RISK MANAGEMENT V1.0

DELIVERABLE NUMBER:	D.1.2
DUE DATE:	31.12.2023
DATE OF SUBMISSION:	15.12.2023
NATURE:	R
DISSEMINATION LEVEL:	PU
WORK PACKAGE:	WP1
LEAD BENEFICIARY	UNIMAN

Grant Agreement No 101092850

Funded by the European Union

Document Control Sheet

Deliverable Title:	Risk Management v1.0
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Document History

Version	Date	Status	Description/Comments
0.1	11.12.2023	Draft	Initial version with Table of Contents
0.2	15.12.2023	Draft	First complete draft
0.3	19.12.2023	Draft	Integrated comments and assembled all sections
0.4	21.12.2023	Draft	Integrated comments from reviewers
1.0	15.01.2023	Final	Final version submitted to EC

DISCLAIMER

AERO has received funding from European Union's Horizon Europe research and innovation programme under Grant Agreement No 101092850. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the granting authority. Neither the European Union nor the granting authority can be held responsible for them.

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Executive Summary

This document describes the principles of the risk management plan that is followed by AERO. Additionally, it reports the risks of the projects that were initially described in the DoA together with new risks that have been identified during the first year of the project. For every registered risk, this deliverable presents the assessment of the impact that it may have on the project and any possible mitigation plans to mitigate it.

Risk assessment is a continuous iterative process that involves all AERO partners. This document is a snapshot of that process.

List of Abbreviations & Acronyms

Abbreviation/Acronym	Meaning
AIER	Administrative, Impact, and Ethical Risk
CRM	Continuous Risk Management
DoA	Description of Action
EPI	European Processor Initiative
OS	Operating System
SEI	Software Engineering Institute
TR	Technical Risk
WP	Work Package

1 Introduction

AERO aims to upbring and optimize an open-source software ecosystem capable of operating on the emerging processor designs of the European Processor Initiative (EPI). The software ecosystem comprises various state-of-the-art software components spanning from OS and virtualization technologies to cloud software orchestration, while also delivering support for hardware acceleration for native and managed programming languages. To realize its ambitious objectives, it is necessary to monitor and assess the risks of the project. Risk management ensures that all partners are prepared for any positive or negative circumstances that may impact the process of achieving the AERO objectives.

This deliverable elaborates on the risk management plan that has been drawn and agreed to be followed by the AERO consortium (Section 0). Additionally, it presents a snapshot of the registered risks that have been identified by the end of the first year and shows how the consortium has mitigated the risks that have already materialized (Section 1).

2 Risk Management Plan

Risk management plays an important role in ensuring the successful outcome of every project. AERO follows a risk management plan based on the Continuous Risk Management (CRM) paradigm developed by the Software Engineering Institute (SEI). The risk management plan has been introduced briefly in the Project Management Handbook (D1.1) and its fundamental steps are summarized in Figure 1. Specifically, the AERO CRM-based risk management plan is composed of six steps that correspond to the following activities:

- **Risk Identification**: The definition of all known project risks in an explicit manner before they become problems.
- **Risk Analysis:** The estimation of the overall probability and impact of the identified risks, and their classification into a taxonomy of three categories: Low/Medium/High.
- **Risk Planning (Decisions/Mitigations):** The preparation of a response and an implementation plan to reduce the negative impact of the risks on the project (or increase any positive effect of relevant risks).
- **Tracking Risks:** Continuous monitoring of the state of the risks as a mean to assess and report on the effectiveness of the risk management plan.
    - **Risk Controlling:** This step regards the correct deviations emerging from the risk mitigation plans.
    - **Communication:** The final step enables the sharing of all information throughout the project.

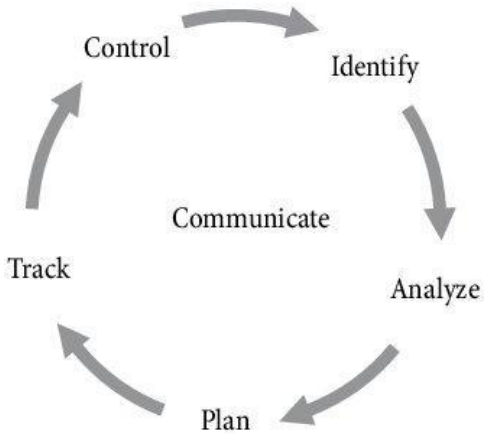

Figure 1. Continuous Risk Management paradigm.

