RISK MANAGEMENT V2.0

DELIVERABLE NUMBER:	D.1.3
DUE DATE:	31.12.2024
DATE OF SUBMISSION:	31.01.2025
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 v2.0
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Document History

Version	Date	Status	Description/Comments
0.1	11.12.2024	Draft	Initial version with Table of Contents
0.2	17.12.2024	Draft	First complete draft
0.3	23.12.2024	Draft	Document ready for internal review
0.4	20.01.2025	Draft	Addressed reviewers' comments
1.0	30.01.2025	Final	Final revised version to be submitted to EC

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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.

TABLE OF CONTENTS

Executive Summary

This document acts as an iteration of the risk management plan introduced in D1.2. This deliverable elaborates on the risks that have been materialized during the period of the second year of the project and presents the assessment of the impact that they may have on the project and any possible mitigation plans to mitigate them. Additionally, it presents an update on the risks that were identified till the second year of the project.

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
DoA	Description of Action
EPI	European Processor Initiative
KPI	Key Performance Indicator
TR	Technical Risk
WP	Work Package

1 Introduction

AERO has a mission to develop and enhance an open-source software ecosystem designed to operate efficiently on the innovative processor architectures developed under the European Processor Initiative (EPI). This ecosystem integrates a range of advanced software components, including operating systems, virtualization technologies, and cloud software orchestration, while also enabling hardware acceleration for both native and managed programming languages. Achieving these ambitious goals requires diligent risk monitoring and assessment throughout the project. Effective risk management ensures that all partners are equipped to address any challenges or opportunities that may influence the attainment of AERO's objectives.

This deliverable extends deliverable D1.2 by elaborating on the project's risk management during its second year (M13-M24). Specifically, it provides an update regarding the status of the identified risks as of the end of the project's second year and outlines the work plan adaptations that will be implemented by the consortium in the forthcoming period to mitigate the impact of those risks that have materialized.

2 AERO Risk Assessment

2.1 Materialized Risks until M24

As presented in D1.2, 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 evaluated alternative ARM-based platforms, enabling partners to perform software compatibility assessments and begin their upbringing activities, which ensured the timely delivery of D6.1.

However, risk TR9 materialized again in M9, when SIPEARL moved the target of Rhea's deployment to Q1 2025, i.e., between M25 and M27 of the project. To mitigate the impact of the delay and allow the project to achieve its objectives by M36, the original work plan was adapted as shown in Figure 1b. This adapted plan was discussed during the technical review meeting that took place in M9 and was described in D1.2.

