RobMoSys

H2020—ICT—732410

RobMoSys

Composable Models and Software for Robotics Systems

Deliverable D7.9
Sustainability Plan – m48

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Executive Summary

This document represents the second deliverable of Sustainability Plan (Deliverable D7.6) for RobMoSys, as part of work package "Exploitation" (WP7). This deliverable describes exploitation and community building activities to ensure sustainability beyond the end of the RobMoSys project.

The main topics of this document are:

1. Global RobMoSys Sustainability Strategy
2. Plans to ensure Sustainability beyond the RobMoSys project life.

The first version of the Sustainability Plan (Deliverable D7.3) focused on establishing the basics and on specifying a **framework for community management and provision of activities** for ensuring a strong sustainability of the RobMoSys results.

The second version of this document (Deliverable D7.6) extended the scope by adding the **feedback from Tier-1 experts** coming from the community management world and by taking into account the **return of experience** from the first RobMoSys Integrated Technical Projects (ITPs), which were selected in the first Open Call, as well as other community building activities.

The current document (Deliverable D7.9) describes the **global RobMoSys sustainability strategy**, summarizes the activities done to ensure the RobMoSys sustainability and provides some details of the plans to pursue RobMoSys sustainability beyond the project duration.

Content

1 Introduction

RobMoSys is about managing the interfaces between different roles (robotics expert, domain expert, component supplier, system builder, installation, deployment and operation) and separating concerns in an efficient and systematic way by making the step change to a set of fully model-driven methods and tools for composition-oriented engineering of robotics systems.

RobMoSys's vision is that of an agile, multi-domain, model-driven European robotics software ecosystem. It will consist of specialised set of players with both vertical and horizontal integration levels, providing both widely applicable software products and software-related services. This ecosystem will be able to rapidly address new functions and domains at a fraction of today's development costs.

The creation of a **sustainable ecosystem** is a major objective of the project, but obviously, this is not something that can be done in a guaranteed or strictly controlled way. However, the more clever, more open and more reactive the strategy is, the better this goal is to reach. Anyway, the project partners though will very actively stimulate active involvement of, and controversial discussions with, a selected variety of different stakeholder groups outside of the consortium of the project representing both technology-pull (application domains) as well as technology push (technical capabilities).

Sustainability is directly related to the business opportunities (see Deliverable D7.8 for full details) to produce RobMoSys artefacts (models, software components and tools). The effects of the commoditization strategy pursued in RobMoSys must be carefully analysed during the project-lifetime. Typically, commoditized software is a software nobody pays for (or is not aware to pay for, as in the case of operating systems). The sustainability of commoditized software directly relies then on open-source communities, and in more structured way through industrial foundations/group of interests. Sustainability through the creation of a foundation or group of interest in existing foundations was investigated during the project life-time with the final objective of keep sustaining the community.

This document addresses sustainability plans of the RobMoSys ecosystem, particularly focused on an open source and open assets strategy. The proposed sustainability strategy and framework have been incrementally specified and continuously aligned to the exploitation and business strategies. This deliverable represents the final version of **Sustainability Plan – Month m48 (Deliverable D7.8)**, as part of work package **"Exploitation" (WP7)**. It aims at summarizing the sustainability activities done during the project and the planning of the activities to ensure sustainability beyond the end of the project.

1.1 Scope: What's New?

The first version of the Sustainability Plan (Deliverable D7.3) focused on establishing the basics and on specifying a **framework for community management and provision of activities** for ensuring a strong sustainability of the RobMoSys results.

The second version of this document (Deliverable D7.6) extended the scope by adding the **feedback from Tier-1 experts** coming from the community management world and by taking into account the **return of experience** from the first RobMoSys Integrated Technical Projects (ITPs), which were selected in the first Open Call, as well as other community building activities.

The current document (Deliverable D7.9) describes the **global RobMoSys sustainability strategy**, summarizes the activities done to ensure the RobMoSys sustainability and provides some details of the plans to pursue RobMoSys sustainability beyond the project duration.

1.2 Document Structure

The remaining of this document is organised as follows:

- Section 2 provides a background sustainability concepts, as well as on other community management aspects.
- Section 3 presents our strategy for sustainability focused on the RobMoSys open source community, including a strategy for a sustainable business, quality management, maturity and long-term longevity of RobMoSys tools and assets.
- Section 4 addresses a plan of action for community building and the governance of the RobMoSys community.

2 Background

2.1 Basics of Sustainability

Sustainability is the ability to develop and implement technologies/methodologies, which are self-sustaining without jeopardising the potential for future generation to meet their needs. An open source approach is good for sustainability of a project as it is an enabler to attract a larger community of developers and adopters, as well as a guarantee that if the existing developers of a project decide to leave, the code will still be available for the community to take over the project.

Governance relates to consistent management, cohesive policies, guidance, processes and decision-rights for a given area of responsibility. The management or governance of an open source community is directly related to the type of this community and what kind of product or result it offers to users. It is therefore a critical aspect to be taken into account when creating an open source community. How the community is managed and the type of licence hold is the key aspect when talking about open source communities.

An **Open Source community** is the keystone for the sustainability of the RobMoSys project. If the project development team is not able to attract and convince people that the code is worth spending time and resources on testing it, providing feedback, providing patches, and contributing in general, then a large part of the intrinsic value of Open Source is lost.

In other words, without **Maturity, Quality, Cost of Acquisition and Contro**l, the sustainability of the code is nearly impossible. And vice-versa, a community of adopters, testers, users, extenders of a technology is a great indicator demonstrating the Maturity, the Quality and the Control of the code.

Metrics: A good way to know if an Open Source project is sustainable and viable, is to check the activity of its community: number of committers, number of commits, regularity of the releases, and the quality and quantity of assets built around the project are a great indicator. In other words, the community is an excellent evaluation metric for a project.

Open source platforms as collaboration catalysts for industry: Publishing software assets in open repositories (e.g. GitHub, Gitlab or BitBucket) is not sufficient to ensure sustainability. We need full open source platforms (including governance and vendor-neutral collaboration infrastructure) to combine the best practices of open source development with a set of services required for open innovation, enabling organizations to foster industry collaborations. Then, it is possible to design added-value products or services to do business on top of the platform. Such platforms can help improve the supply chain of software development tools in a particular industry, create a new technology platform that increases interoperability among organizations and technologies, as well as allow organizations to increase their use of open source technology.

2.2 Eclipse Foundation Model for Community Governance

From the early stages of RobMoSys, a strong candidate for the open-source community, and in particular for hosting the tool and software assets, has been the Eclipse ecosystem.

When doing open source and trying to be sustainable at the same time is when open source foundations, like the Eclipse Foundation, come in to enable vendor-neutral open collaboration. These provide a safe space where companies can share code while collaborating with competitors to develop together common platforms. Then, it is possible to design added-value products or services to do business on top of the platform.

