Major opportunities in the Research Field Key Technologies in Europe

Position paper by the Helmholtz Association

a) Introduction

The Helmholtz research field Key Technologies is positioned at the interface of various disciplines and covers a range of technology readiness levels and value chains, providing the basis for innovative solutions for science, economy and society. They are essential for a wide range of disciplines, sectors and global challenges by linking technology and medicine, chemistry, biology and physics, simulation and big data, supercomputing and brain research, and materials from inorganic to organic and biological systems. Therefore, in FP9, they have to be recognized not only as 'supportive' or providing disciplines but as substantive, discrete research fields with funding possibilities for collaborative research **along the path from fundamental research towards application**. We would like to emphasize that it is inevitable to allocate a major role to research organizations in the development and scientific exploration of Key Technologies and not to rely predominantly on industry led research in the fields of **Supercomputing & Big Data, IT-Security and Information Processing Technologies** as well as **Materials Sciences**. In FP9, **fundamental collaborative research** addressing **low Technology Readiness Levels** is pivotal to ensure long-term impact and innovative concepts for sustainable future solutions. Adequate funding of and close collaboration between **research infrastructures for technological challenges** are also key for Europe to maintain a leading position in these fields.

b) Future Directions

In FP9, the priorities in the research agenda setting and the funding landscape in the field of Key Technologies should lie on the following research areas, which are at the heart of technological advancement in Europe, lay the foundation for tackling grand challenges of the presence and the future and for expanding Europe's competitive capacity:

Big Data Analytics, High Performance Computing and IT Security

In the digital era, increasingly complex demands have arisen for research, economy and society by means of (Big) Data Analytics, High Performance Computing (HPC) and IT Security. The extraction of knowledge and smart data from large, heterogeneous data sets requires **advanced methods and tools** (e.g. scientific deep Learning and generic data curation tools) and **Leading-edge hardware designs for highly efficient data analysis and simulation** (highly scalable supercomputers and modular HPC systems). The huge amount of data and large-scale computing infrastructures are subjects to unprecedented risks regarding user privacy and security issues. **Theoretical and empirical research addressing trustworthy systems and IT security** is of highest relevance in the context of supercomputers, big data systems and computing infrastructures as well as for computational and data intensive sciences at large.

Information Processing

New information processing concepts and technologies have to be explored in order to overcome the limits of current technologies in terms of capacity, speed, energy consumption and security. Developing new principles for the next generation of computing systems requires a comprehensive understanding of the fundamental rules of information processing connecting both inanimate matter and biological systems. This comprises the research for **new paradigms in physical systems, Quantum Materials**, **Quantum Computing** and **Neuromorphic Computing** as well as the integration of **information processing on molecular and cellular Level** and **decoding brain function and plasticity** in a holistic approach of information processing.

Material Systems Engineering

Materials research is fundamental to technological progress and sustainable development. The strong global competition in this area as well the growing demands for more efficient, smarter, and environmentally friendly materials at lower costs call for interdisciplinary efforts in material sciences. This comprises the integration of **systems of inorganic and organic/biological origin**, **3D manufacturing of functional devices,** making use of **computational/virtual design and simulation** in material sciences, enhancing application-driven basic research in the fields of **optics and photonics** as well as developing **scale-bridging designed materials systems**.

An imperative prerequisite for unlocking the full potential of these areas is the integration and coordination of **efforts and initiatives on national and European levels**.

The transfer of technological achievements to application in everyday life demands profound assessment of the **ethical, social, political implications**, limitations and uncertainties (e.g accompanying the discussion on automated and autonomous driving). **Social innovation, value chains, societal acceptance** as well as **sustainability and possible risks of key technologies** are very important to be incorporated in this context.

In addition to the thematic areas, **Research Data Management** and **Open Science and Open Data** are essential overarching topics for the field key technologies.

We highly welcome the implementation of the **Quantum Flagship initiative** and fully support the initiation of **future FET Flagships**, which we consider major instruments to strengthen Europe's role in research and innovation substantially.

c) Missions for FP9

In accordance with the thematic priorities, the Helmholtz Research Field Key Technologies has identified three proposals for missions in FP9. We are convinced that these missions have the potential to bring important benefits to society with regard to the digital transformation of our society and economy, including novel and sustainable technologies in simulation and data analytics, powerful and energy efficient computing systems as well as smart and sustainable materials. The missions have been sent to the European Commission in 11/2017.

- ***Use our data for our purposes***
- ***Decode the essence of information processing***
- ***Materials for sustainable markets, growth and citizens' wellbeing***

(For further details please see our mission paper, updated March 2018.)

Activities in the Research Field Key Technologies are pursued at three Helmholtz Centres: *the Forschungszentrum Jülich (FZJ), the Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG), and the Karlsruhe Institute of Technology (KIT).*

Brief portrait of the Helmholtz Association

The Helmholtz Association contributes to solving major challenges facing society, science and the economy with top scientific achievements in six research fields: Energy; Earth and Environment; Health; Key Technologies; Matter; and Aeronautics, Space and Transport. With some 39,000 employees in 18 research centres and an annual budget of more than €4,5 billion, the Helmholtz Association is Germany's largest scientific organisation. Its work follows in the tradition of the great natural scientist Hermann von Helmholtz (1821-1894).

Please direct further questions and comments to

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