2.1 Risk Identification

Several possible risks have been identified since the conception of the AERO project and have been registered since the beginning of the project. The description of those risks has been included in the AERO DoA along with the corresponding mitigation plans. In AERO, all partners share the responsibility to pinpoint risk scenarios by using the risk management plan, and by considering the project's organizational assets. Additionally, the Quality Manager (FORTH) together with the

management team has and will continue the organization of discussions regarding the identification of potential risks based on the technical expertise of the involved partners.

The AERO consortium has identified two categories of potential risks:

- **Admin-Impact-Ethical Risks:** This group of risks involves any administrative, scheduling, financial and ethical issues of the project.
- **Technical Risks:** This class of risks comprises any issues related to the AERO hardware and software technologies, the delivered technical work, and any deviations from the targeted KPIs.

2.1.1 Risk Registration

Once risks have been identified, they are registered in the AERO risk management tool in order to be monitored and managed by the AERO consortium. The AERO risk management tool acts as a hub accessible to all partners to keep track of all the information about the risks and the corresponding activities to address them. The tool is stored in the project's Google Drive document repository and is built upon the following risk classification:

- **Risk ID:** The identification name of the risk. This identifier uses the short name of the category of risks (*AIER* for Administrative, Impact, and Ethical Risks – *TR* for Technical Risks), accompanied by a sequential number.
- **WP:** The work packages being affected by the risk.
- **Risk Description:** A brief description of the risk stated as an event that will take place if something is done/not done.
- **Probability:** The likelihood of the event to take place.
- **Impact:** The impact on the project's objectives if the risk materializes.
- **Risk Exposure:** This is a composite metric created by combining the impact that a risk has on the objectives of the project and the probability to occur. The risk exposure table is shown in Table 1.
- **Remedial Actions:** The mitigation plan that will be employed to reduce the probability and/or impact of the threat.
- **Who Mitigates:** The partner(s) responsible for handling a materialized risk.
- **Status:** The state of the risk. This can be open, mitigated, closed, n/a.
- **Risk Application Timeframe:** The timeframe that the risk was active. This is the elapsed time from the registration of a risk till its conclusion.
- **Inclusion Date:** The relative project month that the risk was registered in the risk management tool. If a risk has been described in the DoA, then "M1" is referred as the marker for the inclusion date.
- **Risk Materialization:** The relative project month that the risk actually occurred.
- **Comments if Mitigation Measures Cannot Be Applied:** Any comments filed by partners regarding their inability to apply mitigation measures.

2.2 Risk Analysis

The risk analysis phase follows the identification of a risk and is responsible for collecting and registering information about the probability that a risk will occur and its impact on the AERO objectives. The risk analysis phase aims to rank the risks in three exposure classes (Low, Medium, High) based on their probability and the severity of their impact, thereby helping with planning the remedial actions to reduce or eliminate the impact of the threats.

The impact level of a risk is determined based on the effect of the risk on the project's objectives (i.e., schedule, cost, scope, quality) and it is classified in five main levels (Trivial, Minor, Moderate, Major, and Extreme), as shown in Table 1. On the other hand, the probability level corresponds to the likelihood that a risk may occur, and it is classified in five levels (Most likely, Likely, Moderate, Unlikely, and Rare). The combination of the level of probability and the level of impact is mapped to a risk exposure class (Low, Medium, High) that reflects the priority level of a risk, as presented in Table 1. Note that Table 1 is an updated version of the risk exposure table that has been described in D1.1.

The emerging risk exposure class is used in the risk management tool as a metric that reflects the severity of a risk and enables the AERO consortium to prioritize risks based on their criticality and apply different mitigation strategies based on that class.

