardware and open data (also referred to open assets as a general term encompassing all 3Os)
3D	Three dimensional
4Es	The following four emerging technologies: (1) artificial intelligence (2) quantum technologies and Internet of Trust (3) blockchain (4) robotics
AI	Artificial Intelligence
API	Application programming interface
B2B	Business-to-business
B2C	Business-to-consumer
BC	Blockchain
CEO	Chief executive officer
EU	European Union
GDPR	General data protection regulation
IP	Intellectual property
OD	Open Data
OH	Open Hardware
OS, or OSS, or FOSS	Free/Open Source Software
PA	Public authority
QN	Quantum
R&D	Research and development
RB	Robotics
SaaS	Software as a Service

List of Tables

www.zooom4u.eu

Executive Summary

This case study report collects 34 cases from the literature and 25 cases from the in-depth interviews conducted by the members of ZOOOM. The first category covers companies cited across various areas of management and legal studies, and the second category companies, based in the EU area, the activities of which are related to the 3Os: open-source software (OSS), open hardware (OH), and open data (OD). The companies in the first category are categorized from the perspective of which of the 3Os the case refers to. The second category is categorized in more depth with respect to the role of the company as a user or as a maker of the technology, and, in addition, with respect to their activity in the 4Es, i.e., the emerging technologies of AI, blockchain, quantum, and robotics.

We investigate aspects such as: the role of open assets in the company's activities and value creation/capture; the company's approach to IP management issues; the motivations for the adoption of/contribution to open assets; challenges, risks, and opportunities enabled by the engagement in open assets; and the role of the company in their market and ecosystem.

Motivations for engaging in the 3Os: The motivations include strategic and competitive advantages, e.g., in the form of cost savings, interoperability addressing the vendor lock-in, benefits from collaborative ecosystems and collective intelligence, strategic flexibility, "branding effects", credibility and recognition, and visibility and fostering trust. In addition, participation in 3Os drives technological innovation; contributes to standardization and compatibility by providing flexibility, modularity, customization possibilities and quality mechanisms; addresses social and ethical motivations with transparency, collaboration and democratization of knowledge; and, at the same time, even fosters personal motivations of the key developers.

Challenges and risks: Challenges and risks arise from value capture dynamics, legal complexities, security concerns, communicating on open-source and community-related issues.

Role of open assets in the activities of the company: Operating with open assets is a balancing effort between open and closed elements. Open-source software has a more central role compared to open data or open hardware, but both of these can be a strong complementary to open-source software, and vice versa.

Legal aspects: Legal complexities arise in two dimensions. They appear in the numerous forms and terms of licensing, and affect the ways a company should

manage its IP and license compatibility. These require strategic decisions, professional expertise and diverse capabilities.

Evolution of 3Os based business: 3Os based business is dynamic and evolving by its nature. Recognizing the key patterns in the evolution helps companies to navigate the 3Os landscape.

Ecosystemic perspective: There are clear advantages of being embedded in one or more ecosystems where the creation of new knowledge is facilitated by joint research work, collaboration, expertise sharing, or the development of a common knowledge base to which communities of developers, too, contribute. In addition, it should be recognized that the companies participating in the ecosystems have their specific roles within said ecosystems depending on their strategy, main business and network structures.

Based on our findings, we identify four main elements that should form the architectural basis for the ZOOOM framework that aims to integrate business and legal aspects in the field of the 3Os. These are: 1) Combining open and closed strategies; 2) Recognizing the layered structure of open assets; 3) Structuring open hardware and open data as complementaries to open-source software; and 4) Understanding the multi-faceted value-creation and value-capture processes within the 3Os.

Finally, in the final part of the report, we collect some highlights of our findings into propositions that a company investigating the possibility of engaging with the 3Os should take into consideration when constructing their business.

www.zooom4u.eu

1. Introduction

The project identified a number of companies that served as case studies for analyzing best practices, challenges, and risks relating to the use of the 3Os for business purposes. Such companies have been selected through two separate processes: the first category consists of a literature review, which allowed us to single out companies that are often cited across various areas of management and legal studies; in the second category, we navigated the networks of ZOOOM partners, the internet and the social networks (e.g., LinkedIn) to find out about companies, based in the EU area, the activities of which are related to the 3Os (the first list of case studies can be found in Section 2; the second list can be found in Section 3). Therefore, data collection for case studies involved both primary and secondary sources of data.

In the case studies selection process, for both categories of cases, we gave special attention to those companies that are connected to the four emerging technologies chosen by the ZOOOM project (i.e., AI, Blockchain, Quantum, and Robotics). Although the selection process took into account all the verticals equally, most cases revolve around the use of AI and Blockchain technologies. Quantum and Robotics are unfortunately underrepresented, which is probably due to the highly innovative character of such technologies in the EU area, potentially large orientation towards open hardware, and a delay in the academic literature production relating to such areas.

As for primary data, the ZOOOM partners conducted in-depth interviews with 25 companies of the second category, investigating aspects such as: the role of open assets in the company's activities and value creation/capture; the company's approach to IP management issues; the motivations for the adoption of/contribution to open assets; challenges, risks, and opportunities enabled by the engagement in open assets; the role of the company in their market and ecosystem. The document uses the term open assets as a general term to encompass 3Os at places we want to address them from several differing perspectives, e.g., from technological, legal, economic or social aspects.

The document depicts the interviews collected until its due month. Further interviews may be collected in the forthcoming period due to e.g., difficulties in scheduling interview sessions or late answers of the companies engaged. This extra data will not be lost. Cases are one of the highly valued outputs of the project, and the ones not reported in this document will be part of the project toolkit material.

www.zooom4u.eu

2. Cases from academic and professional literature

From the academic and professional literature reviews, the following cases were identified as the most relevant with respect to business and ecosystem aspects relating to the 3Os. The cases have been categorized according to their involvement in the 3Os: free and open source software (OSS), open data (OD), and open hardware (OH). In addition, for those readers wishing to investigate the cases in more detail, sources are listed to give easy access to the cases.

OS	OD	OH	Case	Source
OS		OH	Arduino	Blind, Knut et al. (2021)
OS			Cendio	Dahlander & Magnusson (2008)
OS			CentOS (Red Hat, Linux)	Blind, Knut et al. (2021)
OS		OH	Embedded Linux	Gruber & Henkel (2006)
	OD		ESS-CSDL	Runeson et al. (2021)
	OD		Facebook	Temiz et al. (2022)
	OD		Google	Temiz et al. (2022)
OS			IBM	Watson et al. (2008)
	OD		Jobtech	Runeson et al. (2021)
OS			LibreOffice	Blind, Knut et al. (2021)
		OH	Makerbot	Viseur & Jullien (2022)
OS		OH	MyriadRF	Blind, Knut et al. (2021)
OS			MySQL	Dahlander & Magnusson (2008); Rajala et al. (2012)
OS			Netscape-Mozilla	Dell'Era et al. (2020)
OS			Nextcloud	Blind, Knut et al. (2021)
OS		OH	Open Compute Project (FB)	Blind, Knut et al. (2021)
OS			OpenOSX	Watson et al. (2008)
OS			OpenStack	Teixeira et al. (2015)

www.zooom4u.eu

OS	OD	OH		
	OD		OpenStreetMap	Runeson et al. (2021)
OS			OW2	Blind, Knut et al. (2021)
		OH	Prusa	Viseur & Jullien (2022)
OS			RedHat	Dell'Era et al. (2020); Watson et al. (2008)
		OH	RepRap	Blind, Knut et al. (2021)
	OD		Road Datalab	Runeson et al. (2021)
OS			Roxen	Dahlander & Magnusson (2008)
		OH	SiFive (RISC-V)	Blind, Knut et al. (2021)
OS			Software Heritage	Blind, Knut et al. (2021)
OS			SOT	Dahlander & Magnusson (2008)
		OH	Sparkfun	Li & Seering (2019); Moritz et al. (2016)
	OD		Structural Genomics Consortium	Temiz et al. (2022)
		OH	Ultimaker	Moritz et al. (2016); Viseur & Jullien (2022)
		OH	WhiteRabbit (CERN)	Blind, Knut et al. (2021)
OS	OD		X-Road	Blind, Knut et al. (2021)
OS			Yocto (Red Hat, Linux)	Blind, Knut et al. (2021)

Table 1. Cases from academic and professional literature.

A comprehensive analysis of these cases is beyond the aims of this report, since the literature itself is quite fragmented and, in many cases, publications only make brief reference to their main characteristics and history of a company. However, below is a brief analysis of some cases.

Firms such as RedHat, SpikeSource, and OpenOSX have been analyzed by Watson et al. (2008) to describe the *Corporate Distribution* model of software production or distribution. Here, similarly to an *Open Community* model, the development and support of software is volunteered with limited or no commercial interest; however, in the corporate distribution model, firms create and capture value by identifying best-of-breed OSS projects, improving distribution methods for these products, and providing complementary services in order to make these OSS products more accessible to a broader market. Additionally, CentOS, LibreOffice, Nextcloud and OW2 are cases

encompassing aspects relating to end user applications in connection with open-source software (See Blind, Knut et al. 2021).