The Eclipse Foundation offers an open, vendor-neutral collaboration platform, following the three open source best practices: transparency, openness and meritocracy. All of this is achieved through main four services:

1. ***IP Management and Licensing***, focused on enabling the use of open source technology in commercial software products and services, made possible by the fact

that all Eclipse projects are licensed under the Eclipse Public License (EPL), a commercial friendly OSI approved license.
2. ***Community and Ecosystem Development***, including marketing and promotion of Eclipse projects to the wider healthy and vibrant Eclipse ecosystem, extended beyond the Eclipse open source community.
3. ***Governance & Development Process***, ensuring no single entity is able to control the strategy, policies or operations of the Eclipse community and assisting new project start-up while ensuring they are run in an open, transparent and meritocratic manner.
4. ***IT Infrastructure***. including Git code repositories and code review tools, bug trackers, continuous integration build farms, development-oriented mailing lists and forums, download site and website.

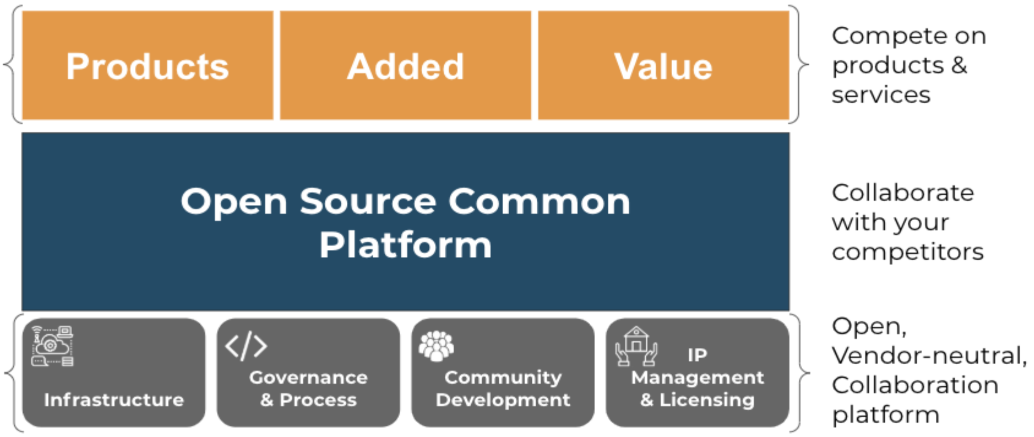

Figure 1: Collaborate on platforms / Compete on Products

2.2.1 Eclipse Working Groups

Eclipse Working Groups provide a vendor-neutral governance structure that allows organizations to freely collaborate on new technology development. Based on the experience within the Eclipse community, collaboration among organizations can:

- help improve the supply chain of software development tools in a particular industry
- create a new technology platform that increases interoperability among organizations and technologies
- allow organizations to increase their use of open source technology.

Eclipse Working Groups make it easy to reuse the Eclipse services provided by the Eclipse Foundation rather than creating them from scratch.

2.2.2 The Eclipse Specification Process

The Eclipse Foundation Specification Process (EFSP) provides a framework and governance model for developers engaged in the process of developing specifications. The EFSP defines a specification as a "collection of Application Programming Interface (API) definitions, descriptions of semantic behaviour, data formats, protocols, and/or other referenced specifications, along with its TCK, intended to enable the development and testing of independent Compatible Implementations." A specification project is, then, an Eclipse open source project concerned with the creation and maintenance of one or more specifications.

With the Eclipse Foundation Specification Process (EFSP) a single open source specification project has a dedicated project team of committers to create and maintain one or more specifications. The cycle of creation and maintenance extends across multiple versions of the specification, and so while individual members may come and go, the team remains and it is responsible for every version of that specification that is created.

The EFSP leverages and augments the Eclipse Development Process (EDP). The EDP defines important concepts, including the Open Source Rules of Engagement, the organizational framework for open source projects and teams, releases, reviews, and more.

2.2.3 Successful Collaboration around Open Source

Since 2013, the Eclipse Foundation has continuously increased its collaboration with academics, researchers, and industries at EU level by participating in several European projects. The Foundation's main objective in these projects is to help the project consortiums build an open source platform and community around their respective project results, but as positive side effect the Eclipse Foundation's recognition as an expert in building open source communities at European level has consolidated over this period. Also, this has given the Foundation the opportunity to bring new academic and industrial members increasing the EU presence in it.

For these reasons, we believe that the Eclipse Foundation is the right place to host a working group focused on Industrial Robotics, that could become the reference in Europe. Leveraging the well-established Eclipse specification process to create open standards and the business friendly license EPL v2.0 (Eclipse Public License), this working group could play a key role in the growth of the EU Digital Industrial Platform for Robotics.

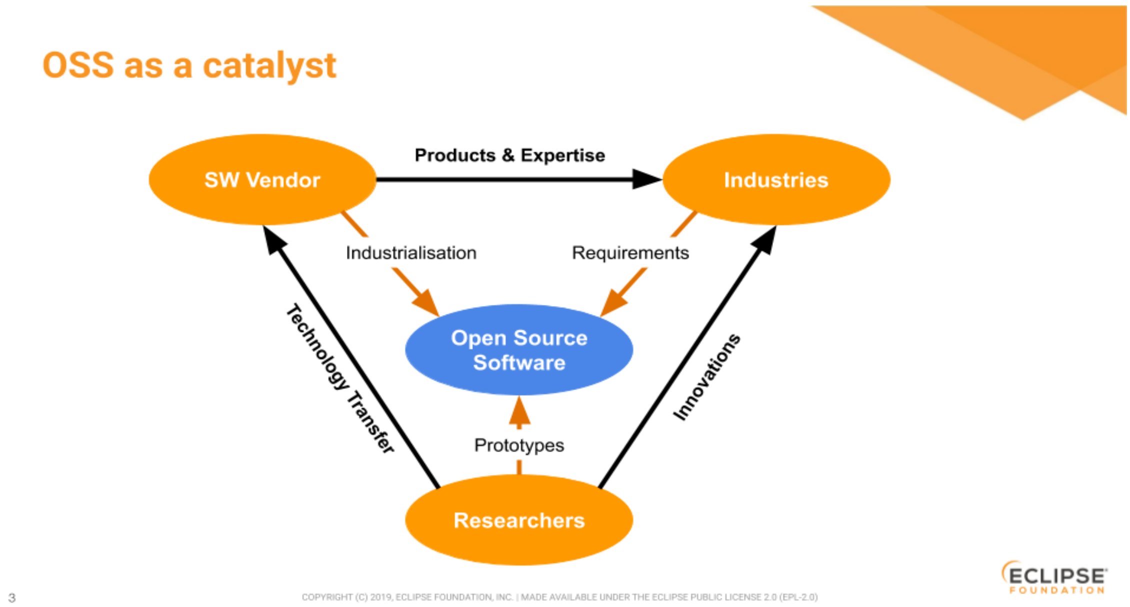

Figure 2: Open Source as a Catalyst for Successful R&D Collaboration

2.3 euRobotics Topic Groups

euRobotics aisbl (Association Internationale Sans But Lucratif) is a Brussels based international non-profit association for all stakeholders in European robotics. It was founded in September 2012 with the aim to strengthen Europe's competitiveness and to ensure industrial leadership of manufacturers, providers and end-users of robotics technology-based systems and services.