Table 1. Mapping of the probability and impact of a risk event and the assigned risk exposure class.

Impact / Probability	Trivial	Minor	Moderate	Major	Extreme
Most Likely	Medium	Medium	High	High	High
Likely	Medium	Medium	Medium	High	High
Moderate	Low	Medium	Medium	Medium	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Medium	Medium

2.3 Risk Planning

This phase involves the discussion of the risk management strategies that are going to be applied for the registered risks. AERO selects a strategy to follow for addressing a risk with respect to the severity of the analyzed risk exposure metric, by taking into account any relevant information reported by the leaders of the WPs that are affected by a risk. The remedial actions that have been developed by AERO are recorded in the risk management tool.

Specifically, for each risk one of the following mitigation approaches that will be followed to address it:

- **Avoid:** This approach is usually applied in cases of threats with high impact and high likelihood of occurrence. The objective is to eliminate the risk by altering the implementation of the project in a way that eliminates the risk. This can be done by removing the risk's source,

thereby isolating the project objectives from the identified risks, and by adding more resources or extending the timeline.

- **Transfer:** This approach is used to transfer the ownership and responsibility for addressing a risk to another party. This approach usually entails a payment to the party that takes over the ownership of a risk.
- **Mitigate:** This approach is focused on reducing or eliminating the impact of a threat that is anticipated to occur by trying to reduce the likelihood of happening or the impact of the risk, upon its occurrence.
- **Accept:** This approach is applied in the case of risks for which there is no possible response and low severity risks, as long as their severity remains the same.

2.4 Risk Tracking

Tracking the risks is a continuous phase that involves the iterative application of all previous phases. This process is actively monitored by the Project Coordinator, the Technical Manager, and the Quality Manager of the project. This process requires the contribution of other AERO parties as well, specifically associated WP Leaders, Task Leaders, or other partners who act as owners of a risk. The risk management tool is used to drive the continuous assessment of the listed risks, by assessing whether the severity of a risk has changed, evaluating the effectiveness of the pre-defined remedial actions, and identifying and planning to mitigate new risks.

More specifically, AERO performs the following actions in a regular basis:

- Track the status of the identified risks and assess whether the mitigation measures or the remedial actions are not valid anymore.
- Identify and register any new risks and ensure that they are sufficiently analyzed, they have been allocated to appropriate parties, and they have been attributed with the appropriate remedial actions.
- Evaluate the success of the risk management process.

3 AERO Risk Assessment

3.1 Identified and Analyzed Risks until M12

This section presents the entries that have been registered in the AERO risk management tool until M12. Table 2 presents the list of risks relevant to the administrative, impact, and ethical activities of AERO, whereas Table 3 presents the list of risks relevant to the technical WPs of AERO.

Table 2. List of identified administrative, impact, ethical risks (AIER1 – AIER6) and mitigation actions.

ID	WP	Risk Description	Prob/ Impact	Risk Expos.	Remedial Actions	Who Mitigates	Status	Risk App. Time frame	Inclus./ Update date	Risk Material.
AIER 1	WP1	Insufficient consortium coordination.	Unlikely/ Extreme	Medium	Assign and continuously review responsibilities among partners.	ICCS	Open	M1-M36	M2	
AIER 2	WP1	The AERO consortium loses a partner.	Unlikely/ Moderate	Medium	The consortium has been designed with complementary to an extent, skillsets. In case a partner is lost, an effort will be made by the remaining partners to uptake the work. If this is not possible the AERO technologies can still be demonstrated by recombining the various components omitting the missing one. Regarding, UK participants (UNIMAN and CPLAY), the UKRI has announced that UK will cover the successful bids under the call that AERO is funded.	ICCS	Open	M1-M36	M1	
AIER 3	WP7	Lack of contribution to communication efforts from partners.	Unlikely/ Moderate	Medium	Keep in touch with all partners and communicate a detailed project plan clearly stating goals and responsibilities.	UNIMAN	Open	M1-M36	M3	
AIER 4	WP7	Failure to identify gaps in the market that can lead in unsuccessful commercial roadmap	Unlikely/ Moderate	Medium	An extensive market analysis will be performed on the EPI ecosystem.	CPLAY	Open	M1-M36	M3	
AIER 5	WP7	Lack of liaison with other EU Processor ecosystem projects.	Unlikely/ Moderate	Medium	The consortium has members that are involved in the EPI initiative, and they participate in other sister projects that have been funded by EU in the same call with AERO. Those partners will enact as bridge for the successful communication of AERO with the relevant projects.	FORTH	Open	M1-M36	M3	
AIER 6	WP2 WP7	Cannot satisfy privacy constraints derived from the SLAs of pilots.	Unlikely/ Moderate	Medium	The use case providers that have sensitive code in their software will ask a direct VPN access to servers that are provided by other partners of the consortium.	SIPEARL	Open	M6-M36	M6	