CentOS and Yocto are projects that enable building customized software platforms for hardware. Firstly, both cases unveil the interlinks of embedded systems to the underlying layers of Red Hat and Linux. Secondly, these cases also demonstrate the possibilities that come when open-source software and open hardware are combined (See Blind, Knut et al. 2021).

IBM is another case analyzed by Watson et al (2008), a high-profile corporation that contributes to developing OSS projects on the Apache's Web server. IBM embraces the so-called *Sponsored Open Source* model, where OSS projects are initiated by corporations releasing previously closed codes and encouraging their employees to continue to work on the now open project - Eclipse is an example of an integrated software development environment released as OSS by IBM.

MySQL, Cendio, Roxen, and SOT have been analyzed by Dahlander & Magnusson (2008) to describe three means by which firms exploit communities: (1) accessing communities to extend the resource base; (2) aligning firm strategies with the community; and (3) assimilating communities in order to integrate and share results. These cases illustrate how firms found it necessary to change their business models to align with the communities. MySQL needed to build a sufficiently large community and engage actively with the community to create a virtuous development cycle. Cendio used an adaptive approach, and did not try to change the direction of the development in the communities in any substantial way, but instead focused on using what was developed in the communities and integrating this work with internally developed components. Both Roxen and SOT founded a community but then had issues with attracting new members; SOT tried to influence community developments by offering incentives to individuals to work with the community, to enhance both its and the firm's reputation, and give the firm more scope for controlling the direction of community developments. For community aspects, the cases Yocto and Software Heritage are also of relevance (See Blind, Knut et al. 2021).

Arduino is an example of a success case on OH, and of a maker community that has evolved into viable business and an international benchmark. The design of the hardware is open for commercial and non-commercial purposes and the business value is based on trademark, sale of physical products, consultancy and even SaaS-type of business (See Blind, Knut et al. 2021).

www.zooom4u.eu

Makerbot, Prusa, and Ultimaker are compared with each other by Viseur & Jullien (2022), who identified two types of business models in the context of OH: *Closed Supply-chain Platform* and *Open Industry platform.*

Makerbot belongs to the first type, which consists of taking control of all the components of a product in order to master its architectures, and therefore favours a closed approach to innovation in order to guarantee the technological consistency of its platform. This involves a razor-blade type business model that relies on the sale of raw materials but requires strong control over the overall quality of the proposed solutions (the assembly of components), and also over the compatibility between the different elements of the hardware. As a result, the community is excluded from hardware developments. This strategy broadly follows the classic pattern identified in the open-source sector, or the more general framework of open innovation, where the community is exploited temporarily at the launch of the activity, to compensate for the lack of resources of the company, with a gradual closure of the development process, because the company is no longer able to capture the value created by the community. The company then develops (contractual) collaborations with suppliers or its own unitary technologies that guarantee it total control over the innovative solutions it proposes.

By contrast, Prusa Research and Ultimaker belong to the second type, embracing a particular form of innovation ambidexterity where the companies have developed their capacities to make both incremental innovation and to explore new offers. Then, Ultimaker has even abandoned the open-hardware strategy, while Prusa's open-hardware strategy remains important for it to maintain exploratory capacities. The publication of machine specifications under a free license is necessary to generate contributions, but also to allow users to test configurations and thus report bugs. in contrast to the Makerbot's approach, *Open Industry platform* strategy does not harm value capture, because the main source of revenue does not come from selling machines to its user-developers, but from printing solutions, for which the company possesses other specific human assets (business experts or experts in 3D technology), which are also expensive to replicate.

Cases White Rabbit (CERN), MyriadRF and RepRap elucidate the role of enabling technologies and Open Compute Project (FB) and SiFive (RISC-V) the role of computing, both within the context of open hardware (See Blind, Knut et al. 2021).

Facebook (Meta) and Google are examples of companies that have been able to leverage OD to target campaigns with unprecedented precision, especially through a

www.zooom4u.eu

combination of data of different type (see Temiz et al. 2022). These are exceptional cases, in the area of OD, due to the difficulty of capturing value from data. Indeed, enterprises face remarkable challenges in order to find, access, and select OD (see Enders et al 2021; Kamariotou and Kitsiosis 2022; Krasikov et al. 2020; Monino 2021). For example, the data must not only be open, but also useful, useable, cleaned, and technically and legally accessible, and it must be matched by investments in information, metadata, software, quality management, and social tools that can cultivate the ecosystem around the open data, in addition to data analytics capabilities.

Case OW2 focuses on infrastructure software, case Software Heritage is meant for preserving software source code, case White Rabbit is a fully deterministic Ethernet-based network and case X-Road manages access to sensitive data. All these cases enlighten aspects that relate to open-source software in the public sector and connections of open source software with data (See Blind, Knut et al. 2021).

Cases ESS-CDL, RoDL and JobTech shed light on emerging open data ecosystems (See Runeson et al. 2021) and open innovation. These cases are compared against the case of OpenStreetMap as a community-driven, truly open data ecosystem. The case studies observes the differences between shared data and open data and highlights the components of open data ecosystems and the need for them to be value-driven.

www.zooom4u.eu

3.   ZOOOM case studies

3.1. Case studies at a glance

Table 2 lists the ZOOOM case studies that were studied through interviews and categorizes the cases in two dimensions: firstly, on the left side, with respect to the form of the open assets, i.e. 3Os, and secondly, on the rights side, with respect to the area of the emerging technologies, i.e. 4Es.

With regard to 3Os, the cases have been categorized in three categories: 1) free and open source software (OS); 2) open data (OD); 3) open hardware (OH). With regard to 4Es, the cases have been categorized in four categories: 1) artificial intelligence and machine learning (AI); 2) blockchain (BC), 3) quantum (QN); 4) robotics (RB).

The table also makes a distinction between two central perspectives on the role of the organizations towards the utilization of the technologies:

User (marked as a gray block):

xx

User is an organization providing products or services that utilize open or emerging technologies.

Maker (marked as a black box):

xx

Maker is an organization participating in developing and contributing to open or emerging technologies.

Other aspects of the analysis are studied in Section 4.

OS	OD	OH	Case	AI	BC	QN	RB
OS			Alps Blockchain		BC		
OS			Atuin Media	AI			
OS			Blumatix	AI			
OS	OD		Cognify	AI			
OS	OD	OH	Company X (anonymized)				RB
OS			Company Y (anonymized)		BC		
OS	OD		Datafund	AI	BC		
OS	OD		Dedagroup				
OS	OD		Georesearch	AI			
OS			Iovavum	AI			
OS			Nethesis	AI			
OS			Notarify	AI	BC		
OS	OD		Openmove				
OS			Pimcore				
OS			Polycular				
OS	OD		Propertune	AI			
OS			Qt Group	AI			
OS	OD		Quanscient	AI		QN	
OS	OD		Semantum	AI			
OS			Solbytech				
OS			Sproof				
OS	OD		Src	AI			
		OH	ThinkIn	AI			
OS	OD		U-Hopper	AI			
OS			Wurth Phoenix				

Table 2. ZOOOM case studies categorized with respect to 3Os and 4Es.

www.zooom4u.eu

3.2. Methodology for the interviews

The members of ZOOOM conducted in-depth interviews with 25 companies, the activities of which involve the 3Os in various forms. The selected companies have a track record of delivering innovative products and services that incorporate open assets. Below are criteria that guided the selection of relevant companies and stakeholders.

Area of expertise
The companies selected for the interviews base their business on open assets, particularly open-source software, open hardware, and open data. A number of companies' activities revolve around the four verticals investigated by ZOOM: AI, Blockchain, Quantum, and Robotics. Compared to the other areas, Quantum technologies and Robotics are underrepresented due to their relatively minor role in the contemporary business landscape. Other activities pursued by companies include additive manufacturing and cybersecurity.

Geographical Location
We focused primarily on companies from the EU area, mostly from the countries of the units that conducted the interviews: Austria, Finland, Italy, Slovenia, and Switzerland.

Interviewees Role
The sample included members with a central role in their companies, including CEOs, founders, technical experts, community managers, and business development experts.

Type of Company
We considered several variables reflecting the companies' size and type, for instance, whether they are startups, SMEs, or large enterprises, as well as whether they are B2B or B2C, product-based, service-based, or consulting-based. This allowed us to better capture a company's position in its ecosystem(s) and the life cycle of the company: many companies in emergent technologies are startups, and it was thus important to collect data on the benefits, risks, and challenges of engaging in the 3Os for emerging businesses. A smaller number of companies have extensive experience in their industry, and can thus inform us about successful best practices in the use and development of open assets, IP management, and community building.

Role in the Development of the 3Os

We covered different roles that a company can play in its industry and ecosystem, such as *users* versus *makers*. Users tend to adopt open-source elements developed by others.

For the purposes of ZOOOM, rather than considering passive or end-users, we mostly focused on companies that base their business on open assets and platforms and thus interact with a community; users often have to navigate complex IP issues in the use of an open asset or platform.