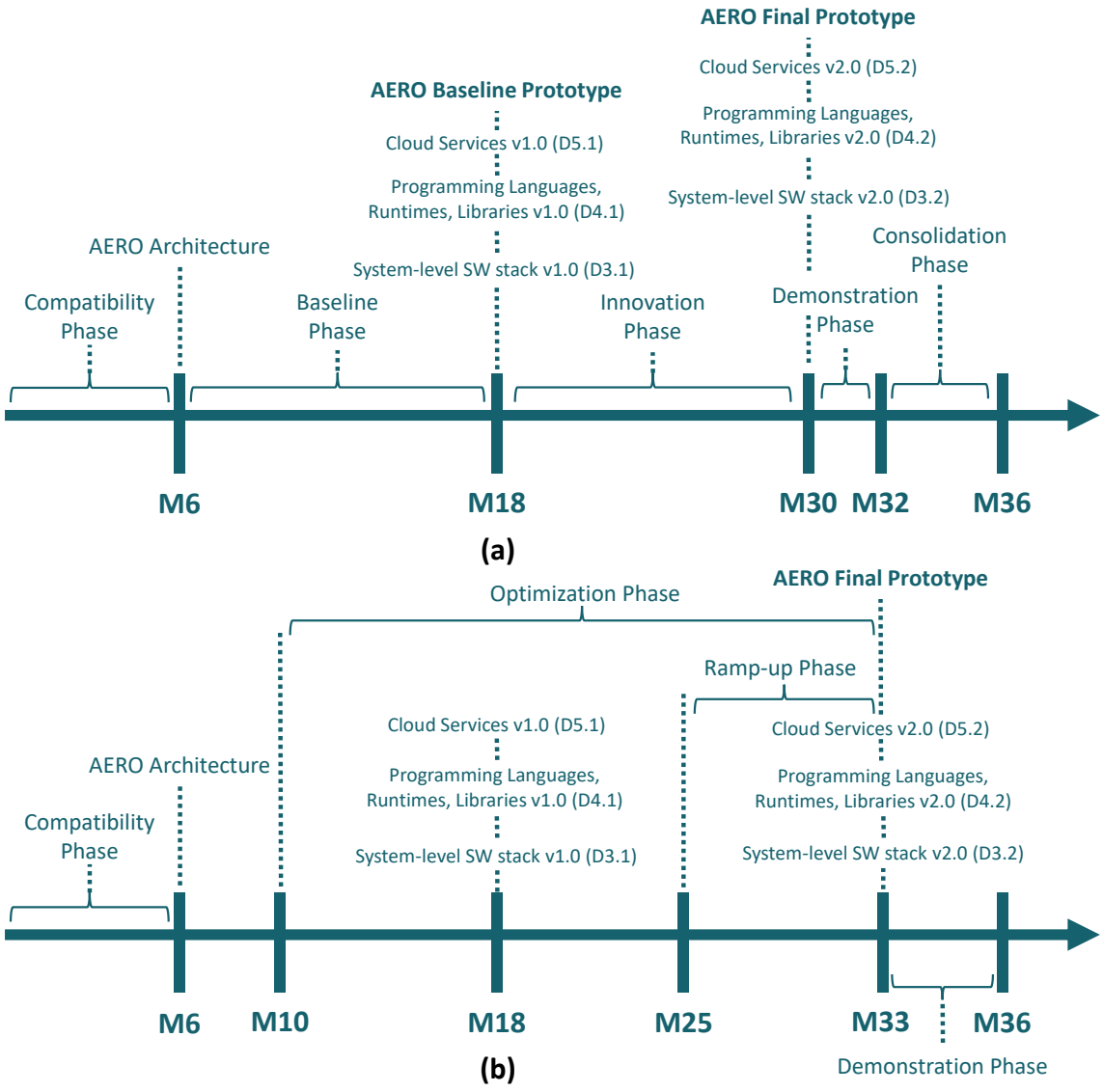

Figure 1: Bird's eye view of the AERO (a) original and (b) adapted work plan

Unfortunately, risk TR9 materialized again twice during the second year of the project, in M18 and M24. As documented in D6.2, in M18 it was estimated that AERO partners will have access to the first Rhea-based prototypes at Q3 2025 (between M31 and M33), i.e., 6 months later than previously expected. Based on this estimation, the AERO consortium presented an adapted work plan in the RP1 project review that took place in M21, assuming an extension of the project's duration by 4 months. The proposed plan was accepted under the condition that the actual length of the extension will be determined in another review around M30.

However, in M24 SIPEARL updated again the Rhea roadmap, delaying further the delivery of the Rhea prototypes to the end of M34 of the project. To accommodate this delay, the plan has been slightly adjusted again, assuming now a 6, instead of 4, months extension of the project's duration. The adjusted plan is presented in detail in Section 2.1.1.

2.1.1 Work Plan Updated in M24

The AERO project has defined a set of KPIs to monitor its progress and verify the achievement of its objectives. These KPIs can be split in two main categories:

- **Functional KPIs** that validate that the AERO software executes correctly on the hardware platform, e.g., execution of TornadoVM on the EU processor targeting 100% pass rate on standard benchmarks.
- **Performance KPIs** that evaluate how efficient is the execution of the AERO software on the hardware platform, e.g., hardware acceleration and optimization via TornadoVM targeting 10x speedup using GPUs.

While the Rhea processor (based on ARM Neoverse V1) is not available, AERO has been performing all development, optimization, testing, validation and evaluation activities on alternative hardware platforms that employ similar processors (based on ARM Neoverse N1, V1, and V2). More specifically, AERO partners have managed to acquire access to all currently available commercial solutions that are as close to the Rheal architecture as possible. Hence, we are highly confident that all functional KPIs achieved on the alternative platforms will be straightforwardly achieved on the Rhea platform as well, i.e., all AERO software components that execute correctly on the alternative platforms will be compatible and operate correctly on the Rhea platform as well.