The objectives of euRobotics are to boost European robotics research, development and innovation and to foster a positive perception of robotics. It aims at:

- strengthening competitiveness and ensuring industrial leadership of manufacturers, providers and end users of robotics technology-based systems and services;
- the widest and best uptake of robotics technologies and services for professional and private use;
- the excellence of the science base of European robotics.

Since 2014, euRobotics collaborates with the European Commission in the Public-Private Partnership SPARC under Horizon2020 to develop and implement a strategy and a road-map for research, technological development and innovation in robotics.

Currenty (2020), euRobotics engages in the preparation of the envisaged partnership on AI, Data and Robotics in the Horizon Europe programme (2021-2027).

Topic Groups are initiated by members of euRobotics and coordinated by the Board of Directors. They identify gaps and challenges, describe the desired paths towards solutions, milestones to be reached at specified instants in time and with a specified quality. Activities span the full spectrum from basic research, to technological development, and concrete innovation, showing smooth paths of knowledge transfer along the covered spectrum, and identifying concrete actual and potential academia-industry cooperation. Topic Groups are the instrument to provide content to the Strategic Research Agenda (SRA) and the multiannual Roadmap (MAR) of euRobotics AISBL.

One Topic Group of special interest for RobMoSys, as we describe in Chapters 3 and 4, is the one on ***"Software Engineering, Systems Integration and Systems Engineering"***. It focuses on the need for a systems engineering approach which goes well beyond the current state-of-the-art, including systematic processes, methods, and tools to create robotic systems for real-world applications. Openness and standardisation are also in the focus of this Topic Group for further spread of robotics technology and for creating a business ecosystem for robotics.

2.4 Existing Robotic Software Platform Communities

The software industry is constantly evolving and is undergoing rapid changes. This is not only because of the evolution of technologies, but also because these technologies drive a fundamental shift in how suppliers and buyers are interrelated. It is the transition from traditional supply chains to a software ecosystem. It is not a simple linear chain anymore, but a complex network of multilateral relationships. A software ecosystem brings co-innovation as a result of different businesses interacting within a shared market for software and services, together with relationships among them. These relationships are frequently underpinned by a common technological platform and operate through the exchange of information, resources and artefacts.

Well-known examples of communities that are seen as software ecosystems are the Apple iPhone with its app store and development tools, the Google Android world, the Eclipse IDEs and, of course, the Web 2.0 technologies which turned the Internet into a platform.

The transition to a software ecosystem also comes with a shift from integration-centric approaches to a composition-oriented approach. In an integration-centric approach, the focus of an organization has been on control of the integration process. Due to the high complexity of nowadays systems, this consequently leads to unacceptable coordination costs - not to speak of the challenges of cross-department or cross-company coordination. In contrast, the composition-oriented approach does away with most of the central mechanisms and relies on a number of principles such as e.g. (i) customers compose their products by selecting from the available functionality and (ii) components satisfy the independent deployment principles.

Most popular robotic communities include ROS, OROCOS and a domain-specific community for neuro robotics is HBP, which are discussed here.

ROS

ROS (Robot Operating System) is a collection of tools, libraries, and conventions that aim to simplify the task of creating complex and robust robot behaviour across a wide variety of robotic platforms. ROS gained tremendous acceptance within the robotics community over the past years, and it has been the first time in robotics software that so many adopted a particular framework.

ROS provides hardware abstraction and device drivers, services such as message-passing between processes (nodes) and tools such as package management and data visualizers. It comes with libraries that implement commonly-used functionality in sensing, planning and control. ROS does not provide anything comparable to an IDE which could support the design, implementation and integration of ROS nodes. Instead, any preferred general purpose IDE (e.g. QtCreator) can be used. Design and implementation agreements are solely the responsibility of the user and are not tool-supported. Some user-driven initiatives tried to address this, e.g. RIDE and rxDeveloper. RIDE aims to "make the creation of ROS controllers from reusable components as easy as possible". Yet, the only provided functionality is to launch and to connect ROS nodes. Similar, rxDeveloper provides a GUI for modifying launch-file parameters of running ROS nodes. This helps in executing the nodes, but neither in their design nor implementation.

ROS is an example for *freedom of choice*. What the ROS founders mean by "we do not wrap your main" is that, among others, they do not want to enforce any architectural design decisions for developers using ROS. In consequence, each developer uses his own personally preferred architecture which is then very likely in conflict with those defined by others. This can lead to confusion as everyone first needs to understand the architectural decisions of each individual component before being able to reuse them in an own system. A proposed solution is just to extensively document each ROS component on the ROS portal. However, this does not circumvent the need to extensively analyse and understand the source code in order to adjust it or to implement workarounds in order to somehow make components compatible and reusable.

ROS, in line with its overall design philosophy, does not yet give enough structure in an appropriate format in order to better support separation of roles and separation of concerns. The minimally required structures are a sound software component model which has to be formalized for use in model-driven tools in order to support separation of concerns (e.g. to maintain semantics independently of the OS/middleware mapping), to assist the different roles in conforming to structures like component life-cycles and to reduce exposed complexity by systematic and computer-assisted management of variation points.

OROCOS

Orocos-RTT is specifically oriented towards programming and executing component-based applications on top of Real-Time Operating Systems (RTOS) and relies on lock-free communication to guarantee a deterministic execution time for all in-process inter-component data exchange. OROCOS offers a collection of commonly used components in robotic applications through a library called OCL (Orocos Component Library). For instance, we can find dedicated components to devices, hardware platforms, motion control and deployment. OROCOS allows also the integration of user-defined types through what is called typekits to ensure data transfer between processes or over a network connection. In OROCOS, there is no guidance about the control architecture to choose. The user is responsible to make his own right choices. Like ROS, OROCOS has no dedicated IDE but many initiatives like BRIDE4, RobotML5 and oroGen6 provide code generators from their models to OROCOS. They allow automatic code generation of component structures, their properties and the communication between them while having a graphical visualization about the system architecture.

Neuro Robotics Platform (HBP)

HBP is developing a novel strategy for advancing multi-level understanding of the brain, by studying brain models in the context of realistic sensory inputs and producing realistic (motor) output that can be compared to experimental data. This is achieved by connecting the brain models to realistic virtual (or physical) bodies that are immersed in realistic dynamic environments.

