

UMD Operations Readiness Review

The UMD ORR took place in Malargue during the Pierre Auger Collaboration Meeting on 24 March 2026 for about 2 hours. The ORR is planned to finish by the Malargue meeting in November 2026.

The committee was formed by (in alphabetical order of family name) by:

- Jaime Alvarez-Muñiz (chair)
- David Nitz
- Lorenzo Perrone
- Eva Santos
- Laura Valore

The committee has conducted its assessment as charged, and provides below its comments and suggestions to the best of its knowledge and understanding. The comments below address the items and questions listed and, where appropriate, incorporate input received from other collaborators.

We thank the UMD group for providing such a comprehensive body of information in a clear, well-organized, and well-presented manner. The slides, on which this report is mainly based, are available in this [link](#)

Detailed frame of the UMD Operations Readiness Review:

- *UMD electronics boards, hardware and on-board software and firmware;*
- *UMD electrical interfaces and interconnection with SD;*
- *UMD communications interfaces;*
- *Detector mechanics;*
- *UMD Power supply;*

Equipment availability and readiness

- *Are components and software fully commissioned, operating reliably, and meeting performance requirements?*

The UMD electronics, firmware, software, monitoring, and data-production systems are operating routinely on the large deployed array, with demonstrated long-term stability and physics performance consistent with design requirements. Several refereed publications report on these topics. As of May 27, 2026 the deployment of the 3 segmented modules composed of 64 plastic scintillator bars is finished at 72 positions (as reported at the Auger general meeting in May 2026). There are 17 positions still not fully commissioned, awaiting power system, surface electronics and/or underground electronics (*eKit*).

- *Are all the hardware, power and software interfaces fully functional, compatible and operational?*

The hardware interfaces between the UMD electronics, UUB, communications network, power system, CDAS, and data-production chain appear to be functioning and compatible. No unresolved compatibility issues affecting operations were identified.

However, emphasis should be placed on mitigating RF noise of the Mikrokit radio. An analysis of what battery size is optimal and most cost-effective should be made.

- Are special tools and testing equipment required for routine maintenance present and available to the Observatory staff?

There is evidence that the tools and equipment required for routine maintenance exist and are being used by the Observatory staff, as demonstrated by the successful deployment and maintenance history of the array.

- Are the most common failures yet known, understood and have a mitigation plan?

The most common operational failures have been identified after several years of deployment and operation with a smaller array. These include software “livelocks” (process active with no useful progress), and hardware/firmware/local network failures. For each, mitigation actions are defined, including remote reboot and field trips with hardware repair or replacement when required. The committee wondered whether the current list of failures is complete or whether potential but yet unobserved failure modes can still be identified. Predictable aging effects of the binary and charge integration operation modes are known and can be included as systematic uncertainties in physics analyses. An improved detailing and logging of the nature of the battery issues would be beneficial.

- Has a reliable source for all spare parts, tools, and consumables been identified for future procurements? Are spares available on site as required?

There are spare inventories for the buried electronics (*eKits*), surface electronics (UUB and Distributor boards) and telecommunications (radios and antennas). The most critical issue is that the current number of *eKits* in stock is 18, not enough to instrument the whole array with 17 positions without the 3 *eKits* needed. The short-term strategy of the UMD group is to instrument all positions with at least 1 *eKit*. The longer-term strategy is to use the 40 *eKits* that are currently being produced and expected for mid-2027 with a number of spares of 7 units. A critical issue has been identified for the discontinued production of the CITIROC chip. A last batch of 60 units is in stock and is being negotiated. A future electronics redesign is foreseen to mitigate this risk. On the other hand the failure rate of *eKits* is very low. The number of spares for surface electronics are considered adequate for routine operations and near-term maintenance needs. The other critical issue is the number of spare radios considered insufficient. Replacement options are being evaluated.

- Is there a long-term plan for component repairs or replacement?

The committee recommends establishing a long-term procurement and replacement strategy for critical components, particularly the CITIROC chip and telecommunications equipment, and ensuring that adequate spare inventories are maintained to support full-array operation and long-term maintenance requirements.

Data Management

- Is UMD data well integrated into the data stream?

UMD data is fully integrated into the standard Auger data stream. There exists an automated data production chain, and data is merged with the Observatory data

(xad_*.root files) at CNAF. Current and projected data volumes are well within the capabilities of the existing infrastructure, and no bandwidth or integration issues have been identified. The committee wonders where the calibration data is stored.