Makers, on the other hand, usually have an active role in the development of open assets, actively engage with a community, and are thus involved in innovation processes that revolve around the 3Os. For instance, they can contribute to an open-source platform, share their projects online with global communities, take on the role of system integrator or an OSS framework leader, or make minor customizations to an already existing product.

The literature defines makers as hobbyists, crafters, and tinkerers who adopt a "do-it-yourself" or "learning-by-doing" strategy to address their personal needs (Browder, Aldrich & Bradley 2019; Li et al. 2020). Some makers turn their projects into commercial products and become maker entrepreneurs (Troxler & Wolf 2017). Li et al (2020) focus on makers who have forgone the patents and copyrights of their product design but instead have licensed their product designs and technologies under open-source licenses allowing the public to use their designs for free. Notably, some types of makers are not strictly relevant for ZOOOM due to their little interest in business aspects or value capture (e.g., "benevolent developers" and research institutions).

3.3. Interview structure and contents

Before starting the interview processes, the ZOOOM team implemented a shared protocol to harmonize the primary data collection process and avoid inconsistencies. One of the interviews was conducted in writing, while the rest were semi-structured and explorative and lasted about 60 minutes each. Major topics explored in the interviews are:

- A company's approach to IP management related to open software, open hardware, and open data
- A company's perspective on the trade-offs between the opening of its products and using a closed, proprietary strategy

- The relevance of the 3Os in value generation and capture in a company's business
- How IP strategies tend to change in response to changes in business and the lifecycle of a company and, vice versa, how changes in business strategies affect IP management
- Whether the questions above depend on the size of a company and their industry
- Challenges, barriers, and opportunities of adopting the 3Os in relation to firms' characteristics (e.g., company routines, core competence) in contrast to traditional strategies

Part 1: Introduction

The first part of the interviews lay the groundwork for the conversation. First, we asked for confirmation about the interviewee's consent to the interview being recorded and informed them that the personal data and information from the interviews would be used for the ZOOOM project's purposes in compliance with the consent given and with the GDPR regulation.

We then introduced the project: we explained that ZOOOM is a research project funded by the EU involving eleven partners across various countries, which investigates IP generation and management in collaborative ecosystems which rely on open-source software, open hardware, and open data. Our working hypothesis is that strategic autonomy and technological sovereignty require identifying the best licensing strategies for specific business models. This includes knowing when and to what degree it makes sense to stay open, and when going proprietary is the best strategy.

Finally, we explained to the interviewees the purpose of the interview and clarified the role of the case studies in the project. Accordingly, the data collected through the interviews will allow us to:
- collect a comprehensive repository of best practices for the legal and business use of the 3Os
- develop tools and training to handle licensing strategies more effectively and identify viable business models;
- develop a legal-business framework to organize the existing knowledge on these topics and identify major issues to be addressed.

Part 2: General Information

The second part aimed to collect information about the company's activities and narrow down the conversation toward its experience with the 3Os. We asked about:

- the company (name, size, role and responsibilities of the interviewee)
- the interviewee's/company's experience with the 3Os
- the role of the 3Os in the company's business
- the role of the company (maker/contributor vs. user)
- expertise in the 4Es emerging technologies: AI/ML, Blockchain, Quantum, and Robotics

Part 3: The Company's Approach to IP

The third part explored the company's approach to IP issues related the 3Os from both the perspective of a maker/contributor and the perspective of a user (see above on this distinction). We expected that IP management for the two roles could involve different issues, and we thus asked slightly different questions to companies that identified themselves as either makers or users.

We investigate this topic through some of the following questions:

- Describe, in general, how your company manages IP issues for its own products (for makers) / in relation to the products of others (for users)
- Do you have an open-source compliance program in place? Or are decisions on open-source compliance made ad hoc?
- In the former case, does your IP policy (or similar) cover one of the following: open source software/open hardware/open data
- Has your approach towards IP changed over time?

Part 4: Motivations

This part was meant to understand the legal and business motivation for "being open", or using open products developed by others, through specific examples. For instance, a company may do so to drive innovation, gain competitive advantage, and influence technological development.

With makers, we explored the topic through the following questions:

- Can you give us an example of a product developed by your company that incorporates open elements?
- What was the basis for the decision to incorporate such elements?
- How has it been used to create and capture value?

- Is there any past situation where your company had to consider IP issues involved in opening their source code, hardware, or data? (e.g., a situation where the company had to decide between protecting its IP and choosing to open software/hardware/data)
- What was the outcome?
- What resources did you use to assess the best course of action in legal terms (experts, training, tools)?
- Did the company ever take inspiration from licensing strategies of other companies in their field or other fields?

To users that do not actively contribute to open assets, we instead asked slightly different questions:
- Can you give us an example of a product that incorporates open elements that the company used to create or capture value?
- Is there any past situation where your company had to consider IP issues involved in using open-source software/open hardware/open data? (e.g., a situation where the company had to navigate IP issues in the use of open software/hardware/data generated by other parties)
- What was the outcome?
- What resources did you use to assess the best course of action in legal terms (experts, training, tools)?
- Did the company ever take inspiration from licensing strategies of other companies in their field or other fields?

Part 5: Trade-offs Between Open and Proprietary Strategies

In this part, we explored the company's perspective on the trade-offs between opening its software, hardware, or data and using a closed, proprietary strategy. At this point of the interview, we noted that different business models can require different strategies for creating and capturing value from 3Os, which can also have different implications for IP management. Also, different industries and technological areas can involve different issues. We thus aimed to assess the company's view of the risks and opportunities related to the adoption of open licenses in their specific business.

We investigated this topic through some of the following questions:
- In comparison to proprietary strategies, how does the company benefit or suffer from openness?

- What are the challenges in transitioning from a closed proprietary strategy to a more open one?
- How does the company balance these potential benefits against various risks? e.g., loss of IP (in the case of makers) or non-compliance with IP (in the case of users)
- How do you perceive the risk of non-compliance? Do you see it more as a reputational risk, or as a legal risk with potential financial consequences?

Part 6: Ecosystems

This part explored how open software/hardware/data generate value in a given industry and the specific ecosystem(s) in which the company is involved. We also investigated how companies have adapted (or plan to adapt) to this fast-changing context:

- What open-source software, open hardware, or open data ecosystems/communities are you involved in?
- What is the role of your organization currently in the ecosystems?
- How did it change over time? e.g., do you think that the boundaries of your company are changing in terms of legal responsibility and innovation strategies?
- What was the initial reason for joining/linking to your ecosystem(s) and community?
- What are the main benefits and challenges for your business relating to collaborations in an "open ecosystem"?
- What steps is your company taking to adapt to this fast-changing environment?

Part 7: Conclusions

To conclude the interviews, we thank the interviewees for their time and ask if they had any questions or further information they want to share, including considerations about potential tools or training that the ZOOOM project could provide. We then directed them to the ZOOOM webpage and asked if they would like to get more information on the project's development and if they would be interested in participating in ZOOOM dissemination activities.

4.   Findings and analysis

Among the 25 organizations interviewed, the sizes of the organizations were: 4 large organizations, 13 SME's and 8 micro/start-up's. Dominating main activity for the interviewed companies was stated as *software development* complemented with different software related services like *consulting* or software *product design*.

Interviewed organizations	Geographical locations
Large (4)	1x Austria, 2x Finland, 1x Italy
SME (13)	5x Austria, 1x Finland, 5x Italy, 1x Slovenia, 1x Switzerland
Micro/Start-Up (8)	3x Austria, 1x Finland, 3x Italy, 1x Slovenia

Table 3. Size and geographical locations of the interviewed organizations.

The majority of the interviewees were familiar with open-source software and were using open source software in their activities, and 16 organizations reported that they were contributing back to the development community. There were 11 organizations which stated they were utilizing open data, with 4 organizations reporting that they were also contributing back to open data. Only 2 organizations were using open hardware and only one respondent was contributing back to the open hardware community.

Users/Makers	Instances
Using Open Source Software	24
Using Open Data	11
Using Open Hardware	2
Making Open Source Software	17
Making Open Data	4
Making Open Hardware	2

Table 4. Categorization of organizations with respect to the role of utilization (users or makers) in the 3Os.

www.zooom4u.eu

Not all of the interviewed companies were actively engaging with the emerging technologies. The emerging technologies were represented amongst the interviewed organization as follows:

Emerging Technology	Instances
Machine Learning / AI	11
Blockchain	3
Quantum Technologies	1
Robotics	1

Table 5. Amount of organizations involved in the 4Es.

Emerging Technology	Using Open Source Software	Using Open data	Using Open Hardware	Making Open Source Software	Making Open Data	Making Open Hardware
Machine Learning / AI	10	5	1	8	0	0
Blockchain	4	1	0	2	0	0
Quantum Technologies	1	1	0	1	1	0
Robotics	1	0	0	1	0	0

Table 6. Correlation of the role of utilization (user/maker) per each of the 3Os and 4Es.