In brain modelling to date, there are two complementary approaches. The first develops top-down or hypothesis driven models that focus on the functional properties of nervous systems. They define control architectures and neural network models, possibly trained by deep learning algorithms, with the aim of solving a particular set of tasks. Examples are the Spaun model (*Eliasmith et al 2012*) and control architectures commonly found in cognitive robotics. The second approach is pioneered by the HBP and consists of digitally reconstructing and simulating neural circuits or even entire brains of mice, rats and ultimately humans, based on experimental data. These bottom-up digital reconstructions focus foremost on the structural and dynamical details of the reconstructed system and regard brain function as an emergent phenomenon.

While many researchers argue in favour of one or the other position, SP10 proposes that the most productive route is to combine the two approaches: For example, many theories exist for higher-level brain functions like visual perception, but not all of these theories can be true at the same time. Some may be appropriate for humans, whereas others may be applicable to cats or rodents. The only way to separate suitable theories from less suitable ones is to give researchers a tool that allows them to confront a given theory of brain function with the anatomical and physiological realities of a particular brain embedded in a concrete body, be it mouse, cat, or human. The Neurorobotics Platform (NRP) aims to be such a tool, following the time-tested approach of analysis by synthesis.

The NRP is a powerful integration of models, simulation tools, visualisation environments and hardware-/software-in-the-loop facilities that allows neuroscientists and roboticists to connect brain models of different complexity to biological or technical robot bodies, real or virtual, that operate in complex virtual dynamic environments. The NRP is the only platform worldwide, which aims at building, operating and monitoring virtual robots of arbitrary complexity and making these models easily accessible both to neuroscientists and roboticists. It will also enable them to find "common ground" over using those robots together in simulated (or partly or fully real) environments, i.e., a basis for the exchange of ideas and concepts. To this date, such common ground hardly exists.

Since the start of the HBP in 2013, a number of commercial and open competitors have emerged. This confirms the validity and the importance of our approach. OpenAI Gym is an online platform to train top-down models in (very simple) virtual environments. A start-up in Barcelona developed a platform similar to the NRP with regard to our robot programming features, called *ROS Development Studio* (http://www.theconstructsim.com/rds-ros-development-studio/) to teach ROS. NVIDIA is offering a commercial robot simulation platform, called Isaac (https://www.nvidia.com/en-us/deep-learning-ai/industries/robotics/), which is heavily slanted towards Deep Learning. Another project that shares NRP's vision to connect brain (or AI) models to agents in dynamic environments was also launched by Google Deep Mind (https://deepmind.com/blog/deepmind-and-blizzard-open-starcraft-ii-ai-research-environment/). However, it uses computer games rather than realistic robot and environment models.

In its scope and ambition, the HBP Neurorobotics Platform is still ahead of its competitors in scope and ambition. No other platform offers such a unique combination of realistic physics based robot simulations and multi-scale neural network modelling. Only the NRP is collaborative, open access and open source. The integration of the NRP into the HBP Collaboratory gives all users access to an unprecedented amount of data and models that can be used in neurorobotics experiments as well as access to supercomputing resources in Europe.

3 Sustainability Strategy

3.1 Principles

RobMoSys aims at building an open sustainable ecosystem around public, royalty-free and implementation-driven software platform standards that will ease the development of new robotic applications in multiple domains. The innovation required to advance RobMoSys methodology and tools needs to be driven by the key industrial companies. This is why RobMoSys partners believe that it needs to join existing industrial communities, which would guarantee a suitable environment for open innovation and industrial feedback.

More concretely, there is a set of specific goals to meet by the targeted community:

- **Open Innovation**: Ensuring the highest levels of productivity, reliability, service, and performance implies a continuous effort of research and development in robotics software tools. To cover the largest possible spectrum of stakeholder groups, we envisage to keep a high degree of openness. Methodological specifications will be open, not just in the sense of a dissemination with non-proprietary intellectual property rights, but also in the sense of the human development process required to reach such specifications.
- **Industry-friendly Business**. As for implementations, we envisage co-existence of both open-source and proprietary solutions. Obviously, a project with public funding and with an industrial focus will push development of industry-grade open-source results. Special attention to open-source (with so-called "industry-friendly" licenses) is needed to make the approach accessible and to spread it easily in the community and in the market.
- **Rich Tool Ecosystem**: The numerous and complex operations required to develop and maintain robotics systems imply a high level of automation based on mature software tools. RobMoSys must be connected with a solid ecosystem of software tools providing support beyond RobMoSys features. This is why, RobMoSys target "**harmonisation**" of critical aspects of the various established digital platforms (such as OPC/UA, ROS, etc.), in particular the interactions between sub-systems, as an essential enabler.
- **Long Term Support**: The tool chain needs to remain operational for the life cycle of the robotics products; many domains need more than 10 years, and some need up to 30 years. Firstly, we will enable "**growth**" into a bigger ecosystem by helping existing players to expand through our dissemination and networking activities, and by lowering entry barriers for new players through productising core functionality, thus growing the overall market. Secondly, "**scalability**" means solving bigger problems with equal or reduced costs, which we achieve, on the one hand, through improved tool-chains, and on the other hand through model-driven predictable integration. This latter aspect is squarely aimed at the complexity-from-diversity problem mentioned in the motivation.
- **Conformance**: The project has set up a process for expressing the conformance of assets with respect to RobMoSys: Conformance assesses and describes the degree to which a specific asset follows the RobMoSys methodology and approach. An asset can be tools, models, components or methodologies. An asset that is conformant to RobMoSys can use a **conformance label** to make its conformance visible. This is an important contribution from the technical side to the RobMoSys sustainability. The purpose of conformance to relate different assets in the RobMoSys approach in order to create a "map" of the ecosystem. Conformance thus serves as a guide for users to choose the right assets for their task, role, or intended purpose of use. It helps users to find along in the RobMoSys ecosystem.

RobMoSys partners expect that the project solutions will evolve in pace with the more challenging requirements of modern robotics engineering teams. RobMoSys solutions needs flexible extensibility and customization that makes it easier to adopt its tools, methods and processes by robotics engineering teams.

3.2 Towards an EU Digital Industrial Platform for Robotics

The world is entering an era in which ideas and insights come from everywhere, and crowds, clouds, collaborators, competitions, and co-creators can fundamentally help define our shared future. The business environment is being permanently altered as a result. Ecosystems are dynamic and co-evolving communities of diverse actors who create and capture new value through both collaboration and competition. A distinctive characteristic of many ecosystems is that they form to achieve something together that lies beyond the effective scope and capabilities of any individual actor (or even group of broadly similar actors).

The RobMoSys vision is to build an EU Digital Industrial Platform for Robotics to deal with different coexisting levels of maturity, acceptance, innovation, as well as to achieve evolvement, be inclusive, to achieve trust, to go beyond project life times.