Table 3. List of identified technical risks (TR1-TR10) and mitigation actions.

ID	WP	Risk Description	Prob/ Impact	Risk Expos.	Remedial Actions	Who Mitigates	Status	Risk App. Time frame	Inclus./ Update date	Risk Material.
TR1	WP3 WP4 WP5	Delays in development of various components of the AERO software stack.	Moderate/ High	High	More effort will be shifted to the upbring activities by delaying the innovation phase of affected components. Additional AERO components that are affected in terms of integration will continue development on the secondary development route.	WP Leader	Open	M1-M33	M1/ M10	
TR2	WP3 WP4 WP5	Development of software components of the AERO software stack are ahead of time.	Moderate/ Trivial	Low	Components that are ahead of time will transition to the innovation phase prior to M18. Alternatively, focus and effort can be placed to other components that may be delayed.	WP Leader	Open	M1-M33	M1/ M10	
TR3	WP2	Parallelization of algorithms might be limited to Amdahl's (pessimistic) or Gustafson's (optimistic) law overlaid with GPU architectural constraints (memory bandwidth, memory layout, GPU kernel recompilation needs). Furthermore, such parallelization might be under-optimized even more by the generic nature of GPU-kernels generated by TornadoVM.	Moderate/ Moderate	Medium	UNIGE sees cooperation with the TornadoVM team (UNIMAN) as a fundamental requirement to fix obstacles in the GPU code generated and is willing to try to adjust the algorithms by CU7/DPCG to be easier to port to TornadoVM.	UNIGE	Open	M1-M33	M1/ M10	

TR4	WP2	Current technologies deployed by the use cases are too complex to be ported/implemented within the timeframe of the project.	Rare/ Moderate	Low	The various software parts will be deconstructed to business logic (i.e., the actual application code) and to orchestration/cloud logic (i.e., tools are being used for deployment, management, etc. - e.g., Docker, Kubernetes, etc.). Based on this deconstruction, first the business logic will be ported and tested (the actual programming languages and runtimes) and then the remaining software parts will be tested if their complexity allows it. In addition, standard benchmarking will be used to use individual software components.	UNIGE	Open	M1-M33	M1/ M10	
TR5	WP4	ARM port of the JVM is not stable enough to support JVM-related activities of AERO.	Moderate/ Moderate	Medium	AERO will utilize the expertise of RHAT and UNIMAN to put joined effort in providing necessary patches and bug fixes to OpenJDK to improve JVM stability.	RHAT	Open	M4-M33	M1/ M10	
TR6	WP4	RHAT might not be able to keep working on GraalVM/Mandrel, e.g. due to legal issues.	Moderate/ Major	Medium	In that case RHAT will shift all its efforts towards the OpenJDK Leyden project implementation. If that's also not possible RHAT will focus all its efforts on Quarkus JVM-mode only.	RHAT	Open	M4-M33	M1/ M10	
TR7	WP3 WP4 WP5	Intel GPU drivers are not stable on the SIPEARL Rhea Platform.	Most Likely/ Moderate	High	Intel committed via their letter support to provide support and engineering effort to mature their GPU driver ecosystem on the EU processor. In addition, regular meetings with Intel engineers will be set up to help solve these issues.	UNIMAN	Open	M4-M33	M1/ M10	
TR8	WP7	Open-source projects (e.g. KVM, Docker, etc.) might not accept contributions from the project.	Unlikely/ Minor	Low	The majority of the partners have a track record of successfully managing to upstream contributions to their respective open-source projects. If problems are encountered, and no alternative solutions can be found, then the repositories will be forked, and results will be made public via the forked repositories.	SIPEARL	Open	M1-M36	M1	