4.1. Motivations for engaging in the 3Os

In the dynamic landscape of modern business, open assets of 3Os have emerged as a powerful force driving competitive advantage, fostering innovation, and shaping the ethos of companies across various industries. Open-source software, open hardware, and open data present a unique opportunity for organizations to leverage collaborative development, harness external expertise, and participate in a global community

www.zooom4u.eu

committed to shared progress. In this section, we delve into the multifaceted motivations driving the interviewed companies to embrace the 3Os and explore how these motivations shape their strategic decisions, technological advancements, standardization efforts, and organizational culture.

In the Table below, it is a summary of the motivations indicated by the interviewed companies.

Motivations	Instances
Strategic and competitive advantages	18
Technological innovation	7
Standardization and compatibility	6
Social and ethical motivations	6
Personal motivations	3

Table 7. Main motivations for adopting the 3Os as emerging from the interviews conducted by the ZOOOM partners.

4.1.1.   Strategic and competitive advantages

At the heart of many companies' open-source engagement lies strategic and competitive considerations. The allure of cost savings is a first, compelling driver, particularly for small and resource-constrained firms like start-ups. Open assets enable companies to tap into a vast repository of ready-to-use solutions, thereby bypassing the resource-intensive path of developing products from scratch. This not only accelerates time-to-market but also empowers smaller players to compete effectively with their larger counterparts, erasing the traditional resource barriers that once limited their ambitions.

A second crucial aspect is that open assets offer a solution to the challenge of vendor lock-in for both companies and customers, namely, the dependence on a single vendor's proprietary solutions, which can limit innovation and flexibility. Open source combats these issues by promoting interoperability. On one hand, by incorporating open-source software, data, and hardware, businesses avoid relying solely on one vendor: they can customize and extend these technologies, ensuring alignment with their unique needs. On the other hand, customers benefit from open source by

accessing a competitive marketplace and enjoy interoperability and competitive solutions: multiple vendors offer compatible solutions, driving innovation and preventing monopolistic practices. In this sense, customers can easily switch vendors or integrate third-party offerings, ensuring uninterrupted services.

Relatedly, the dismantling of barriers that once confined companies to proprietary ecosystems is another crucial aspect that enables companies to join new, collaborative ecosystems. Open assets provide the interoperability necessary for seamless integration across diverse platforms. This newfound freedom empowers companies to assemble a technology stack tailored to their unique needs, incorporating best-of-breed solutions from the open-source realm and proprietary offerings as needed (oftentimes, the interviewed companies adopt a hybrid licensing strategy endorsing both proprietary and open solutions). This strategic flexibility amplifies innovation and accelerates responsiveness to market demands.

Moreover, the collaborative nature of open-source development introduces an element of collective intelligence that significantly contributes to a company's competitive standing. External developers and contributors become virtual extensions of the company's R&D team, collectively enhancing code quality, addressing bugs, and continually improving software and hardware solutions. This distributed innovation not only accelerates product development but also augments the expertise within the organization, recruiting possibilities and even customer acquisition, positioning it at the forefront of technological advancements.

Finally, the "branding effects" associated with open-source engagement offer a distinct competitive edge. In an era where transparency, community participation, and values-aligned business practices hold sway, companies that align themselves with the ethos of open source are better positioned to attract a growing segment of consumers and clients who prioritize these values. This is especially evident for startups environment, where credibility and recognition can make or break an emerging venture. Involvement in the 3Os serves as a powerful avenue for such companies to showcase their commitment to innovation, collaboration, sustainable business, and a global community, thereby enhancing their visibility and fostering trust.

4.1.2.   Technological innovation

According to the interviews, OSS seems to be closely connected to driving innovation forward. For example, OSS is used in R&D activities and the results of research

projects feed the OSS community in the form of OSS contributions and publications. Innovation is present also in more indirect ways such as in the efforts of building infrastructure or forming standardized practices that serve the main business of the company.

The 3Os serve as a catalyst for technological innovation within companies. Participating in the open-source ecosystem exposes organizations to the latest developments, emerging trends, and cutting-edge solutions within their respective fields. This exposure fosters a culture of continuous learning, expanding the knowledge base of the company and its employees. By actively contributing to or leveraging existing open-source projects, companies gain insights into best practices, novel approaches, and creative solutions that might not have been apparent within the confines of a closed environment.

The collaborative nature of open-source development encourages experimentation, iteration, and the sharing of innovative ideas, driving technological progress beyond the confines of individual organizations. This exposure to diverse perspectives and novel methodologies enables companies to stay ahead of the curve, anticipating industry shifts and positioning themselves as leaders in innovation.

4.1.3.   Standardization and compatibility

Standardization is a critical consideration for many companies, particularly in an era of rapid technological proliferation and increasing complexity. Open source technologies provide a platform for establishing and promoting industry standards, facilitating interoperability and compatibility among diverse systems. The advent of standardization forums, such as APIs (Application Programming Interfaces) and reference implementations, has become increasingly important, particularly for smaller players seeking to navigate complex ecosystems. In some areas, such as additive manufacturing, providing more compatibility is crucial for the success of collective efforts, where companies and organizations work in the same network and ecosystem.

PROPOSITION 1:

Assess if doing business in your area is feasible at all without using open assets.

Open-source solutions, characterized by flexibility and modularity, are well-suited for customization. Companies can adapt these solutions to their specific needs, tailoring features, functionality, and interfaces to align with their strategic objectives. This adaptability empowers organizations to create differentiated offerings while maintaining compatibility with established industry standards, allowing for seamless integration with other products and services.

In certain cases, companies' contributions to open-source projects, whether in the form of plugins, tools, sensors, or data formats, not only enhance existing standards but also set the stage for future services. For instance, companies providing OSS and OD services for the public administrations (PAs) often aim to improve the existing platforms and formats mostly for the potential that such contribution will have for future projects, rather than for immediate economic possibilities. This indirect value-capture mechanism emphasizes the importance of collaborative innovation and the long-term benefits of driving industry-wide progress.

PROPOSITION 2:

Consider the non-immediate value-generation mechanisms that your contribution will potentially have.

Furthermore, participation in open-source development compels companies to uphold international standards, ensuring that the software, data, or hardware they produce adheres to recognized quality benchmarks. During an interview, it was made an analogy between making open-source codes and making scientific research: since scientific publications are under the scrutiny of the global scientific community and, at the same time, scientific findings must be accessible to anyone, they need to meet the highest standards possible (here, the peer review process is the mechanism that helps make this possible). Likewise, open-source codes get collective attention and can be adaptable to different purposes. This encourages developers to do a better job than if the source code was only for internal use.

PROPOSITION 3:

Take into account the quality standards required and fostered by open source.

www.zooom4u.eu

Commitment to open source not only enhances the credibility of the company (see branding effects above) but also results in a more consistent and homogeneous user experience. End-users, in fact, can benefit from products that adhere to established norms, ensuring compatibility, stability, and reliability.

4.1.4.   Social and ethical motivations

Beyond the strategic and technical aspects, the motivations for open-source engagement often carry social and ethical underpinnings. Many interviewees highlighted the role of open source in enhancing security, reliability, support, and control. Open-source solutions, with their transparent and community-reviewed code, are perceived by companies as more secure, offering them greater confidence in the integrity of their products. This enhanced security posture becomes particularly pertinent in industries that handle sensitive data or operate in regulated environments.

Moreover, for some companies, open source is not merely a pragmatic choice but "a cultural one", in the words of one interviewee, which reflects a set of values that align with transparency, collaboration, and the democratization of knowledge. This ethos resonates strongly with both employees and customers who value social responsibility, openness, sustainability, and community-driven development. One noteworthy example, in our dataset, is a company that has embraced open source as its business philosophy, exemplifying a commitment to reshaping the industry by advocating for technology democratization.

Starting to contribute to open assets is also appealing to many companies, at some point, to give something back to the community after years of using open tools. This highlights peculiarities of the open-source context, namely, the role of reciprocity and altruism in driving business choices. Some of the companies even felt responsibility to foster the surrounding ecosystem.

Importantly, in some cases, social and ethical motivations are prioritized over the "make-profit" imperative, suggesting the emergence of a new way of doing business. In such cases, companies can make certain strategic decisions on its business goals and market position, even though they prioritize limitations and constraints of such choices. In other words, there might be decisions that they want to avoid at all costs or areas in which they want to contribute for non-financial reasons.

PROPOSITION 4:

Reflect on the social and ethical reasons to engage in the 3Os and contribute to open assets.

4.1.5. Personal motivations

To many companies, developing open assets is a stimulating activity. In fact, the role of key developers within an organization cannot be underestimated in shaping technology decisions. These individuals, often holding significant influence over technology choices, gravitate toward open-source solutions that align with their expertise, preferences, and the unique requirements of the project. Their personal motivations, driven by a desire for flexibility, collaboration, and the empowerment to tailor solutions to specific needs, directly impact the company's technological development. Key developers, as gatekeepers of technology adoption, prioritize open source for its flexibility and the diverse ecosystem it offers. They recognize the power of open source in allowing them to choose the tools and platforms that serve them best, resulting in greater job satisfaction, self-enjoyment, increased productivity, and the ability to experiment with new approaches.