However, the extrapolation of the performance KPIs achieved on the alternative platforms to Rhea is not straightforward, as performance is highly dependent on the actual hardware implementation, which could vary significantly. For example, on the NVIDIA Grace Hopper superchip the processor implements the ARM Neoverse V2 architecture but utilizes NVLink, a proprietary interconnect to communicate with the GPU; on the Rhea platform, GPUs will be connected through PCIe, which offers significantly lower bandwidth than NVLink. On the other hand, Rhea will use HBM memory, which is highly performant compared to the DRAM modules used in the alternative platforms AERO has access to.

Based on these observations, we are highly confident that the ramp-up phase of the project will be mainly devoted to achieving the performance KPIs, as ***all functional KPIs should be straightforwardly validated on Rhea***. To be able to realize the ambition of the project, we estimate that a ramp-up phase of 5-6 months will be required. Additionally, by adjusting the duration of the

demonstration phase from 3 months to 2 months**, a total of 7-8 months is required from the point we acquire access to the Rhea prototypes**. As this access is currently projected for M34, an extension of 6 months is necessary in order to enable the project to achieve its objectives and fulfil its vision.

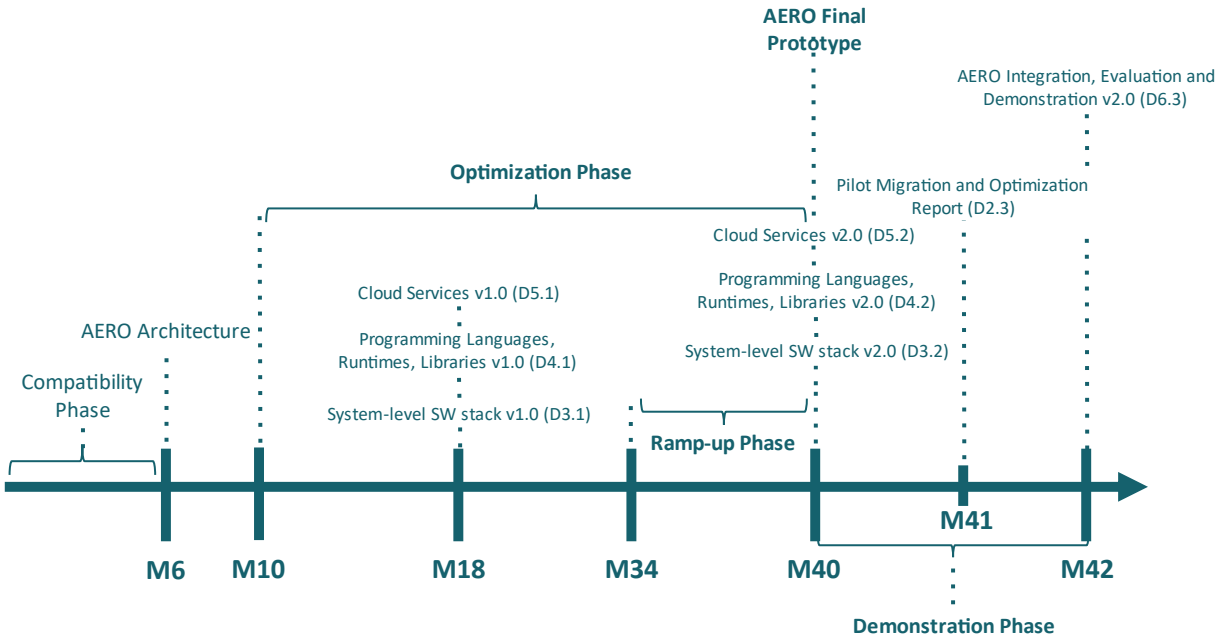

Figure 2: Bird's eye view of the current AERO work plan as adapted based on the latest Rhea roadmap (M24).