- Is the UMD data consistent and reliable?

The UMD data is stable, growing with the number of deployed modules, with a stable rate of 700 kB per day and module. The detector response is stable over time. The two UMD arrays (433 m and 750 m) give compatible results, and the data have already been successfully used in physics analyses (measurements of muon size) and searches for photons with the UMD-433 that led to refereed journal publications.

- Is the communication interface with UUB stable?

The communication interface between the UMD eKit and the UUB includes: the triggering (UMD works on slave mode with T1 trigger timestamps received from the UUB), serial (control and power management), and Ethernet (T3 broadcast, data transfer, monitoring information) links. These have been verified to be stable based on T3 rate matching.

- Can CDAS handle the volume of data produced by UMD?

The UMD data volume is modest compared with the standard Auger data stream, currently about 120 MB/day and expected to reach only about 200 MB/day for the fully deployed array. No issues with bandwidth or storage limitations are anticipated.

- Is the monitoring of UMD in place and well understood?

UMD monitoring is fully integrated into the regular Observatory operations. UMD shift tools are part of the SD shift tools for data quality checks, generation of reports and slow-control monitoring. Field reports have been integrated into the Observatory “elogs” since 2023 and tools for easy visualization exist.

Technical Documentation

- Are drawings, schematics, and any other relevant documents complete and posted to CERN EDMS and/or PMS?

Documentation repositories exist, including mechanical designs, electronics schematics, firmware, software, maintenance field reports, and monitoring/shift documentation. The documentation is still being gathered at a repository at the ITEDA GitLab. Migration to CERN EDMS/PMS is planned upon completion. The migration from GitLab to EDMS seems to be complicated so having only links on EDMS pointing to GitLab could be acceptable but only if the sustainability of the Ahuekna GitLab can be guaranteed.

- Are instructions for operating and maintaining software code, as well as the code itself, available and organized?

The software and firmware architecture is well defined and organized into FPGA firmware, a Linux-based boot layer, and AMIGA-specific acquisition software. The software is available in repositories. It supports remote upgrades and configuration to reduce maintenance burden and on-site interventions. All software used is freeware except for ALTIUM. A plan for renewing licenses is needed. The committee wonders whether firmware updates can be carried out by the observatory staff and whether the

necessary tools, documentation, and procedures are in place to support this task. Are the production files for printed circuit boards, mechanical drawings, and related documentation available in formats that do not require proprietary software licenses, thereby facilitating future modifications or maintenance activities?

- Is a complete list of equipment and components including part numbers and vendor contact information available?

Partially. The information on specific components, part numbers, and vendors for the electronics, power, and telecommunications systems, exists. However, completion and accessibility of a comprehensive inventory does not appear to be currently available.

Maintenance procedures.

The following procedures must be complete:

- General operation.*
- Hardware and software troubleshooting and maintenance.*
- Process for handling major repairs.*
- Inclusion of safety considerations in all procedures.*

Procedures for operation, monitoring, maintenance, and field interventions are documented and have been exercised and refined during several years of detector deployment and operation. Documentation repositories, maintenance workflows, field-reporting mechanisms, and training plans are in place; however, safety procedures need to be completed. Much of the documentation is in Spanish and is being translated into English and migrated to repositories.

Training.

- Has an appropriate number of observatory personnel been trained to operate and provide routine maintenance?

There is a knowledge-transfer and training plan for Observatory personnel. The experienced AMIGA team members will transition into Observatory operations to ensure continuity of expertise and training of incoming technicians. The estimated personnel requirements of 2 technicians appear reasonable. However, it remains to be clarified how the required effort will be covered, including whether the necessary personnel can be drawn from the existing Operations team. This required vs available person-power should be assessed in more detail during the November review.

Operations costs.

- Evaluate the annual resources (person-power & costs) required for routine operation and maintenance for each subsystem, including materials and equipment. Discuss anticipated rates of failures and frequency of repairs and replacements.

Estimates of the maintenance effort required is given including approximately 134 maintenance visits over three years (approx. 34 field days/year) with two technicians needed for routine operations. Failure modes are identified and ranked by frequency, with corresponding mitigation procedures, and spare inventories are documented for the major subsystems. A final estimate of annual operating costs by subsystem (electronics, power, telecommunications, etc.), and of replacement rates, spare consumption, and long-term procurement costs would be needed.