PROPOSITION 5:

Do not forget the central role of the key developers.

4.1.6. Concluding remarks on motivations

In sum, the motivations for companies to engage in open assets are multifaceted and rich in their implications for business, innovation, and industry transformation. Strategic advantages, technological innovation, standardization, compatibility, social and ethical considerations, and personal preferences collectively shape the open source landscape. Recognizing these motivations empowers companies to navigate the complex terrain of the 3Os with clarity, purpose, and an understanding of the diverse benefits that await those who embrace the power of collaboration, openness, and community-driven progress. At the same time, companies that are still not fully engaged in open source, can often see a variety of benefits and potentialities. As the open-source movement continues to evolve, companies that harness its potential stand poised to lead the way in innovation, efficiency, and societal impact.

4.2. Challenges and risks

All the interviewees agreed that open assets represent an invaluable resource, providing their companies with a dynamic realm of possibilities. Nonetheless, businesses leveraging the 3Os must navigate a variety of challenges at both legal and economic levels. Drawing on insights from the interviews, this section delves into the multifaceted challenges associated with the use and development of open assets for business purposes, encompassing legal complexities, value capture dynamics, security concerns, customer biases, and community-related considerations.

Table 8 summarizes the main challenges and risks discussed by the interviewed companies.

Challenges and risks	Instances
Legal complexities	8
Value capture dynamics	11
Security concerns	5
Communicating Open Source	5
Community-related issues	6

Table 8. Main challenges and risks relating to the use and development of the 3Os discussed in the interviews conducted by the ZOOOM partners.

4.2.1. Legal complexities

Navigating the legal landscape of open-source licenses and forms of IP protection can be labyrinthine, engendering compliance challenges that have far-reaching implications. Companies face the intricate task of understanding the nuances of licenses and IP to ensure that their use of open source components aligns with legal requirements and the business goals of the companies. Indeed, non-compliance with license terms can result in financial penalties, reputation damage, and legal disputes that divert resources from core business pursuits. Non-compliance of the license terms can also be regarded as a "real-world" phenomenon manifesting differently in different parts of the world and, thus, in order to be resolved, requiring time and increase of awareness among all stakeholders.

The dynamic nature of open-source projects, coupled with the diverse array of licenses and forms of IP protection, further exacerbates these challenges, necessitating constant vigilance and expertise in the legal domain. These legal complexities appear in many forms: for instance, in the need for modularization and more detailed design of said modules; in the need for acquiring legal expertise, in establishment of mitigation strategies; and sometimes even in decisions not to release software as open source. On the other hand, at times, organizations may consider the legal complexities as secondary issues. This is a topic that will be explored further in Subsection 4.4 from the perspective of licensing and IP management.

4.2.2. Value capture dynamics

The allure of open-source, grounded in collaboration and community-driven development, is counterbalanced by more intricate value capture dynamics than classical proprietary solutions. Open assets often lack the ad-hoc assistance that proprietary alternatives offer, raising concerns about the availability of dedicated support when critical issues arise.

This challenge is further accentuated by the influence of major industry players who can wield substantial power over open-source projects: in industries where proprietary models dominate, transitioning to open source can disrupt established value chains and revenue streams. For instance, in the additive manufacturing sector, a shift towards open source could potentially disrupt the intricate network of raw material suppliers and software vendors that drive revenue. As another example, an interviewee noted that big firms (e.g., Microsoft, IBM, Amazon) and influential organizations (e.g., FSFE, Apache) can direct software developments and research towards specific directions relating to their own interests. Small companies need to catch up and constantly evaluate their risk in engaging in a given community or refocusing their attention towards different projects. The result is a delicate balancing act between community collaboration and preserving business independence.

4.2.3. Security concerns

While open source is often valued for its community scrutiny that helps identify and mitigate vulnerabilities, security challenges persist. The vast and diverse codebase of open-source projects can inadvertently harbor security gaps. Businesses utilizing open assets must implement rigorous security measures, including regular code

reviews, continuous monitoring, and prompt response to emerging threats. Failure to address security concerns can lead to breaches, data leaks, and reputational damage that undermine the very benefits that open source offers.

4.2.4. Communicating Open Source

Convincing customers of the value of open-source, particularly when free alternatives exist, presents a formidable challenge. Overcoming the perception that open-source inherently equates to "free" can be complex: businesses need to effectively communicate the additional value, security, and support that paid open source offerings provide. One interviewee explained that he often makes an analogy between OSS and water: while water is a free resource and a public good, the services associated with providing, packing, and commercializing it are not.

This communication challenge is further compounded by the rapid pace of technological evolution, where understanding the nuances of open-source licensing and usage can be overwhelming for non-technical stakeholders (see above).

Finally, one interviewee noted that OSS is perceived by customers as risky in terms of lock-in with their company, with little awareness about actual lock-in effects with proprietary software (surprisingly, companies providing proprietary solutions are believed to be more reliable).

PROPOSITION 6:

Assess how to effectively communicate the benefits of open-source solutions for your customers (e.g., security, compatibility, flexibility, avoiding vendor lock-in).

4.2.5. Community-related issues

Engaging with open source communities holds immense potential, yet it introduces a degree of unpredictability. Companies may become reliant on services provided by the community, exposing them to risks if these services are disrupted or discontinued. This potential loss of access underscores the need for meticulous community management and the cultivation of alternative channels to ensure continuity. The

www.zooom4u.eu

evolving dynamics of open source communities necessitate adaptability and a forward-looking approach to community engagement.

One interviewee, with extensive expertise in community leadership and management, advised new startups to plan ahead to which community - or communities - their products is intended to address, rather than developing a complete OSS, for instance, and, only then, looking for a community that can contribute to it.

PROPOSITION 7:

Be clear as regards the target audience of your product(s) and which communities you will be interacting with.

4.2.6. Strategies to mitigate risk

Some interviewed companies have devised strategies and continuously monitor and evaluate risks to navigate the open-source landscape. Some opt to avoid legal risks altogether by not releasing their products as open source, preserving their proprietary advantage. Diversification emerges as another risk-mitigation strategy: one company involved in blockchain technologies uses multi-blockchain networks to spread risk and minimize concentration. For others, maintaining secrecy becomes pivotal, leveraging the uniqueness of their product as their competitive advantage in a landscape driven by collaboration.

PROPOSITION 8:

Devise risk-mitigation strategies for IP management and investments.

4.2.6. Concluding remarks on challenges and risks

In conclusion, embracing open assets for business advancement is a nuanced endeavor that balances innovation potentialities with risks. The legal intricacies of open-source licenses, value capture dynamics, security concerns, customer perceptions, and the dynamics of open-source communities collectively shape the

decision of a company to become a user or developer of open assets. By understanding and proactively addressing these challenges, businesses can harness the transformative power of open source while navigating risks effectively. The journey toward open-source excellence demands strategic acumen, community engagement, and a commitment to innovative problem-solving.

4.3. Role of open assets in the activities of a company

4.3.1. Balancing openness and closeness

The interviews reveal the intricate relationship between openness, proprietary solutions, and innovation in software development. Open assets play a significant role across various companies' activities, fostering innovation, collaboration and competitive advantage. The companies leverage OSS, OD, and OH to varying degrees in combination with closed elements to create a synergy that drives their business operations. The closed part of the activities may entail additional software, but it can also be other types of intellectual property, like confidential information, trade secrets and know-how, or it may be based on patents, closed infrastructure or computing capacity, or even on layers of capabilities and services.

While OSS seems to play a central role across different companies' activities, it is important to note that the degree of emphasis on each component can vary based on the specific industry as well as the products and services each of them offer. Some companies may use open source libraries, whereas others start to build their own open source framework. In many cases, OSS sets the basic software framework within a company's operations base, which can explain its central role in the context of the responses in the interviews.

Companies utilize customized solutions to meet client needs while safeguarding intellectual property. This requires flexibility from the companies. Many actively contribute to the open-source community, striking a balance between collaboration and monetization by combining open-source and commercial licenses. Cloud architecture, often based on major providers, sets standards, and open-source components play a key role in R&D initiatives.

The combination of open and closed elements used by the companies, represents a strategic balance. Several of the companies seem to have analyzed the interplay between their open elements and closed elements. They appear to be making strategic decisions about how to balance and leverage these elements to achieve their business objectives. Open assets, such as OSS and OD, provide the basis for innovation, enabling companies to build upon existing resources, collaborate within communities, and reduce development time and costs. Companies indicated, this collaborative approach often leads to enhanced code quality, faster problem-solving and the ability to reach a broader audience.

4.3.2. OSS as the main source of 3Os related business

OSS is a widely recognized and adopted concept in the tech industry, and companies from our cases are actively engaged in OSS communities and projects. It appears, OSS has a more central role compared to OD or OH: it is often highlighted as a key enabler of innovation, collaboration, and differentiation across various companies' activities. However, OSS-related businesses frequently rely on OD sources to enhance their products and services. This contributes to more accurate analysis, predictions, and decision-making for various sectors such as public transport, manufacturing, pharmaceutics, energy, retail, and finance.

