16 Participants and Support

HiPER is an international project that benefits from the involvement, either formally or informally, of partners drawn from Europe, Asia and North America.

16.1 Formal Participants of the HiPER project

Figure 16.1 Map of Europe indicating the countries where institutions have signed up as formal participants of the HiPER project. Note that USA is involved through the formal participation of General Atomics (GA)

Of the formal participants approximately half are engaged at the funding agency or ministerial level and almost all of the partners are providing significant levels of co-funding to advance the HiPER mission. The HiPER partnership strikes a healthy balance between the political engagement necessary to move key decisions forwards and academic engagement to principally address risk issues. Other European and International partners are involved due to their specific expertise in key areas. Great care has been taken during the 2-year design phase to select a balanced team capable of taking on the challenge of the preparatory phase project. Details of the formal participants are presented below

European Commission - The European Commission is formally the contracting body for the HiPER Preparatory Phase Project. However, the preparatory phase process is very much one of building partnerships and thus the existing relationship between the HiPER consortium and the EC is much more one of parity and proactive engagement, rather than a traditional one of customer-supplier. In the preparation of the HiPER proposal this positive and active engagement from the

Directorate General for Research Infrastructures, as a partner, has been very welcome and we fully expect this to continue during the preparatory phase. The EC brings considerable political and strategic advice which the HiPER mission will benefit greatly from. It also provides the basis for engagement with other European agencies, for example, the European Investment Bank (EIB) which will be vital for the financial engineering aspects of HiPER

United Kingdom – the project benefits from the formal involvement of the Science and Technology Facilities Council (STFC). This funding agency has the main responsibility within the UK for all strategic investments in major scientific infrastructures. It operates and develops a wide range of large scale infrastructures that include the world renowned Rutherford Appleton Laboratory (RAL), which includes the UK's High Power Laser programme, the Central Laser Facility (CLF). Access to the CLF as part of the HiPER mission has been formally agreed by STFC. UK academia is also heavily involved in the HiPER project and this is also represented by the STFC involvement. The STFC has formally endorsed the project and has agreed to take the lead and co-ordinating role in the HiPER preparatory phase project. This level of engagement in the HiPER mission enables the STFC to credibly provide the strategic leadership that will be needed to advance the HiPER mission.

France – the engagement of France in the HiPER project is very substantial. Both of the major national funding agencies in France – the Commissariat à l'Énergie Atomique (CEA) and the Centre National de la Recherche Scientifique (CNRS) are formal participants of the project and are fully engaged at the highest levels of their respective organisations. Support for the HiPER mission in France has been formally secured at ministerial level. This level of political engagement of France in the HiPER mission has and will continue to be absolutely vital to its success.

The CEA has developed near Bordeaux (CEA-CESTA) over the last decade or so the Ligne d'Intégration Laser (LIL) and the multi-billion Euro Laser MégaJoule (LMJ) systems that are central pillars of its national strategy to advance the Inertial Confinement Fusion concept. It therefore brings to the HiPER project unrivalled expertise within Europe. The HiPER strategy relies very heavily on leveraging this expertise and the huge defence programme investment it represents into the civilian arena for the pursuit of fusion energy through the HiPER mission. The CEA's technical and political involvement is substantial and they are formally prepared to make available to HiPER people, information, technology, costs etc that will be crucial to developing HiPER. The CEA also provides an important portal to French industry that has developed most of the technology for LMJ.

Moreover, the local regional funding agency, the Conseil Régional d'Aquitaine (CRA) in conjunction with the French government, has recently invested more than 40 M€ in the PETAL enhancement to the LIL system to explore the fast ignition approach to Fusion Energy. CRA as a funding agency is also a formal partner in the HiPER project. Access to the PETAL system will be a key element of reducing risk within the HiPER project and crucially, in recognising the importance of the PETAL system to the HiPER mission, the CEA and CRA have agreed to the reconfiguration of PETAL system as per the needs of the HiPER project. An international panel of experts has thus recently been appointed to advise on the exact nature of this.

Furthermore, the CNRS and CEA support the operation and development of the Laboratoire pour l'Utilisation des Lasers Intenses (LULI) in Paris where some of the most advanced facilities in the world for experimental laser-plasma physics exist. Access to these facilities and the expertise contained therein will also be crucial for risk reduction in the HiPER mission. This access has now been formally agreed. Finally, both agencies support the Centre Lasers Intenses et Applications at the University of Bordeaux-I (CELIA) which hosts one of the worlds leading theoretical and computational plasma physics teams. This team has been placed at the disposal of the HiPER mission and will be important in developing target point designs for HiPER.