The cornerstones are three different tiers (see Figure 3):

- **Tier 1: Stewardship for Knowledge Harmonization**. The role of a trusted steward and host for a consolidated *body of knowledge*, trustee for de-facto standards.
- **Tier 2: Technology Harmonization.** An institutionalized setting for a *horizontal structured dialogue* for coming up with aligned proposals for extending Tier 1 to the technological dimension (harmonization between tools and software assets).
- **Tier 3: Solution-Specific Communities.** The individual activities with their platforms, tools and partners.

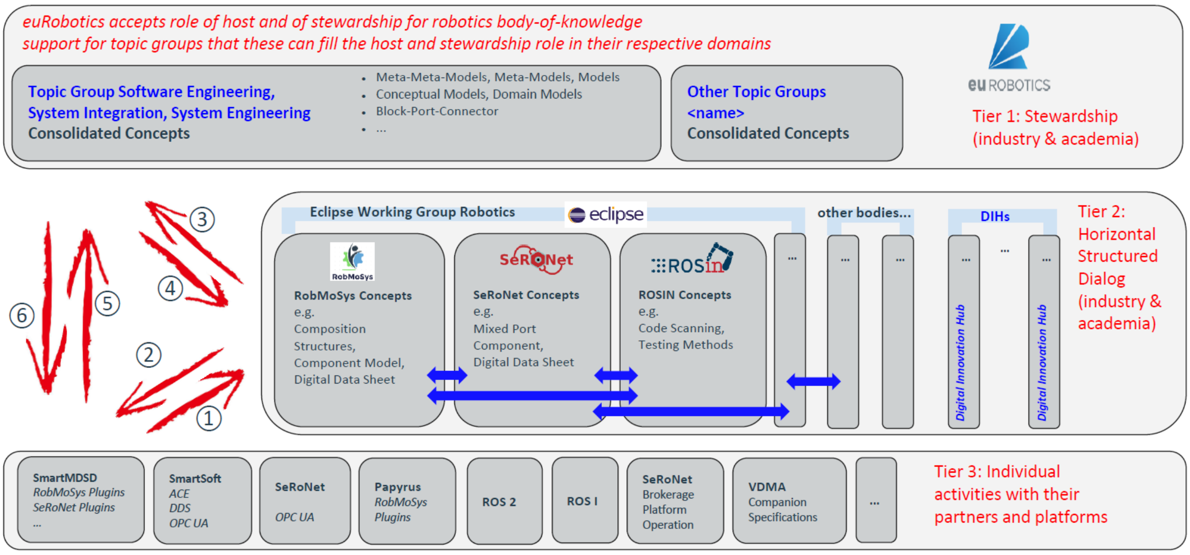

Figure 3: The Three Tiers of the RobMoSys Sustainability Strategy

The RobMoSys vision for Stewardship (Tier 1) is to let euRobotics be the hosting organization to create a body of knowledge for system and software engineering in Robotics, as well as some standards for the European robotics ecosystem. To this purpose, RobMoSys provides a conceptual structure and mechanisms to deal with different coexisting levels of maturity, acceptance, and innovation in robotics software and system engineering (via metamodels, domain models and services). The stewardship will be developed and maintained in the context of the euRobotics Topic Group "*Software Engineering, Systems Integration and Systems Engineering*".

The goals of the Eclipse Working Group for Industrial Robotics (Tier 2) is to develop an open source platform and open source specifications for industrial robotics or for what is sometimes called Industry 4.0. This working group would leverage connections with other Eclipse working groups like IoT, Edge Computing as well as connections with leading Eclipse technologies like Eclipse Modeling in order to address the challenges of software for industrial robotics, including composability, interoperability, etc.

This Working Group will interact with the European research ecosystem, especially with euRobotics AISBL, a Brussels based international non-profit association for all stakeholders in European robotics. euRobotics is a key initiative that collaborates with the European Commission to develop and implement a strategy and a roadmap for research, technological development and innovation in robotics. euRobotics was formed to engage from the private side in a contractual Public-Private Partnership, SPARC, with the European Union as the public side. euRobotics already hosts some groups that identify gaps and challenges, describe the desired paths towards solutions, milestones to be reached at specified instants in time and with a specified quality.

In addition to that, the working group will connect the strong Ecosystem of research projects (Tier 3) addressing some of the main Industrial concerns in the industrial Robotics' field. This integration is open to all projects that want to publish open source results in this context.

As a starting point we identified several projects that fit well in the scope of the Working Group:

- SeRoNet aims to significantly simplify the design, development, and deployment of service robots in a variety of areas
- BaSys provides a virtual middleware for industrial automation, which implements Industry 4.0 concepts leading to efficient changeability and adaptability in production processes.
- RobMoSys aims to promote open and sustainable industry-grade software development for robotics based on composable model-driven methods and tools
- ROSIN offers ROS-industrial quality assured robot software components

All of these projects and initiatives conform the EU Digital Industrial Platform for Robotics. The platform is built on top of a huge body of knowledge coming from research projects, European bodies and academia involved in the industrial robotic research. Such body of knowledge is maintained and managed by euRobotics, and should ideally issue several open standards with their compatible implementations.

3.3 Role of the Community Platform

The goals of the potential community platform must be:

- Providing means of collaboration between end user companies.
- Organizing sustainable commercial services and ecosystems around open source models, software components and tools.
- Fostering exchanges between academics and industry partners.
- Managing the quality and maturity of tools and components from early research prototypes through to obsolescence.
- Providing the documents and qualification kits required for certification.
- Recognizing project maturity and company know-how and commitment through a branding process.
- Ensure long-term longevity of models, software components, and tools since they must last for a long time.

The idea of joining an existing community is to avoid re-developing community management aspects but also to connect with other software communities. A lot of very good solutions answering some industrial needs already exist in open source. But most of the time, specific issues like durability or certification are not taken into account. In this case, the community platform must play its part by providing tool components assets, setting up specific support, and coordinating development and support.

3.4 Role of Contributors to the Platform

The role of RobMoSys contributors in such a community would be:

- Preparing RobMoSys models, software components and tools to be released/hosted in open source.
- Operating dedicated code repositories, build chains, test facilities, etc.
- Fostering exchanges between RobMoSys partners and industry partners.
- Proposing RobMoSys tool enhancements (industry-friendly functionalities, new features, reliability features, tool connectors with other external tools, among others).
- Managing the quality and maturity of RobMoSys tools
- Ensuring open innovation through the sharing of the research, development, and maintenance efforts as far as possible
- Fostering sustainable commercial services and ecosystems around the RobMoSys tools.

The main goal is to use RobMoSys partner's technical expertise in the models, software components and tool platform and comprehensive understanding of the ecosystem challenges, in an effective way by offering continuous support for industrial players wishing to use these technologies in a cost-effective way for long-term projects.