As emerges from the interviews, the use of open libraries, software, and tools contributes to efficiency and cost effectiveness, enabling, especially smaller companies, to compete effectively. Collaboration within the open-source community strengthens code quality, encourages community engagement, and supports business growth.

While most of the cases focus on OSS, one case highlights also the incorporation of OH. By adopting these open systems, the company leverages a wider pool of expertise and accelerates its R&D efforts. This approach involves selectively opening hardware elements to maintain system integrity while benefiting from community collaboration and innovation. This can indicate the potential for synergy between OSS and OH.

4.3.3. Relationship of OSS business with OD and OH

The relationship between OSS related businesses, OD, and OH is intertwined, creating a comprehensive ecosystem of open assets. Our cases suggest that OSS serves as the main source of innovation and value creation in various sectors. The

integration of OD and, in our case to a lesser extent also OH, adds depth and breadth to the OSS business landscape.

OSS related companies can play a crucial role in supporting OD and OH initiatives by providing free and open tools, platforms and data that can be used, modified and shared. They collaborate and co-create with OD and OH communities, by contributing to the development and distribution of OD and OH and by engaging in open dialogue and feedback. OSS relates to OD and OH differently in each case. Some use OSS to work with OD or OH, some use it to offer services or solutions, some use it to collaborate or co-create and some use OSS to promote or advocate for openness.

While some companies utilize OSS solely as a tool, others contribute to the open-source community actively. Sector and regional disparities exist and certain companies generate revenue beyond OSS. Notably, cases like OpenStreetMap (OSM) showcase harmonious coexistence in these domains and demonstrate how OSS and other open elements can synergize. OSM uses OSS to collect, edit, and share geospatial data and also promotes OD and OH by making the data available to anyone under an open license.

Monitoring and recognizing interaction between OSS and other open-source domains is essential for companies looking to harness the full potential of open assets and foster a collaborative ecosystem, because it drives continuous innovation and growth. The interlinks between OSS, OD, and also OH are apparent in various dimensions of these companies' strategies. Whether it is the incorporation of OH components, utilization of OD sources, or the use of OSS platforms, the integration of these elements strengthens the companies' offerings and enhances their competitive advantage. The various 3Os domains can interact well and complement each other in several ways and across different sectors.

4.4. Focus on legal aspects

In the use of an open asset, open platform or database, users have to navigate complex IP issues. Establishing terms and conditions under which software/hardware/data can be accessed and used requires legal and business expertise. Licenses differ significantly in terms of requirements for attribution, redistribution, modification, and compatibility with other licenses. Especially the latter issue (compatibility with other licenses) can be very challenging in practice, as some licenses can be combined in a single project, while others are not compatible and may

create conflicts if used together. In addition to this, some open-source licenses have multiple versions (e.g., GPL 2.0, GPL 3.0) with different terms.

Legal complexities manifest themselves especially in two dimensions: how the companies *interact with other companies* through the licensing terms, and how the company manages its IP and keeps track of the license compatibility *internally within the company*.

4.4.1. Licensing terms

The following universally known OSS licensing terms were used by the interviewed companies:

Strong copyleft:
- GPL
- AGPL

Weak copyleft:
- LGPL (sometimes categorized as strong copyleft, see ZOOOM D1.1)
- Eclipse

Permissive:
- Apache
- MIT

Thus, in terms of reciprocity, the interviewed companies use licenses from all categories of OSS: from strong and weak copyleft to permissive.

When discussing the type of license used by the companies, some of the companies mentioned open-source systems, frameworks or communities, e.g., Kubernetes, Symfony and Raspberry Pi. This is quite understandable, as these frameworks are formed around technologies with several components that differ from each other. Some of the components may be software, some hardware; some consist of kernels, operating systems and design files; some extend heavily to APIs. As these frameworks consist of different types of technological components, also the licenses involved may be numerous and even difficult to be found.

An example of the combination of licenses can be observed in the framework of Raspberry Pi, https://www.raspberrypi.com/licensing/, (Raspberry Pi, n.d.). The structure of licenses relating to Raspberry Pi consists of:

Document licensing:
- Online documentation: all CC BY-SA 4.0 (some CC BY-SA 3.0)
- Product documentation: most CC BY-ND 4.0
- Out-of-print books: CC BY-NC-SA 3.0
- Other: All rights reserved

Software licensing:
- most BSD-3-Clause (some MIT and some GPL)

Design file licensing:
- Raspberry Pi, no limitations (some original manufacturer licenses and some patented designs)

Contribution licensing:
- CC BY-SA

Navigating the complexities of license terms requires strategic decisions, professional expertise and diverse capabilities, and, depending on the role of the company in the ecosystem, even active management of a framework by permanently hired staff.

4.4.2.   IP and license management

Understanding the open-source licensing and usage can be overwhelming, especially for start-ups and SMEs, who do not have enough resources to hire an expert/consultant for IP issues. Licencing strategies are a challenge to both types of companies that we interviewed – the 3Os user companies and maker/contributor companies. This challenge seems to be more manageable in large companies where they have enough resources to approach this issue professionally. All the interviewed large companies have adopted specific strategies to address intellectual property (IP) issues related to their products or services. These strategies are designed to ensure legal compliance, manage risks, and maintain a balance between using open solutions and protecting their proprietary assets. All the interviewed large companies have an in-house legal expert, responsible for IP management issues, or an external

legal consultant. All large companies work a lot on licensing strategies and licensing compatibility. On the other hand, start-ups and SMEs take ad hoc decisions to address IP issues, as they lack knowledge and resources to develop specific IP strategies.

The ad hoc process can either be internal or external. One of the benefits of the ad hoc processes is flexibility. Some companies considered IP or license management being quite straightforward, whereas others acquired external legal consultancy.

Some companies identified a more standardized way of handling the IP and license management issues, such as internal checks, screening, and processes. These internal mechanisms included, e.g.,:
- using try-outs before decision-making,
- assessment of the benefits and limitations of using a specific open-source component,
- having allowed and non-allowed categories of licenses (such as no copyleft, no GPL, or no MIT),
- using predetermined development tools,
- using license compatibility checks or tools,
- avoiding unusual licenses,
- IP and licensing strategies with continuous updates.

It is clear from the answers of some companies that their approach to intellectual property management issues has changed/developed over time. At the beginning, the companies generally didn't have any IP management strategy, their approach was aimed only at legal compliance. Over time, as they grow from start-ups to SMEs (or large companies), they develop specific IP strategies. Not all of them rely on open innovation - some companies take a proprietary approach; others rely on a business secret approach. Their IP strategy differs also on the basis whether they are 3Os users or contributors. As 3Os users, they usually follow the IP management requirements set up by the open tools they use. As 3Os makers/contributors, they offer their product under different licenses, from strictly proprietary to fully open (or even without a license).

PROPOSITION 9:

Consider easy, standardized ways of managing your licenses, for instance labeling the types of licenses that fit your business model into green (can be used), yellow (subject to consideration) and red (not allowed) categories.

From a more controlled end of license management spectrum, one company, being the keystone company of the OS-community, mentioned that it would not even exist without the OS-community and framework. Operating such an OS-community, requires a company setting the community development, including license management, as core element of its activities. This company had over 20 years of experience in managing the OS-framework. In its activities we are also able to monitor the evolvement of the licensing terms: the company has shifted from GPL licenses to LGPL, shifting the power towards the community by enabling community members to take even more advantage of the OS-framework. The same company stated that it is very difficult to control if someone "steels from the community" or uses the code against the license. Controlling compliance is not merely an issue for taking legal action, it is more about a gradual increase in awareness and community management.

One issue raised by several companies was the emphasis on customers' requirements. Customers may have requirements that determine what kind of open source components can be used and some of the customer cases may have stricter screening requirements for licenses. Despite these stricter customer requirements, it was also pointed out that contributions to open source components can also be done through implementing customer cases, provided this is agreed with the customer.

PROPOSITION 10:
Examine win-win open-source strategies for your customers.

4.5. Evolution of 3Os based business

Companies have varying approaches to 3Os based businesses, and the approaches may change in time. They mainly start with the use of open licenses to simplify their own work. The approach can then change subsequent to different business models. Dual licensing, where companies offer their software under both open-source and proprietary licenses is one possibility. Another way is the "freemium" approach, where you differentiate between a limited version and a premium version with more features. A tendency to a more open minded ecosystem approach can be seen.

A typical way of evolution of a company's 3Os based business, could be described as follows.

The interviews indicated that developers start to use OSS from the beginning of their career. Especially for repetitive tasks they use OSS and inform themselves about the proper use of licenses. Apart from OSS the companies' business dictates whether

they deal with open data or open hardware. After a while most of the companies start to provide information for the 3O-ecosystems, give feedback or contribute with open elements.