It has been agreed between these three agencies (CEA, CNRS, RA) that all HiPER related activity will be co-ordinated and managed by the Institut Lasers et Plasmas (ILP) in Bordeaux. ILP is the

coordinating Institute in France for research in lasers and plasmas. It officially represents the associated laboratories working on these subjects from CNRS, CEA, University Bordeaux1 and Ecole Polytechnique.

Italy – The HiPER preparatory phase project benefits from the formal support of the Italian Science Ministry, the Ministero dell' Università e della Ricerca (MUR). This enables two of the primary national scientific funding agencies of Italy, the Consiglio Nazionale delle Ricerche (CNR) and the Ente per le Nuove Tecnologie, l'Energia e l'Ambiente (ENEA) to be formal participants of the HiPER project. In particular, CNR supports the Intense Laser Irradiation Laboratory (ILIL-CNR) which is focused on fundamental aspects of high-intensity laser interactions with matter. Studies of direct relevance to inertial fusion are also performed at ILIL within a Ministry of University project (MIUR-FIRB-BLISS), coordinated by ILIL. ENEA hosts a laser laboratory which has pioneered the field since the mid 60's. Finally, the project benefits from the formal participation of the Universities of Rome "La Sapienza", Milan-Bicocca and Pisa through the Consorzio Interuniversitario per le Scienze Fisiche della Materia (CNISM). It brings considerable academic expertise in theoretical and experimental laser-plasma and inertial fusion physics, including the advanced models and codes used for defining the HiPER parameters. These collaborating university groups are partly funded by national competitive programmes (MIUR-PRIN) on intense laser interaction and also participate in the above quoted FIRB-BLISS project

Spain – Spain's formal participation in the HiPER project at funding agency level has been agreed through the support of the Ministerio de Educacion Y Ciencia (MEC), as well as at regional funding agency level through the formal support of the Direction General for Universities And Research, Comunidad Autonoma de Madrid (CAM). This national and local ministerial level involvement is to be formally delegated to the Universidad Politécnica de Madrid (UPM) which will represent the Spanish interest in HiPER as well as bringing to the project crucial skills and capabilities. This includes some of the most advanced computational modelling of ICF and fast ignition physics at the Grupo de Investigación en Fusión Inercial (GIFI) which has formed the basis of the preliminary specification of HiPER. Furthermore, key target design and fabrication issues, materials studies and understanding the physics of technology for inertial fusion energy which are vital to the HiPER mission are enabled through the expertise at the Instituto de Fusión Nuclear (DENIM). The UPM is also an access portal to one of the world's most powerful supercomputers, MARENOSTRUM in Barcelona as well as MARGARIT supercomputer in Madrid. Access to both systems will be made available to the HiPER project through the UPM

Czech Republic – The Ministry of Education, Youth and Sports (MSMT), as a funding agency, are formal partners to the HiPER preparatory phase project. Execution of the Czech participation will be through the Academy of Sciences of the Czech Republic (CAS). The CAS operates and develops the Prague Asterix Laser System (PALS) and is one of the leading experimental facilities in Europe for laser plasma interactions. Access to this system will be made available for HiPER related work and a formal agreement covering this is now in place.

Greece – The participation of Greece in HiPER has been secured at funding agency level through the formal involvement as partners of the General Secretariat for Research and Technology (GSRT). Furthermore, the HiPER project benefits from the participation of the Technological Educational Institute of Crete (TEI) and the Technical University of Crete (TUC) who bring valuable expertise in experimental plasma physics and diagnostics.

Portugal – The Portuguese Science Ministry, the Fundação para a Ciência e a Tecnologia (FCT) has formally agreed to its involvement at a funding agency level as a partner to the HiPER project. Furthermore, the Instituto Superior Técnico, Universidade Téchnica de Lisboa (IST) will be a formal partner in HiPER thereby securing the involvement of some of the world's foremost computational plasma scientists.

Poland – Poland will participate in the HiPER project through the formal involvement of the Institute of Plasma Physics and Laser Micro-fusion (IPPLM) in Warsaw. The institute has many

years experience in laser plasma interactions and will concentrate on a variant of the fast ignition concept – proton fast ignition. Participation of the Polish Ministry of Science and Higher Education is currently being negotiated. Their future involvement could release additional national funds.

