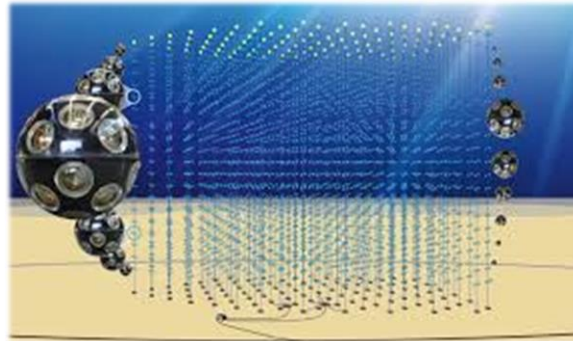


# KM3NeT



## Acoustic Positioning System Product Readiness Review

### Review Summary

V. 1 – 9 December 2019

	Name	Signature
<b>Reviewed by panel members:</b>	Frits van der Knaap	
	Alessandra Tesei	
	Jaime Ramis Soriano	
	Domenico Di Mauro	
	Silvano Buogo	

## 1. Scope

This document summarizes the results of a Product Readiness Review (PRR) done by external panel members on the KM3NeT Acoustic Positioning System. A meeting for this was held at INFN LNS in Catania, Italy, on 13<sup>th</sup> – 14<sup>th</sup> November 2019, after which a Review Item Discrepancy (RID) file containing details of all review findings was produced.

Full names, affiliations, and e-mail addresses of panel members are listed below.

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## 2. Documents presented for the Acoustic Positioning Review

Note: document numbers were not present in the original list of documents and have been added in the RID Excel file to facilitate sorting and filtering.

Doc No.	Doc Id	Rev.	Title	Short description	Remark
1	KM3NeT-PRR_2019_006	1	Documentation for the KM3NeT positioning system review	List of documents included in the data package	Source of this table
2	KM3NeT_DET_2019_001	1	General design and interface requirements (GDIR)	Overall instrument requirements	
3	KM3NeT_CALIB_2019_002	2	Scientific and technical requirements specification (STRS) for the positioning calibration system	Scientific and technical requirements	
4	KM3NeT_CALIB_2016_010	8.7	Positioning system for the KM3NeT Telescope	Technical Design Report (TDR)	Main technical document
5	KM3NeT_CALIB_2019_003	1	Positioning Conformity Matrix	Conformity Matrix	Document in Excel format
6	KM3NeT_DET_2014_003	3	KM3NeT Risk Management Report	Risk management plan	
7	KM3NeT_RiskRegister_2019_0729_filtered	-	KM3NeT Risk Register	Filtered Risk register	Document in Excel format
8	KM3NeT_PRR_2019_003	-	RID template	Template for RID report, supporting document for external reviewers	Document in Excel format
9	APS_Nantes_final	-	Acoustic Position System: first results	APS compliancy close out reference	Presentation

Doc No.	Doc Id	Rev.	Title	Short description	Remark
10	KM3NeT_PRR_2019_006	5	Study of the EM susceptibility of the piezo hydrophone in the Digital Optical Module (DOM)	Technical Note	
11	KM3NeT_QUAL_2018_003	3	KM3NeT Hydrophone Qualification procedure	Technical Note	

### 3. Review summary

1. Firstly, panel members wish to express their gratitude and appreciation to KM3NeT Collaboration for hosting an open and transparent review meeting. Moreover, the impressive effort dedicated by the Collaboration in designing and implementing this ambitious system, as well as all the difficulties to implement, deploy and maintain it at more than 3000 m depth are well recognized.
2. The complete list of Review Panel comments on the PRR datapack are collected in the RID Excel file attached to this document.
3. At the end of the meeting there has been only limited time for exposing and discuss the referee's concluding remarks: it is suggested to allocate more time in future meetings of this kind.
4. The scope of this review is set to focus on measurement principle and not on the acoustic measurement system design and its implementation. However, choices made earlier on the design are affecting the acoustic measurements and position estimate accuracy.
5. The primary function of the positioning system, which is to track position of Digital Optical Modules (DOMs) with the required accuracy, should be followed more strictly, rather than extending its scope so that more options for its use can be obtained.
6. The accuracy of magnetometers used in the system is based on calibration at component level. It is believed that compass calibration needs to be performed after integration into the DOM, i.e., into the full system.
7. The required accuracy on DOM position can be improved if highly accurate pressure sensor(s) and a correct sound speed profile are employed in a 3D model. In general, the assumption made in the algorithm for position calculation of a constant sound speed value is not considered to be valid. Obtaining sound speed from CTD data along with using sound velocimeters is encouraged, since water temperature and conductance (salinity) are not believed to have great impact on accuracy as their variations and measurement uncertainties are expected to be small.
8. As a calibration base hosts one transmitting device and one receiving device with fixed and well known relative distance, a method for measuring sound speed independently could be realized using these two devices, therefore reducing the overall measurement uncertainty. Furthermore, to cancel out the influence of sea current on travel time, it is suggested to design and deploy a sound speed measuring system based on a two-way travel between a transducer and a good reflector kept at a fixed, known

distance. The effort in adding this component is believed to be justified, as knowing sound speed with very high accuracy is believed to be a key element for the positioning system.

9. The actual movements of DOMs while they are on site should be compared to ground-truth data along a significant amount of time. This is to support the assumptions made in analyzing several data sets under different conditions (see also remark 15).
10. It is suggested to conduct a quantitative time correlation of observed variables using two independent measurement methods, in order to obtain more reliable confirmation of assumptions, for example on DOM tilt angle.
11. One minor aspect, albeit relevant once technical documentation is disseminated to various stakeholders, to a wider scientific community and to the public, regards terminology which should be made more consistent with standard practice especially in the main TDR document.
12. A clear split of ARCA (Capo Passero) and ORCA (Toulon) performance description would ease comprehension by the management of their specific features, enabling proper decisions to be taken.
13. The reason for the requirement on the absolute position of underwater assets (e.g. DU bases) during the deployment phase is not well understood. It is suggested to state it with a clearer reference to its impact on future system performance, or to relax it.
14. From the presented measured data, it seems that sensors in the network are not showing a stable behavior in their early lifetime: failures occurred so far should be carefully investigated considering the planned system redundancy, to ensure system performance would be within its specifications throughout its 20 years' lifetime.
15. A pre-processing analysis of data is recommended to conduct continuous data quality check, and for a better interpretation of processed data. Examples of this analysis are cross-correlation of received acoustic signals between DOMs.
16. A complete overall model of the detector positioning system seems not to be in place yet, while it is believed to be of great benefit for a more robust performance as it would better exploit the relations between system characteristics (electrical, acoustical, mechanical, etc.).
17. It is suggested to include (or refer to, in the TDR) a model of the positioning system that, in order to theoretically meet the requirements given by optics-based neutrino detection and tracking objectives, may set a number of parameters such as: minimum number of acoustic sources and receivers; range interval between each transmit/receive pair; bandwidth to be able to send sufficient number of waveforms to label all sources; and so on. This will give a good indication on the required values of the acoustic quantities (SL, SE, TL, Rx sensitivities, etc.), so that, based on the existing design specifications, one may evaluate the discrepancies to be expected.

## **Annex**

RID file: KM3NeT\_PRR\_2019\_003\_RID\_Template\_Positioning\_v2.xlsx