4 Sustainability Plans

In this section, we describe our plans for defining and consolidating the RobMoSys community, as executed during the project duration and as planned for future actions.

4.1 Activities During the Project

As a part of the community building strategy (joint WP6-WP7 work), we defined three phases for community building (Figure 4): Preparation, Creation and Consolidation.

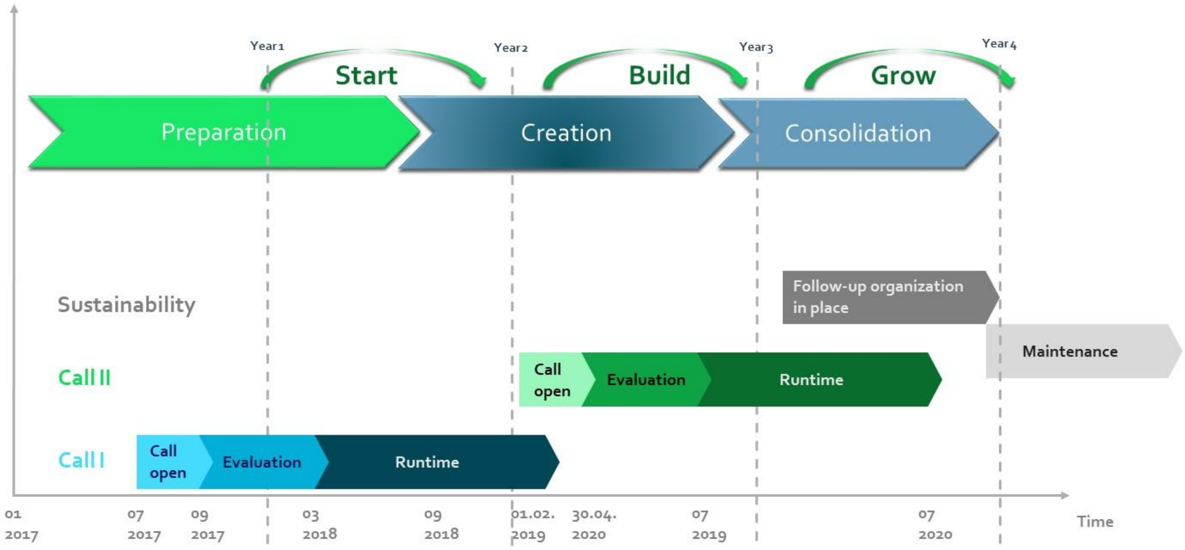

Figure 4: Community Roadmap phases

We defined a set of actions to execute this roadmap (see Table 1).

- During the **Preparation phase**, we focused on identifying stakeholders, principles, and potential sustainability models. At the same time, we created the SmartMDSD and Papyrus4Robotics tooling projects as part of the Eclipse Ecosystem.
- During the **Creation phase**, the focus is on setting the community infrastructure (Discourse forum, code repositories for tooling baselines and ITPs, RobMoSys methodology wiki), as well as on defining maintenance and governance objectives and getting the support from hosting organizations (euRobotics and Eclipse Foundation).
- During the **Consolidation phase**, the goal was to get the community engagement, make the RobMoSys ecosystem public and well known, and consolidating the hosting organizations and the governance charter in those organizations.

We took the concern regarding long-term sustainability of the RobMoSys concept very seriously. It was one core aspect in the work of RobMoSys to not only develop methodologies, tools, and software during the EU-funded phase, but to establish an enduring ecosystem that will continue to grow and flourish in the future. We stressed the project messages regarding the sustainability of the approach by focussing our outreach on how RobMoSys fits together and interlinks with other industry-related approaches, e.g. ROS, OPC UA and its companion specifications. The messages should be rather open regarding a collaboration, but also carefully describe limitations.

We organized workshops where the project partners were very active in stimulating the involvement of, and controversial discussions with, a selected variety of different stakeholder groups outside of the consortium of the project representing both technology-pull (application domains) as well as technology push (technical capabilities). This involvement (and thus commitment) of relevant stakeholder groups were "secured" by both, Tier-1 Experts Workshops and by Third-Party Funding.

The Open Call mechanism allowed us to identify the best tools already available, the best modelers and developers to adjust them and the best application areas to validate the results and establish benchmarks. Cascade funding also facilitated the access to integrated sets of common tool chains and real-world test installations to support the development of complex robotics systems. During Open Call II, the "Fast Adoption" instrument allowed us to work with selected individual industrial third parties, to help the company's engineers to adopt the RobMoSys approach and models and code in the context of that company. This joint effort helped to get less risk for the adopting company, faster and more effective dissemination with more direct results, and more intense feedback from industrial reality.

Table 1. Community Action Plan

Activity	Date	Resp.	Target Content	Audience	Promotion Mean
Twitter Communication plan	Targets due 13/07/18; ongoing effort	Anna, Susanne, Huascar	Updates on RobMoSys, modelling approach, EC news, ITPs	community	Min. 2-3 tweets a week (incl. Retweets)
Gathering of external stakeholders	Ongoing, every 2 weeks	Technical core consortium, ITPs (Anna & Susanne to coordinate)	Short technical articles - how does RobMoSys contribute to solving user needs (e.g. composability, quality of service)	Industrial community	LinkedIn, technical articles (to be cross-posted in Discourse, etc.) One article every two weeks
Stronger involvement of technical community	ongoing	WP6 + Technical team input	major technical development, crucial issues that require understanding and agreement by community	Technical community (software engineers) / MDE community	Discourse Forum
Actively gather "supporters"	Q3-Q4/18	Susanne	Statements of Stakeholders	General	Website
Tier 1 Workshop	11/09/18	Anna, Huascar	Preparation of Call II	Tier 1 experts	presentations, discussion
Open Community Workshop	12/09/18	Anna, Susanne, Huascar	Summary of Tier 1 workshop, how to use what is already available, general progress, pilots, outlook on call 2	community	talks, presentations, discussions, maybe life demonstrations
ITP Workshop	13/09/18	Anna, Susanne	what has been achieved to far, exploitation of results	ITPs	discussion, presentations, demonstrations
Tutorial (first version, online)	01/10/18	Gaël	RobMoSys modelling approach, Toolchains (early)	MDE community (tool developers)	Talks, Videos, Presentations
"Models" Tutorial	16/10/18	Herman, Christian	RobMoSys modelling approach, tool support	MDE community (tool developers)	Talk, hand-on training, video (steaming ?)
Technical video	02/19	Anna (input from HSU, KUL, CEA)	RobMoSys modelling approach, tool support	MDE community, early adopters	video
Brokerage Day (+ online streaming or VOD?)	12/02/19	Anna, Susanne	Open call explain what is already available	early adopters, pilot users	presentations, discussion, networking
Short WS / talk at Schunk Expert Days	27-28/02/19	Susanne	Open call, RobMoSys modelling approach, available tools	SR community	presentations, discussion, networking
ERF 2019	20-22/03/19	Anna, Susanne	Explain progress, explain open call, allow for pitch presentations of possible applications	MDE, robotics community	Workshop, booth
Online Tutorial (second iteration)	05/19	Gaël	RobMoSys modelling approach, Toolchains	MDE community, Tier 1, early adopters	Talks, Videos, Presentations
Official Training Video	01/20	Anna, technical team	how does RobMoSys work - what can be used and how?	industry, MDE community	video
Online Training	03/20	Anna, technical team	how does RobMoSys work - what can be used and how?	industry, MDE community	webinar
ERF 2020	03/20	Anna, Susanne	introduction of sustainable structure / organisation after RobMoSys, exploitable results	general	Workshop
Summer School	06/20	KUL, HSU	train students and MDE community how to use RobMoSys	R&D	Presentation, talks, videos, hand-on training, life demonstrations
Pilots demonstrators (+promotion material) - Videos	06/20	WP4	showcasing RobMoSys results, pilots, demonstrators, user benefits	pilot users, early adopters, supporters	Videos
One video of every Call II ITPs	06/20	ITPs	showcasing RobMoSys results, pilots, demonstrators, user benefits	pilot users, early adopters, supporters	videos - should be required as mandatory from every ITP
automatica 2020	16-19/06/20	Anna, Susanne	showcasing RobMoSys results, pilots, demonstrators, user benefits	general	booth and forum talk
Composition Festival (Plug Fest)	09/20	Technical core consortium, ITPs (Anna & Susanne to coordinate)	proof of concept for RobMoSys approach, training	pilot users, early adopters, supporters	hand-on training and "experiments"