TR9	All WPs	Delay in deploying the Rhea processor from SIPEARL.	Most Likely/ Moderate	High	The consortium will work with alternative ARM-based platforms such as Mt Mitchel or Supermicro, Grace Superchip (SuperMicro), GraceHopper (SuperMicro) or a hardware emulator/virtual platform of Rhea. In case the requirements of specific tasks cannot be satisfied by those alternative platforms, AERO partners will use other alternatives, such as Fast models (VOSYS in the context of T3.1), simulators for RISC-V/RVV accelerators (CPLAY in the context of T3.2), FPGA-based platforms (UNIPI in the context of T3.3) and RISC-V based platforms (UNIMAN & CPLAY in the context of WP4 and UBI in the context of WP5).	SIPEARL	Miti-gated	M1-M36	M1	M1, M9
TR 10	WP3 WP4 WP5	Further delays in delivering Rhea, not allowing enough time for the required development and upbringing of the AERO software.	Unlikely/ Extreme	Medium	Alternative hardware will be assessed for the final evaluation of the AERO software. Also, potential extension of the project may be triggered.	ICCS/ SIPEARL	Open	M4-M33	M9	

3.2 Materialized Risks until M12

As shown in Table 2 and Table 3, during the first year of the project, risk TR 9 "*Delay in deploying AERO software components on the Rhea processor from SIPEARL*" materialized. It first materialized at the start of the project (M1), when SIPEARL updated the schedule of deployment on the Rhea processor to M13-M15 (Q1 2024) instead of M1. To mitigate the impact of the delay, SIPEARL assessed alternative ARM-based platforms available at that point of time. Table 4 presents some of those alternative platforms and how they compare to Rhea. Based on that information, each partner selected the most suitable available platform that satisfied the requirements of its software components. That way, all partners were able to perform their software compatibility assessment and initiate their upbringing activities leading to the successful delivery of D6.1 on time. This meant that even though the Baseline phase started its activities on the alternative hardware platforms, there was still enough time to complete the upbringing of the software components on the actual Rhea platform and reach milestone M4 "Baseline System" on time in M18.

Table 4: Alternative HW platforms to the Rhea processor at the start of the project.

Name	Type	Config	Comment	Availability
AWS G5G	Cloud	Neoverse N1 cores + NVIDIA GPUs	Cloud instance with not the same cores as Rhea but with GPU. Good solution for SW porting and utilizing accelerators. No access to low level firmware.	M1
AWS C7G	Cloud	Up to 64 Neoverse V1 cores	Cloud instance with same cores as Rhea. Good solution for SW porting and optimization. No accelerators. No access to low level firmware.	M1
Mt Jade (Wiwynn)	Server	2x Ampere Altra (up to 80 ARM Neoverse N1 cores)	Not the same cores as Rhea. Useful for SW porting. Good solution for utilizing accelerators (GPUs).	M1
Mt Snow (Gigabyte)	Server	1x Ampere Altra (up to 80 ARM Neoverse N1 cores)	Server with ARM N1 instead of V1 cores. Good solution for utilizing accelerators (GPUs).	M1
Mt Hamilton (Supermicro)	Server	1x Ampere Altra (up to 80 ARM Neoverse N1 cores)	Server with ARM N1 instead of V1 cores. Good solution for utilizing accelerators (GPUs).	M1
HW emulation	Emulator	Rhea	HW emulator of Rhea. Really slow but fully accurate	2023
Virtual Platform	VP	Rhea	Virtual platform of Rhea. Useful for prototyping deep features	2023

However, the risk materialized again in M9, when SIPEARL moved the target for deployment of the Rhea processor to Q1 2025, i.e., between M25 and M27 of the project. This delay has a significant impact on the progress of the project, as it means that milestone M4 cannot be reached on time and that deliverables D2.2, D3.1, D4.1, D5.1, and D6.2, cannot be produced and submitted by M18. These deliverables entail: i) the release of the ported software components to the Rhea platform (D3.1, D4.1, D5.1), ii) the necessary improvements to enable AERO pilots running on the Rhea platform (D2.2), and iii) the report and demonstration of the AERO platform (D6.2).