Germany – The involvement of Germany is through the participation of the Gesellschaft für Schwerionenforschung mbH (GSI) and the Technische Universität Darmstadt (TUD). GSI is a large organisation that is home to the PHELIX High Power Laser system. PHELIX is unique internationally in that it is coupled to a heavy ion accelerator and thus will offer major experimental opportunities both in fast ignition physics and other areas of Warm Dense Matter (WDM). This is complemented by the TUD who have significant expertise in WDM and target fabrication

Russia – Two institutes of the Russian Academy of Sciences are formal participants. These are the Institute of Applied Physics (IAP-RAS) in Nizhny Novgorod and the Quantum Radiophysics Division of the P.N. Lebedev Physical Institute (LPI) in Moscow. The involvement of these two partners brings access to the considerable resources of the RAS, and in particular advanced large aperture laser technology (IAP-RAS) and target design and fabrication (LPI)

United States of America – General Atomics Inc. (GA) is the world's leading organisation for the manufacture of ICF targets. Their role in developing and producing the specialist cone targets required for the fast ignition approach to ICF will be absolutely vital to the credibility of the HiPER mission. There is no other organisation worldwide that has the necessary skills or technology to make such targets to the specifications required in the timescale needed. This is reflected in many ways in the close working relationship that exists between GA and the CEA in France. The involvement of GA in the HiPER project brings key advantages as it will both enable HiPER to benefit from the many years of investment this expertise represents and will, through closer working, stimulate the growth of a European capability in this crucial area.

16.2 International Partnerships

The following international partner countries are also involved in the HiPER project through the involvement of the listed institutes

Asia

Figure 16.2 Current Asian nations with institutions involved in HiPER

Korea – The Korean Atomic Energy Research Institute (KAERI) are supporting the HiPER mission and we fully expect a bi-lateral agreement between HiPER and KAERI once the HiPER project is launched. Collaborative access to their facilities and linking to their research programme has already been agreed. Korean Government funds to advance this collaboration are being sought.

China – Support for the HiPER project from China is strong. Formal agreements are planned once the project receives the go-ahead. A UK-China agreement has recently been signed which significantly aids this process and has already led to Chinese involvement in HiPER related science projects in the UK. As well as an obvious academic benefit, this will also open up alternative supply routes for key components, thereby reducing future risk. We have secured the formal engagement, at the highest levels, of the Chinese Academy of Sciences (CAS), Shanghai Jiaotong University (SJU), and the Shanghai Institute of Optics and Fine Mechanics (SIOM).

Japan – Academic collaborative links to Japan on laser fusion science are naturally very strong given the leading role that the Institute of Laser Engineering (ILE) at Osaka University has played in recent years. The ILE are very strong supporters of the HiPER mission and bi-lateral agreements are in place between the ILE and several of the European partners involved in HiPER. Continuation of this collaboration is already planned, which opens up access to the FIREX laser facility at the ILE for HiPER related work. The FIREX facility is a major laser infrastructure dedicated to the pursuit of the fast ignition approach to inertial fusion energy.

North America

Figure 16.3 Current North American nations with institutions involved in HiPER

Canada – Formal agreements are in place linking HiPER to the emerging fusion programme in the Alberta province of Canada. This is represented through the involvement of the University of Alberta (UofA) in the HiPER mission who are currently midway through a process of securing substantial funds for a Canadian Laser Fusion programme. Secondment of Canadian scientists to the HiPER partners in Europe is being planned as part of the early stages of this programme.

USA – It is expected that the strong link to the USA will see the secondment of EU personnel working on the HiPER project to the Lawrence Livermore National Laboratory (LLNL) as well as to GA (a formal partner) to facilitate critical technology transfer. Early engagement with the US Department of Energy, Office of Fusion Energy Science (DOE - OFES) has indicated a strong desire to align their science programme with HiPER as part of our long-term goal of a fully international roadmap.

16.3 Other Partners

Industrial Links – Working with industrial partners will be a central issue during this preparatory phase to ensure costs are well known and supply routes are available for the construction of HiPER. Already, there has been a significant engagement with many potential industrial stakeholders in HiPER and this will continue during the preparatory phase (see previous chapter on industrial engagement)

Other Preparatory Phase Projects – There is much to be gained during the preparatory phase through working with the other projects. This applies equally to technical and scientific issues, as well as those related to strategic, governance, financial engineering and legal aspects. Furthermore, there is the potential for both risk and cost sharing in places. We propose to work with other

projects and have already signed two Memoranda of Understanding (MoU) covering these issues with the Extreme Light Infrastructure (ELI) and the European Extremely Large Telescope (E-ELT). In a similar fashion we have signed an MoU with the Laserlab-Europe Integrated Infrastructure Initiative.

16.4 Forward plan

Critical to the success of this next preparatory phase will be to convert the significant support already obtained from these nations and organizations into commitment for the construction phase. This will require a robust cost-benefit analysis, clarity in the through-life funding mechanisms and sources, an agreed framework for the accountabilities and responsibilities that follow from funding, an achievable procurement strategy, an agreed site, and a detailed understanding of how HiPER will impact the existing science and energy communities and facilities. The project also needs to ensure coordination between the fundamental building blocks of a laser fusion energy programme (the laser source; the target supply; the reactor design; and the inherent plasma physics) and management of key risks in these areas that could threaten construction.

The project has addressed these critical areas in designing the management structure, work plan, deliverables and milestones for the forthcoming preparatory phase.