One of the first steps in the evolution of the companies mentioned in the interviews was a check of the desired license. This check can be done for instance through questions like:
- What is allowed in the use and what is forbidden?
- Is the license well maintained?
- Is a big crowd using this license?

With this experience, the use of OSS is getting more confident and expands.

First contributions are mostly feedback on used licenses or to report bugs in a license. Later some components are issued to the community. Some companies contribute to OSS as they are developing software, for instance, in governmental funded projects.

Market position and phase of the market is also important at the phase a company decides to proceed from a closed business towards a more open one. In an early market a lot of piloting and pivoting is needed. The evolution from a user to a contributor needs time and strategic decision making, as a lot of companies are dependent on selling their products or want to keep their software-as-a-service product as secret as possible.

For those companies, starting to initiate a community, there's a need for several partners and contributors of different clusters within the ecosystem. The contributions need to be accumulated on a developed platform. After those first steps the next big issue is the standardization.

The evolution stage of operating a OSS community requires additional capabilities. Healthy ecosystems would need several partners and contributors. Partners need to agree on a standardization of the community. Quite often there is also the need for a keystone company that leads the community.

PROPOSITION 11:

Understand the dynamic and evolving nature of participation in 3Os projects.

4.6. An ecosystemic perspective

The interviewed companies are mainly aware of being part of ecosystems involving economic and non-economic players, cooperating and competing through both value creation and capture processes. All companies recognised the advantages of being embedded in one or more ecosystems where the creation of new knowledge is facilitated by joint research work, collaboration, expertise sharing, or the development of a common knowledge base to which communities of developers, too, contribute. Ecosystems growing around the 3Os can be recognised as *knowledge ecosystems,* where knowledge sharing and knowledge creation are central activities. As suggested by Koening (2012), open-source communities are a well-known example of knowledge ecosystems.

However, each company identifies itself into specific roles depending on the strategy, the main business, and the network structures of the company. The Table below summarizes the main ecosystemic roles in which the interviewed companies identified themselves.

Roles	Instances
System Integrators, Platform Developers, Enablers	7
Focal Firms	2
Innovators	2
Other Types of Networks	2
Distinctive Community Roles	9

Table 9. Summary of the main ecosystemic roles.

System Integrators, Platform Developers and Enablers
Various interviewed companies identify themselves as having an integrating or enabling role across various organizations and industries:

- *System integrator for reusing IP (both OSS and OD):* One company defined their role as system integrator for reusing IP across different audiences, in

particular Public Administrations (PAs). For them, the ecosystem is seen as a distinctive approach to make business, i.e., as a business model (Li and Seering, 2019). By facilitating the sharing and integration of IP, these companies create a collaborative environment where various stakeholders can contribute and benefit depending on their own strategy and view. The reuse of OSS and OD in multiple PAs demonstrates the value of interoperability and data sharing, which are key features, for instance, in the emerging picture of smart cities. The literature on ecosystems emphasizes how a well-orchestrated ecosystem can drive innovation through cross-pollination of ideas and resources. Notably, system integrators are not identified as focal firms of these ecosystems. This element invites questions about the evolution of these ecosystems and the opportunities for systems integrators to eventually legitimate themselves as focal firms (Moore 1993).

- *Platform developer for OD:* This role consists of integrating OD for both the PAs and public services companies, such as transport companies. By providing a platform that connects a diversified set of stakeholders, this kind of ecosystemic strategy fosters a networked environment where data flows seamlessly, enabling better decision-making and efficiency improvements. Ecosystems thrive on relationships between participants and the mutual benefits they gain from interactions for the implementation of their own value propositions. There is not, indeed, a common value proposition at the core of the ecosystem, but there is a platform enabling the implementation and delivery of each value proposition. This evidence aligns with the literature's view that ecosystem models encourage collaboration, resource sharing, and value co-creation.

- *Platform developer and system integrator for OSS:* One firm bases its strategy on the provision of a comprehensive platform of services OSS and the integration of different standards for removing barriers. The strategy also needs to align the platform to the principles of the communities to take advantage of the contribution of different players. The removal of barriers and the alignment of the platform to general recognised standards allow external players to easily join the ecosystem. This strategy straights ecosystems that are known for their ability to break down value chains, industries, and enable seamless collaboration. This firm could be identified as the focal firm of emerging ecosystems that did not reach the legitimization phase.

- *Enablers (Technical Solutions Providers):* Four companies enable new ways of doing business by helping other companies to cross the boundaries of their

value chains and industries. For instance, one company focuses on enabling a fair data economy in the context of the EU data spaces. Another company creates connections between companies along an additive manufacturing value chain. Such company sees "openness" as a password for potential partners including researchers: competitors are implementing their technologies in their attempt to be open; other companies can put their IP (closed) on their systems. Finally, Two companies are initiators in an environment where not many companies provide similar services (OSS, OD, AI, simulations, modeling, and engineering automation). More generally, the strategy is here to see the ecosystem as a tool for reaching the differentiated goal. Ecosystems are known for their ability to bring together players with complementary skills and resources to tackle complex challenges. This strategy highlights how ecosystems can serve as vehicles for addressing broader societal and regulatory goals, a point emphasized in the literature on ecosystems (Appio et al. 2019).

Focal firms
Two companies declare to have the role of defining a common value proposition for the players of an OSS business ecosystem. Their strategy is to provide direction, setting standards, and facilitate coordination among ecosystem participants. By acting as a central point of reference for different types of firms, the focal firm establishes a sense of cohesion and shared purpose among the diverse stakeholders.

Innovation ecosystems
Companies active in OH apply a strategic approach that combines open-source collaboration, access to universities, and cross-disciplinary interaction to reach high innovation performance. By partnering with universities, the company gains access to emerging talents, leveraging on a population of skilled and passionate professionals. This approach not only accelerates innovation but also positions the company at the forefront of the market, unlocking new possibilities and reshaping the industry's trajectory. The collaborative strategy accelerates the development of new materials, shapes, and applications, allowing the company to stay ahead of industry trends.

Other network roles
Two companies can be considered as part of a smaller co-creation network where more than one actor has access to shared assets and open assets, e.g., libraries or software. Here, the use of shared resources is regulated "informally", rather than by strict legal mechanisms (see the notion of Open Source Service Network, Feller et al. 2008). In the context of blockchain technology, for instance, where cooperation and

interoperability are crucial, this company navigates a space with minimal competition and emphasizes mutual benefits.

Community roles
Through the interviews, we identified a variety of community roles. Within smaller communities, several companies play the role of contributors to OS libraries and plugins. They actively engage in enhancing and expanding open assets, sharing valuable resources, code, and solutions. This collaborative contribution benefits not only their organization but also the wider community that utilizes the OSS. Two companies have a Community Leadership and Management role, namely, they established a community around their platform of OSS services and they facilitate all types of interactions within the community. Finally, one company is actively involved in a community that shares ideals and ethical principles (democratization of knowledge, decentralization). These various roles foster a community-based approach to innovation.

In each of the analyzed case studies, companies are engaged in activities that resonate with ecosystem models. They are creating environments where participants collaborate, share resources, and collectively innovate. These examples underscore how ecosystem thinking can drive business success in an interconnected and rapidly evolving world, reinforcing the ideas presented in the literature on ecosystems. The case studies confirm the multi-layered structure of the ecosystems emerging in the 3Os environment. All the interviewed declare that they are part of ecosystems led by other firms or communities of firms.

www.zooom4u.eu

5. Discussion and core elements

From the case studies, we identified five predominant features that should be taken into account in the architecture of the ZOOOM framework aiming to raise awareness on the possibilities of open assets at the intersection of legal, business and societal aspects.

5.1. Combining open and closed strategies

Several companies use open-source components and, in addition, use or consider using proprietary strategies. The companies encountered questions like how to handle IP issues of collaborative software; should the company apply for protection or rely on mere secrecy; how to take export control into account. It was pointed out that service-based business allows the use of the keeping-secret strategy. One issue mentioned to enable this kind of dual strategy is modularity which allows the integration of components with differing licenses.

> **PROPOSITION 12:**
>
> Assess the possibilities of modularity in your business.

Companies should not address open assets as being something contradicting their proprietary technologies. Instead of open source vs. closed business, the companies should assess their business from the perspective of which part is best to keep closed and proprietary and which part or which components to open as open source to a wider community. This decision should be aligned with the business model chosen by the company.

Establishing a strategy that balances the open source part and the closed part of the product portfolio requires a thorough assessment and clear strategic decisions. The need for this discussion is most evident at the phase when a company decides to shift from a protectionist approach to a more open one by making the initial contribution to be opened as open source. At such a phase, there are professionals from different areas involved in the decision-making, such as technical developers, IP experts, lawyers, managers, and top decision-makers. Once the initial, strategic decision is

www.zooom4u.eu

made, it becomes possible to shift the focus on the operational management of the licenses and community.

> **PROPOSITION 13:**
>
> Identify the open and the closed components and align them to the chosen business model.

