**Area IIIa – Supporting Technologies, Advanced Modeling**

The Advanced Modeling section of the magnet development program aims to leverage state-of-the-art computational tools and methodologies to enhance the design, understanding, and performance of superconducting magnets. The working group will focus on three primary areas: development of design tools, fundamental understanding, and performance limitation studies. Each area contains main efforts aligned with the needs and challenges of the other working groups. The overall workflow of the area is shown in Fig. x.

**Development of Design Tools**

The primary objective in this area is to create and refine computational tools that facilitate the design process of superconducting magnets. While the actual design tasks remain within other area groups, focus of the advanced modeling area will be on developing and optimizing the tools that these groups use, giving them access to the latest advancements in modeling techniques. The integrated approach will allow to synergize the development efforts between different areas: for example, tools developed for Nb3Sn could potentially be adapted for use with Bi2212 and REBCO.

**Fundamental Understanding**

This area is dedicated to deepening our knowledge of the underlying physical phenomena that governs the behavior of superconducting magnets. By conducting advanced simulations and comparing them with existing or dedicated measurements, we aim to uncover the fundamental principles that dictate performance at the wire, cable or magnet level. The modeling working group will also weigh in the definition of experiments performed in other areas, in order to maximize the knowledge extracted from these. Tasks in this category include developing reliable cable electromagnetic models for REBCO, investigating quench dynamics and propagation in high-temperature superconductors (HTS), and creating current sharing models. These efforts will provide valuable insights that can inform both the design and optimization of future magnet systems.

**Performance Limitation Studies**

The third focus area involves using advanced modeling tools to analyze and interpret test data, with the goal of understanding the eventual limitations encountered during magnet testing. By identifying and addressing the factors that limit performance, we can develop strategies to mitigate these issues and enhance the overall efficiency and reliability of superconducting magnets.

Fig. x – Workflow



**Main Tasks:**

An overview of the efforts associated to each area is provided below. A more detailed milestone list is provided in Table I.

*Development of design tools:*

1. Developing a powerful, user-friendly workflow for magnet design (using and integrating existing tools, and developing new ones where needed)
2. Develop new tools for magnet design, e.g. quench protection tool for 20 T, 20 K REBCO magnets

*Fundamental understanding:*

1. Mechanical stiffness and strength of LTS and HTS cables
2. Reliable electromagnetic modeling of REBCO cables, that accurately capture their performance characteristics from individual tape measurements
3. Dynamic modeling of quench propagation in high-temperature superconductors
4. Current transfer and current sharing models

*Performance limitation studies:*

1. Develop advanced models to investigate training and quench performance of as-tested superconducting magnets
2. Test mitigation strategies devised to remove performance limitations

Table x – Milestone Plan for the Advanced Modeling Group