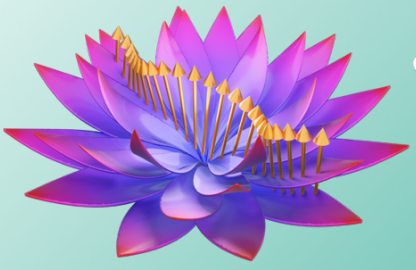

NIMFEIA

Deliverable D1.14

Risk Assessment reevaluation

Project Number	101070290
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1. Introduction

After NIMFEIA's first review on June 19th, 2024, the reviewers recommended to reevaluate the list of critical risks in light of the current progress of the project. Following several discussions regarding risk assessment among the work package leaders, several new risks emerged. Below, we will first briefly discuss the list of risks as initially defined in the Grant Agreement and then state the risks that have become eminent towards the second half of the project's run time.

2. Evaluation of risks formulated in the Grant Agreement

Here, we briefly discuss the list of risks as initially defined in the Grant Agreement. Risks that were not encountered are printed in green, risks that are still prevailing are printed in purple.

1. *One or more partners do not provide information in time for the launch of the NIMFEIA website.*
   → Website will go online anyway and will be complemented asap. The project coordinator will ensure an intense communication. Best practice examples and templates will be provided.
   This risk was not encountered. The content for the NIMFEIA website was provided in time, yet the acquisition of the web domain as well as the set up of the necessary infrastructure took longer than expected.
2. *No consensus can be reached regarding a data policy and a delay of the DMP occurs.*
   → A DMP with a limited number of partners has to be realized.
   This risk was not encountered. The data management plan was delivered in time with all partners agreeing to its content.
3. *New antenna design of coplanar waveguides does not provide sufficient excitation field to reach nonlinear regime.*
   → Known Ω-shaped antenna design will be used.
   This risk was not encountered. The new antenna design exploiting continuous coplanar waveguides not only provided sufficient excitation fields to reach the nonlinear regime but also opened the path towards a novel type of excitation by harnessing the in-plane component of the microwave driving field. Thereby, we were able to unravel Floquet magnons, a novel kind of magnon eigenmodes living on the background of a periodically changing equilibrium state.
4. *Metallic materials suffer from too high damping so that nonlinear thresholds cannot be reached.*
   → Use insulating materials such as TmIG, with significantly lower damping.
   This risk was not encountered. The damping in metallic materials such as NiFe and CoFe, which are compatible with standard CMOS processes, is low enough to easily reach the nonlinear regime. Nonetheless, for future optimization, the exploration of novel magnetic materials with lower damping provides a promising road towards further energy optimization.
5. *Electrical read-out using MTJs does not provide high enough signal strengths.*
   → Use inductive coupling or inverse spin-Hall effect to detect magnetization dynamics.
   First results indicate that this risk will not be encountered. The partners GF and HZDR were able to integrate a magnon-scattering reservoir in form of a disk on top of a standard MRAM cell which allowed for the detection of magnons with unprecedented spectral resolution.
6. *Double layer vortex structures do not provide key requirements of a reservoir.*
   → Use other kind of spin structures instead.

The in-depth study of double layer vortex structures has yet to be provided. Hence, this risk still remains.

7. *Real-world use cases are not classified by the magnon reservoir.*
   → Optimize handling of input data streams.
   This risk was not encountered, but also probably formulated too vague. During the initial phase of the project, we realized that our magnon-scattering and skyrmion reservoirs cannot provide universal solutions for all real-world use cases. While NARMA and gesture recognition can be accomplished by the skyrmion reservoir, the magnon-scattering reservoir excels at chaotic time-prediction tasks like the Mackey-Glass time series. However, the demonstration of indoor person recognition with micro-Doppler data turned out to be a task not suitable to be solved with our proposed reservoirs. Therefore, the process of finding suitable tasks for the different reservoirs is still ongoing and will continue until the end of the project.
8. *Local pinning due to granularities strongly influences vortex dynamics, reducing power efficiency and device to device yield*
   → Modifying material stack to reduce pinning defects (i.e. new materials, reduction of roughness through buffer layers)
   This risk still prevails.
9. *Etching process for multiple contacted MTJ produces low performance devices*
   → Novel nanofabrication techniques can be utilised including creating local nanocontacts through an insulating barrier
   This risk still prevails.

10. Formulation of new risks

1. Detection of electrical microwave signal after passing the multiplexer stages for addressing the individual MRAM cells in the array is more difficult than anticipated
   → Optimize the relevant output range of our magnon-scattering reservoir towards lower frequencies.
2. Long term failure of major equipment like electron-beam lithography or a deposition tool.
   → Shift corresponding tasks to a partner in the consortium with similar equipment.
3. High frequency resonances in antiferromagnets feature qualitatively different nonlinear scattering not well suited for down conversion.
   → Focus on ferrimagnetic systems hosting both high frequency exchange modes and more conventional low frequency ferromagnetic resonances.