To address this problem and ensure the progress of the project, the AERO consortium has agreed on adapting the original workplan as shown in Figure 2.

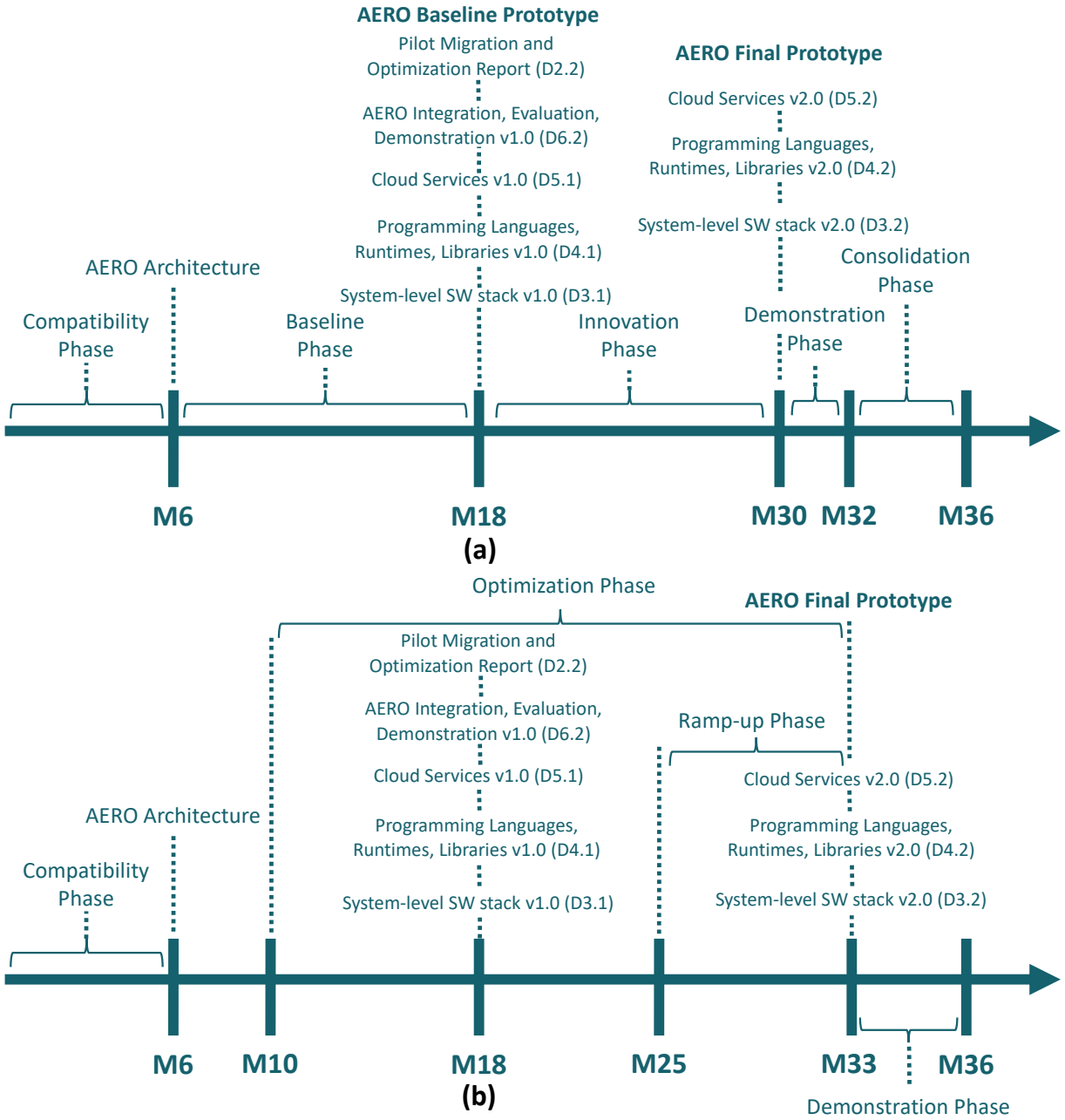

Figure 2: Bird's eye view of the AERO (a) original and (b) adapted workplan.