4.2 euRobotics Stewardship

In 2019, RobMoSys partners worked in the establishment of the concept of Stewardship within euRobotics. After some meeting with euRobotics members (Rich Walker, José Saenz and Reinhard Lafrenz). As a result, the following citation was stated by these euRobotics members:

> *euRobotics' presence as the "centre of gravity" for European roboticists, spanning research, industry and policy, makes it natural that euRobotics champion the Stewardship of "community knowledge".*
>
> *Historically, euRobotics has "led the charge" to develop the Multi-Annual Roadmaps and the Strategic Research Agendas for the European robotics community, whilst at the same time setting up and enabling Topic Groups to do the community engagement and technical work to drive these processes.*
>
> *Stewardship of the consolidated "body of knowledge" and steering and trusteeship of the community's "de facto" standards is a natural follow-on to this, and will form part of the Topic Group refresh process that euRobotics Directors José Saenz and Rich Walker are leading.*
>
> *A working meeting with the Systems Engineering TG represented by Christian Schlegel and Dennis Stampfer, has set out a process to establish Stewardship within euRobotics in a formal way, and the Secretary General, Reinhard Lafrenz, will prepare suitable motions and briefings for the next Board of Directors meeting in late November 2019.*
>
> *The vision is to have the software systems engineering body-of-knowledge as first example of a euRobotics Stewardship Body in place by the ERF 2020.*

It is important to note that this was an excellent step into the absolutely right direction. This concept was approved by the euRobotics Board of Directors in ERF 2020. This concept has been refined as in Figure 5.

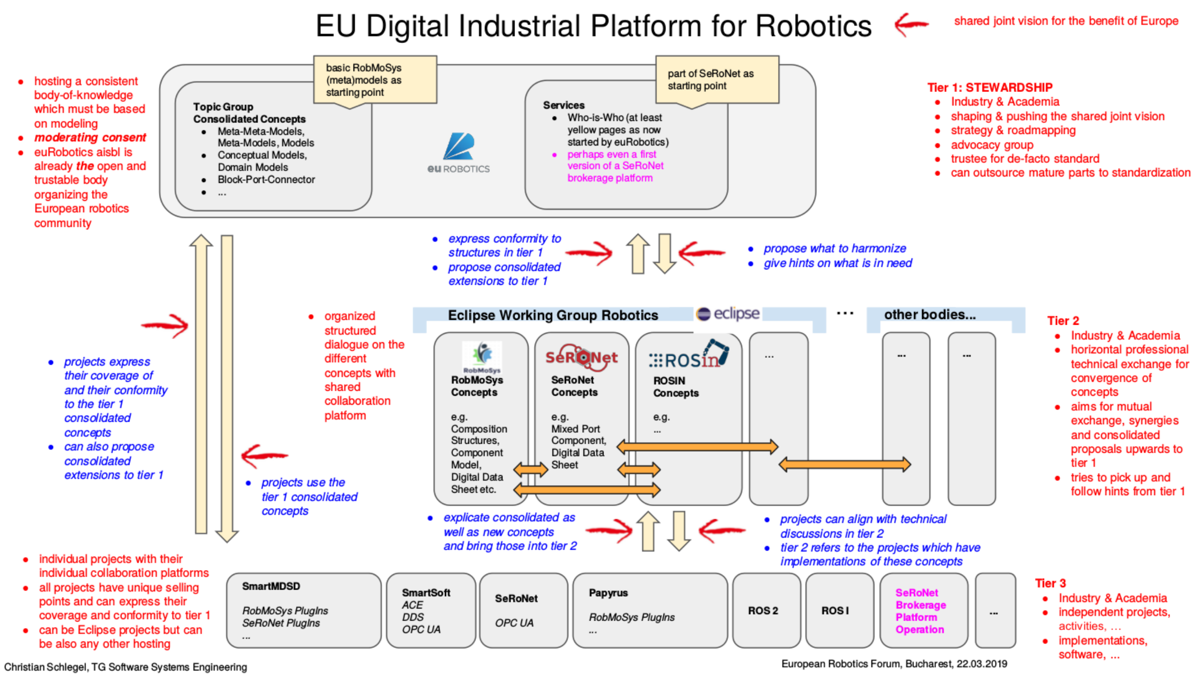

Figure 5: Establishment of the RobMoSys Sustainability approach

The RobMoSys ideas, processes and experiences from RobMoSys are used as a baseline, to be scaled by the euRobotics Topic Group on:

- Processes for horizontal interaction / vertical interaction in the ecosystem.
- Processes for coverage / conformance.
- Processes for incubator status.
- Transfer of RobMoSys Wiki to TG Wiki (keeping the RobMoSys brand for that content).
- Principles of Meritocracy.

The Topic Group will moderate the strategy and road mapping. It will also shape, push and disseminate the joint vision.

There is for the first time a real chance to shape an EU Digital Industrial Platform for Robotics EU Digital Industrial Platform for Robotics. The RobMoSys methodology not only allows us to structure the robotics body methodology, it also provides processes to take up new knowledge, and it provides processes to take up new developments and to be more inclusive. Figure 5 shows a first idea for bodies and roles to achieve sustainability.