5.2. Layered structure of the open assets

Based on the above analysis, it would be useful for the companies to identify the layers of the components the company is using. A typical layered structure could contain for instance following types of layers:

1. Hardware layers:
   a. Design files
   b. Documentation
   c. Product documentation
   d. Other
2. Operating system layer (e.g., of which Kernel is part of)
3. Container system layer (e.g., for Blockchain)
4. API layer
5. Software layers:
   a. System Software
   b. Product software
   c. UI software
   d. Applications
   e. Other
6. Data layers
7. Services layers
8. Content layers

When looking at the technologies used in their entirety, it is not sufficient to make a distinction solely at the level of hardware, software, or data. In each of these broad technological areas, companies should look into all the layers the technology consists of and the interconnections thereof.

> **PROPOSITION 14:**
>
> Unravel your technology into layers.

5.3. OD and OH complementing OSS

Open assets which include collaborative software, tools, libraries and methodologies, hold substantial value in diverse aspects of companies' operations. While OSS takes center stage, OD and OH also play complementary roles within the OSS business model. These elements foster innovation, collaboration, cost reduction, and community engagement. By integrating open solutions, companies access shared resources, contribute to collective knowledge and navigate a strategic balance between innovation and cost savings. Embracing open assets not only spurs business growth but also strengthens the broader open-source community. Adapting to an innovative yet competitive landscape while complying with open-source licensing complexities and expanding community management are critical efforts.

PROPOSITION 15:

Acknowledge the complementing role OD and OH take in relation to OSS.

5.4. Multifaceted value-creation and value-capture within the 3Os

The value for the companies involved in 3Os is created in multifaceted ways in several areas. Some of the value can be derived by economic means, other types of value through social and ethical considerations. Strategic and competitive advantages can be generated in the form of cost savings, interoperability addressing the vendor lock-in, benefits from collaborative ecosystems and collective intelligence, strategic flexibility, "branding effects", credibility and recognition, and visibility and fostering trust, to name some. In addition, participation in 3Os drives technological innovation; contributes to standardization and compatibility by providing flexibility, modularity, customization possibilities and quality mechanisms; addresses social and ethical motivations with transparency, collaboration and democratization of knowledge; and, at the same time, even fosters personal motivations of the key developers.

The key question is, how a company is able to capture this value in a networked environment. This is profoundly context dependent and requires multidisciplinary capabilities.

PROPOSITION 16:

Understand different dimensions of the value creation in 3Os.

5.5. Community participation in projects and social value-creation

Communities participating in development projects around open assets are one of the core and most prominent values that an organization could strive for in its open source strategy.

The communities growing around projects represent a source of new ideas, competences and contributions. The best results for an open source software, open hardware or open data strategy can be achieved through the creation of and participation in communities. Organizations able to interact with developers that are outside their boundaries and not under their control – on the one hand entrusting them and on the other hand letting them contribute in an open and transparent way to the governance of the project – can benefit the most from the decision to open their assets.

Maintaining a stable approach to the openly licenced asset in time, being consistent in supporting the projects, following the communities needs, and expressing the company needs in a clear and transparent way can often lead to increased appreciation of the developers that are not "on the payroll", thus constituting a type of "community share of the company".

This translates to three major competitive advantages for companies, the first, and most obvious one, is the possibility to use the open asset created with lower costs by translating it to a more competitive product/process/service development. The second one is the possibility to identify and hire skilled personnel from the communities – considering they are proactively contributing to the project in their

free time, they could be happy of being paid to do what they like. Finally the third one, building positive interactions with communities may help if the organizations want to start new open projects, as the communities they have already cooperated with could be more engaged and responsive from early on because of the positive experiences they have had in the past.

Without communities, an open asset approach could reduce the value for the organization initiating the project. There are many examples of online development platforms having open projects without live updates and contributions and seeing them just as a source of inbound assets for other projects or products. This is a relevant aspect to consider when assessing open assets as an IP valorisation strategy.

PROPOSITION 17:

Communities are key to value creation from open assets projects.

6.   Recommendations in a nutshell

1.   Assess if doing business in your area is feasible at all without using open assets.

2.   Consider the non-immediate value-generation mechanisms that your contribution will potentially have.

3.   Take into account the quality standards required and fostered by open source.

4.   Reflect on the social and ethical reasons to engage in the 3Os and contribute to open assets.

5.   Do not forget the central role of the key developers.

6.   Assess how to effectively communicate the benefits of open-source solutions for your customers (e.g., security, compatibility, flexibility, avoiding vendor lock-in).

7.   Be clear as regards the target audience of your product(s) and which communities you will be interacting with.

8.   Devise risk-mitigation strategies for IP management and investments.

9.   Consider easy, standardized ways of managing your licenses, for instance labeling the types of licenses that fit your business model into green (can be used), yellow (subject to consideration) and red (not allowed) categories.

10. Examine win-win open-source strategies for your customers.

11. Understand the dynamic and evolving nature of participation in 3Os projects.

12. Assess the possibilities of modularity in your business.

13. Identify the open and the closed components and align them to the chosen business model.

14. Unravel your technology into layers.

15. Acknowledge the complementing role OD and OH take in relation to OSS.

16. Understand different dimensions of the value creation in 3Os.

17. Communities are key to value creation from open assets projects.

References

Appio, F. P., Lima, M., & Paroutis, S. (2019). Understanding Smart Cities: Innovation ecosystems, technological advancements, and societal challenges. Technological Forecasting and Social Change, 142, 1-14.

Blind, Knut, Böhm, Mirko, Grzegorzewska, Paula, Katz, Andrew, Muto, Sachiko, Pätsch, Sivan, & Schubert, Torben. (2021). *The impact of Open Source Software and Hardware on technological independence, competitiveness and innovation in the EU economy* (p. 390) [Final Study Report.]. Publications Office of the European Union. https://ec.europa.eu/newsroom/dae/redirection/document/79021

Dahlander, L., & Magnusson, M. (2008). How do Firms Make Use of Open Source Communities? *Long Range Planning*, *41*(6), 629–649. https://doi.org/10.1016/j.lrp.2008.09.003

Dell'Era, C., Di Minin, A., Ferrigno, G., Frattini, F., Landoni, P., & Verganti, R. (2020). Value capture in open innovation processes with radical circles: A qualitative analysis of firms' collaborations with Slow Food, Memphis, and Free Software Foundation. *Technological Forecasting and Social Change*, *158*, 120128. https://doi.org/10.1016/j.techfore.2020.120128

Feller, J., Finnegan, P., Fitzgerald, B., & Hayes, J. (2008). From peer production to productization: A study of socially enabled business exchanges in open source service networks. *Information Systems Research*, *19*(4), 475-493.

Gruber, M., & Henkel, J. (2006). New ventures based on open innovation an empirical analysis of start-up firms in embedded Linux. *International Journal of Technology Management*, *33*(4), 356. https://doi.org/10.1504/IJTM.2006.009249

Li, Z., & Seering, W. (2019). Does Open Source Hardware Have a Sustainable Business Model? An Analysis of Value Creation and Capture Mechanisms in Open Source Hardware Companies. *Proceedings of the Design Society: International Conference on Engineering Design*, *1*(1), 2239–2248. https://doi.org/10.1017/dsi.2019.230

www.zooom4u.eu

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard business review*, *71*(3), 75-86.

Moritz, M., Redlich, T., Grames, P. P., & Wulfsberg, J. P. (2016). Value creation in open-source hardware communities: Case study of Open Source Ecology. *2016 Portland International Conference on Management of Engineering and Technology (PICMET)*, 2368–2375. https://doi.org/10.1109/PICMET.2016.7806517

Rajala, R., Westerlund, M., & Möller, K. (2012). Strategic flexibility in open innovation – designing business models for open source software. *European Journal of Marketing*, *46*(10), 1368–1388. https://doi.org/10.1108/03090561211248071

Runeson, P., Olsson, T., & Linåker, J. (2021). *Open Data Ecosystems -- an empirical investigation into an emerging industry collaboration concept* (arXiv:2109.01378). arXiv. https://doi.org/10.48550/arXiv.2109.01378

Teixeira, J., Robles, G., & González-Barahona, J. M. (2015). Lessons learned from applying social network analysis on an industrial Free/Libre/Open Source Software ecosystem. *Journal of Internet Services and Applications*, *6*(1), 14. https://doi.org/10.1186/s13174-015-0028-2

Temiz, S., Holgersson, M., Björkdahl, J., & Wallin, M. W. (2022). Open data: Lost opportunity or unrealized potential? *Technovation*, *114*, 102535. https://doi.org/10.1016/j.technovation.2022.102535

Viseur, R., & Jullien, N. (2022). 3D printer builders' Open-hardware strategies. *The 18th International Symposium on Open Collaboration*, 1–8. https://doi.org/10.1145/3555051.3555069

Watson, R. T., Boudreau, M.-C., York, P. T., Greiner, M. E., & Wynn, D. (2008). The business of open source. *Communications of the ACM*, *51*(4), 41–46. https://doi.org/10.1145/1330311.1330321

www.zooom4u.eu

This document is an output of the ZOOOM Project

(GA 101007385)

www.zooom4u.eu