In particular, the following adaptations have been decided:

- Instead of working on the upbringing of their software components on the Rhea platform until M18, AERO partners will complete the upbringing on suitable alternative hardware platforms and start working on optimizing them as soon as possible. Hence, the "Innovation Phase" is rebranded to "Optimization Phase" and extended to start earlier, in M10. Section 3.2.1 elaborates on the mapping of the alternative platforms that are going to be targeted by each AERO software components, as derived from the Task Leaders of each technical work package.
- The "Baseline Phase" is rebranded to "Ramp-up Phase", which starts with the actual deployment of the Rhea platform (M25) and entails the integration of all AERO software components on Rhea along with the optimizations developed during the Optimization phase. However, there is no

guarantee that all developed optimizations will be able to be deployed on Rhea, as it depends on the available time.

- The scope of deliverables D2.2, D3.1, D4.1, D5.1 and D6.2 is changed. More specifically, D3.1, D4.1, and D5.1 will entail the releases of the AERO software components including any optimizations developed on the alternative hardware platforms until that point; D2.2 will report on the porting of AERO pilots on the alternative platforms, and D6.2 will report on the upbringing of the software components on the alternative hardware platforms and present any optimizations developed until that point.
- The Ramp-up and the Optimization phases converge with the release of the AERO final prototype comprising deliverables D3.2, D4.2, D5.2. To ensure enough time for their successful delivery, their due date has been moved from M30 to M33, which allows 3 months (M33-M36) for the demonstration and final evaluation of AERO.
- Since the integration with the actual Rhea platform is moved towards the end of the project, if the upbringing on the alternative platforms is quickly completed, AERO partners may have the opportunity to work longer than originally anticipated on optimizations. In that case, partners are encouraged to consider optimizations and ideas that were not originally described in the DoA, as long as they are aligned with the European processor ecosystem and the general EU vision and expected outcome. As an example, UNIMAN is considering porting the TornadoVM on a RISC-V host as well as collaborating with CPLAY on optimizing TornadoVM to leverage RISC-V accelerators; both these developments were not originally foreseen in the AERO project but are completely relevant to the European Processor Initiative.

Finally, since the ecosystem is constantly evolving, SIPEARL has updated the available alternative platforms that can be used from this point until the deployment of the Rhea platform. Table 5 lists the new platforms and compares them to Rhea.

Table 5: New alternative hardware platforms (as of M10).

Name	Type	Config	Comment	Availability
Mt Mitchel or Supermicro	Server	2x AmpereOne	Good solution for SW porting (SVE available) and GPU or accelerator bring-up	Q2 2024
Grace Superchip (Supermicro)	Server	Dual chip with ARM Neoverse V2	Good solution for SW porting (SVE available) and GPU or accelerator bring-up	Preview
GraceHopper (Supermicro)	Server	CPU+GPU SoC with ARM Neoverse V2	Good solution for SW porting (SVE available) and testing offload to an NVIDIA GPU	Preview
HW emulation	Emulator	Rhea	HW emulator of Rhea. Really slow but fully accurate	2024
Virtual Platform	VP	Rhea	Virtual platform of Rhea. Useful for prototyping deep features	Q1 2024

Based on this information, the best alternative platform is the Grace Superchip server which can use GPU or other accelerators, while the ARM cores have a similar instruction set to the one used by the Rhea cores. Therefore, SIPEARL has proceeded to purchasing Grace Superchip servers and expects to have them up and ready to be shared with AERO partners in Q1 2024.