4.3 The Robotics WG at Eclipse

Eclipse Working Groups provide a vendor-neutral governance structure that allow organizations to freely collaborate on new technology development. Leveraging the Eclipse specification process to create open standards, and the business-friendly license EPL-2.0, this Working Group could play a key role in the growth of the EU Industrial Robotics ecosystem.

4.3.1 Purpose and Scope

The goal of this Eclipse Working Group is to harmonize the development of an industry platform for robotics based on open technologies. It will also foster the development, adoption, and evolution of open source technologies for intelligent robotics, through industry collaboration of practice to produce commercial grade open source software.

This is an opportunity to create an Eclipse Working Group to gather the community from RobMoSys, Seronet, ROSIN, ROS Industrial Europe. In addition, there are some other potential connections with the Eclipse Edge Native Working Group (Siemens, Adalink); Eclipse IoT Working Group (CEA, Siemens, Adalink); and new WGs on Industry Automation (Fraunhofer IESE, ZF, KUKA, FESTO, BOSCH, ABB, fortiss, among others).

The tentative topics to be discussed, developed and maintained by this WG are:

Model-Based Engineering:

- MBE tooling for robotics, compatible with other existing ecosystems (ROS, YARP, etc.)
- Automatic system composition and deployment
- Bridging design and operation time (DevOps)
- Integration with other automation systems and standards (e.g. Basys for Industrial Automation, supporting Asset Administration Shells)

AI for Robotics:

- Specific robot applications for increased autonomy (welding, navigation, bin picking, etc.)
- How to integrate AI as components?
- AI Trustworthiness: Error detection, recovery behaviours, self-adaptation.
- AI for SSE: e.g. agility, how to span robot lifecycle, react to requirement changes in MBE toolchains in an agile way?

Tools Maturity and Usability:

- How to make model driven tooling more user friendly / better?
- How to make deployment more user friendly?
- New WGs on Industry Automation (Fraunhofer IESE, ZF, KUKA, BOSCH, ABB, …)

The main cross-concern are the following:

- **Conformance:** The ecosystem will have the ability to expand to support existing and upcoming RobMoSys standards or technologies such as the architectural patterns and Data Sheets. This means that organizations wanting to make their standard or product compatible with the RobMoSys ecosystem are welcome.
- **Integration:** The technologies provided by our Working Group are licensed under the Eclipse Public License 2.0 and will form an open platform that provides base technologies and solutions. Commercial or Open Source products can be built on top of it.
- **Standardization:** The Eclipse Robotics WG is committed to standardize the core elements of the RobMoSys technologies provided. An important example here is the Mixed Port and Data Sheet concepts, which can provide a backbone for interoperability with other key technologies.
- **Practise:** The WG will collect reference solutions and provide educational materials for the implementation of the next generation of production environments.

4.3.2 Governance Principles

To be successful the Robotics WG will need its governance rules and regulations defined and published in the Working Group Charter. Best practise and experience shows that these rules need to reflect the following principles:

- **Clearly defined boundaries:** Membership levels define the boundaries of participation. Members in turn define the scope of the development initiatives.
- **Rules adapted to local conditions:** Specific rules, such as those relating to the formation of a Steering Committee, selection of its chairperson, or frequency of meeting can be adapted to meet the preferences and constraints of the members.
- **Open decision-making process:** Transparent voting processes, meeting rules, openly published minutes etc.
- **Effective monitoring:** Transparent development process and requirements setting allows all members to monitor progress and raise issues.
- **A scale of graduated sanctions:** Working Groups set the requirements for participation and membership and have processes in place for revoking membership.
- **Cheap and easy conflict resolution:** The conflict resolution process is embedded in the democratic instruments and issue management processes of the Working Group governance and software development process.
- **Self-determination of the community:** User-driven; those who pay make the decisions

4.3.3 Process

At the time of writing, the process of creating the working is in the state of definition of a charter and identifying interested parties as core founding members. Typically, this process takes time because Eclipse Working Groups are not loose collaborations without binding. Committing to a working group means committing time, effort, and budget to implement, maintain, and marketize open source technologies in cross-organizational collaborations. The next steps to create this WG will be done in mid-2021 after ERF 2021.

4.4 The Eclipse Projects

A project is the main operational unit at the Eclipse Foundation. Specifically, all open source software development occurs within the context of a project. Projects have leaders, developers, code, builds, downloads, websites, and more. Projects are more than just the sum of their many parts, they are the means by which open source work is organized when presented to the communities of developers, adopters, and users. Projects provide structure that helps developers expose their hard work to a broad audience of consumers.

Two Eclipse Projects have been created during the RobMoSys Project: Eclipse Smart MDSD and Eclipse Papyrus for Robotics.

Eclipse SmartMDSD is an Eclipse-based Integrated Development Environment (IDE) for robotics software development. The SmartMDSD Toolchain provides support and guidance to apply best practices for the development of individual software building blocks, as well as their composition to robotics applications and systems. Eclipse SmartMDSD went through the Eclipse Development Process, was accepted as an Eclipse Project in December 2019 and had its first full release in July 2020. As of today, the project has four active committers and has a solid foundation for becoming a successful open source project. The project is in the Incubation Phase. Incubation indicates that the Eclipse community is helping this project "learn the ropes" about being a full open source project producing high quality extensible frameworks and exemplary tools. Projects typically stay in the incubation phase for a year or two before graduating to the Mature Phase.

Papyrus for Robotics is a graphical editing tool for robotic applications that complies with the RobMoSys approach. It manages the complexity of robotics development by supporting composition oriented engineering of robotics systems and separating the task into multiple tiers executed by different roles. It is based on Eclipse Papyrus, an industrial-grade open source Model-Based Engineering tool. Eclipse Papyrus has notably been used successfully in industrial projects and is the base platform for several industrial modeling tools.

4.5 Next Steps

The change of industrial practices is a complex and long process. A single research project, like RobMoSys, cannot realistically expect to cause a revolution in industrial robotics processes in a short-term. However, the project has demonstrated a feasibility of the advocated approach and industrial RobMoSys partners, Tier-1 experts and third-party partners committed to internal dissemination of the outcomes and gradual adoption of both individual concepts and the entire framework developed by the project.

Our target now is to establish the networks between industrial and research, training and consultancy stakeholders. Combined with exposure of industrial partners to cutting-edge concepts and principles this will naturally facilitate future smaller-scale collaboration that will, in turn, facilitate adoption of RobMoSys concepts in industrial practices.

In the coming months, we will complete the preparatory steps necessary for the Eclipse WG creation and Stewardship kick off meeting. Our hosting organisations Eclipse Foundation and euRobotics are open to accept support of RobMoSys new members and invites them to actively contribute to its governance structure.