Figure 2 presents the latest adapted work plan, which entails the following adjustments compared to the previous work plan illustrated in Figure 1b:

- The optimization phase is prolonged till M40. AERO partners will continue performing all development, optimization, testing, validation and evaluation activities on alternative hardware platforms that employ similar processors (based on ARM Neoverse N1, V1, and V2). As mentioned earlier, AERO partners have secured access to commercial solutions closely aligned with the Rhea architecture.
- The ramp-up phase will start in M35, when the first Rhea engineering samples will be made available to our consortium, and will last for 6 months, i.e. until M40.
- In M40, the final prototype of the AERO software stack will be delivered, beaconing the transition from the ramp-up phase to the demonstration phase. The duration of the demonstration phase is adjusted from 3 months to 2 months.

Following these adjustments, Figure 3 depicts the extended AERO Gantt chart, where the end of the project has been moved to M42. The main changes compared to the original Gantt chart in the DoA are as follows:

- **WP1** and all its tasks are extended from M36 to M42.
- **WP2** and all its tasks are extended from M32 to M41. **D2.3** that reports on the migration and optimization of the AERO pilots on Rhea will be delivered in M41.
- **WPs 3**, **4**, and **5** and all their tasks are extended from M30 to M40. **D3.2**, **D4.2**, and **D5.2** that entail the final optimized AERO software modules will be delivered in M40.
- **WP6** and task **T6.3** are extended from M36 to M42, while task **T6.2** is extended from M32 to M41. **D6.3** that demonstrates the final AERO platform will be delivered in M42.

	Months	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42
WP1	**Project & Technical Management (ICCS)**																																										
T1.1	Administrative & Financial Planning and Coordination																																										
T1.2	Technological and Scientific Strategic Steering																																										
T1.3	Quality Control, Risk Management and Contigency Planning																																										
T1.4	Reporting																																										
	Deliverables			**D1.1**									**D1.2**												**D1.3**																		
WP2	**Pilot Migration and Optimization on the EU Cloud (SED)**																																										
T2.1	High Performance Algorithms for Space Exploration																																										
T2.2	Automotive “Digital Twins” with IoT-Cloud Interoperability																																										
T2.3	HPC/Cloud Database Acceleration for Scientific Computing																																										
	Deliverables						**D2.1**												**D2.2**																							**D2.3**	
WP3	**Operating Systems, Firmware, Drivers and Security (VOS)**																																										
T3.1	Operating System & Virtualization Support																																										
T3.2	Firmware and Drivers																																										
T3.3	Software/Hardware Security Extensions																																										
	Deliverables																		**D3.1**																							**D3.2**		
WP4	**Programming Languages, Runtimes and Libraries (UNIMAN)**																																										
T4.1	Hardware Acceleration of Managed Programming Languages																																										
T4.2	Hardware Acceleration of Native Programming Languages																																										
T4.3	Optimizations of Cloud-based Enterprise Microservices																																										
	Deliverables																		**D4.1**																							**D4.2**		
WP5	**EU Cloud Services (UBT)**																																										
T5.1	Cloud Containerization & Orchestration																																										
T5.2	Acceleration-aware Cloud Scheduling and Deployment Frameworks																																										
T5.3	Optimization of Emerging Serverless Frameworks																																										
	Deliverables																		**D5.1**																							**D5.2**		
WP6	**System Definition, Integration, and Evaluation (SIP)**																																										
T6.1	Software/Hardware Architecture Definition & Technical Specifications																																										
T6.2	Continuous System Integration & Validation																																										
T6.3	Component and System Evaluation																																										
	Deliverables						**D6.1**												**D6.2**																								**D6.3**
WP7	**Dissemination, Communication & Exploitation (CPLAY)**																																										
T7.1	Dissemination and Communication Activities																																										
T7.2	Impact Enhancement, Commercial Roadmap & Exploitation Activities																																										
T7.3	Alignment of AERO Project with EU Processor Ecosystem and Projects																																										
T7.4	Standardization Activities																																										
T7.5	IPR Handling & Data Management																																										
	Deliverables						**D7.1**												**D7.2** **D7.4**																								**D7.3** **D7.5**
	AERO Milestones			**MS1** **MS2**			**MS3**												**MS4**																							**MS5**		**MS6**

Figure 3: Extended AERO Gantt chart as adapted in M24

- **WP7** and all its tasks are extended from M36 to M42. **D7.3** and **D7.5** that report on dissemination, communication and exploitation actions will be delivered at the end of the project, i.e., in M42.
- **MS5** that is verified by the delivery of D3.2, D4.2 and D5.2 will be achieved in M40.
- **MS6** (Demonstration) and **MS7** (Consolidation) will be merged into a single milestone that will be achieved in M42 and will be verified by the delivery of D2.3, D6.3, D7.3 and D7.5.

Furthermore, in order to be able to meet the project's objectives within the proposed timeline even in the event of further delays in the delivery of Rhea, the following mitigation actions have been decided:

- SIPEARL has already started performing many more pre-silicon activities to speed up and reduce the risk of bring-up. More specifically, SIPEARL is using an emulation platform to prepare the full bring up of the platform and low-level firmware bring up is done on the platform coupled with an FPGA board to make sure first level boot is fully functional before Rhea is back for bring-up. This low-level firmware bring-up is expected to be completed by Q2 2025, enabling the assessment of the readiness of the firmware components by M30.
- SIPEARL will investigate and propose a methodology to extrapolate the performance of the AERO pilots and software components on the Rhea processor, based on their actual performance on comparable systems like AWS Graviton 3 and NVIDIA Grace Superchip. This methodology is expected to become available in Q2 2025. SIPEARL will support the AERO partners towards extracting the appropriate performance estimations, which will enable them to adapt their optimization activities accordingly. Thus, once Rhea becomes available, the AERO partners will be able to focus on the validation of the extrapolated performance, instead of performing at this point a full investigation and characterization of the pilot or the software component.
- VOSYS activities (in the context of task T3.1) will be performed on SIPEARL's Virtual Prototype solution or a hybrid solution (mix between Virtual Platform and emulation) currently developed by SIPEARL, which is becoming fast enough to perform such tests.
- As the ecosystem is constantly evolving, the AERO consortium will keep monitoring for any other solutions that may appear as competitive platforms to the SIPEARL Rhea processor based on ARM Neoverse V1. To the best of our knowledge, at the time of writing this report, no other platform, besides the ones that we are already using, exists that can substitute the AERO deployment platform.

Finally, it should be noted that all partners had already confirmed during the RP1 project review in M21 their ability to financially support an extension of the project's duration by 4 months. As of January 2025 (M25), the majority of the partners have also confirmed their ability to support the currently proposed 6-months extension, as well. However, three partners (VOSYS, UNIGE, SED) are still assessing the financial sustainability of the proposed extension. If these partners are eventually unable to support the last two months of the extension, risk AIER2 "*The AERO consortium loses a partner*" will materialize. In that case, as defined in Table 1, the remaining partners of the AERO consortium will take over the outstanding work.

2.2 Update of Identified and Analyzed Risks until M24

This section provides an updated overview of all risks registered in the AERO risk management tool up to M24. Table 1 presents the risks associated with the administrative, impact, and ethical activities of AERO, while Table 2 lists the risks related to each technical WP of AERO.

As presented in both tables, there are no new entries since the previous deliverable D1.2. The status of all risks remains open, but the timeframe of the registered entries has been adapted to the new plan presented in Section 2.1.1. In addition, risks TR9 and TR10 have been updated in response to the delays in the delivery of the Rhea platform.

Table 1. 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-M42	M2, M11, M24	
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-M42	M1, M11, M24	
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-M42	M3, M11, M24	
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-M42	M3, M11, M24	
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-M42	M3, M11, M24	
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-M42	M6, M11, M24	

Table 2. 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-M40	M1, M10, M11, M24	
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-M40	M1, M10, M11, M24	
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-M41	M1, M10, M11, M24	

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-M41	M1, M10, M11, M24
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-M40	M1, M10, M11, M24
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-M40	M1, M10, M11, M24
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-M40	M1, M10, M11, M24
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-M42	M1, M11, M24

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). Additionally, SIPEARL will devise an extrapolation model that will enable AERO partners to deduce the envisioned performance of the Rhea processor based on the actual performance when executing on an alternative platform, such as Grace Superchip (Supermicro) or GraceHopper (Supermicro).	SIPEARL	Miti-gated	M1-M42	M1, M9, M18, M24	M1, M9, M18, M24
TR10	WP3 WP4 WP5	Further delays in delivering Rhea, not allowing enough time for the required development and upbringing of the AERO software.	Likely	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-M40	M9, M11, M24	