HELMHOLTZ SPITZENFORSCHUNG FÜR GROSSE HERAUSFORDERUNGEN

HELMHOLTZ IMAGING PLATFORM (HIP)

INHALTSVERZEICHNIS

EINLEITUNG IN
INFORMATION & DATA SCIENCE IN DER HELMHOLTZ-GEMEINSCHAFT

Information & Data Science – Eine globale Herausforderung

Die digitale Transformation ist eine der größten Herausforderungen für Wissenschaft, Wirtschaft und Gesellschaft zu Beginn des 21. Jahrhunderts. Sie bietet enorme Chancen in nahezu allen Bereichen des Lebens – innovative Formen von Arbeit und Zusammenleben, völlig neuartige Plattformen für Handel und Wissenschaft, ungeahnte Möglichkeiten für die Medizin, revolutionäre Ansätze für Netzwerke der Energieversorgung, zukunftsweisende Verfahren für Klimaschutz und vieles mehr.

Im Kern der digitalen Transformation steht die Wertschöpfungs- und Erkenntniskette „von Daten zu Wissen zu Innovation“. Dies ist auch die entscheidende Herausforderung in allen wissenschaftlichen Disziplinen, welche die Grundlagen für den gesellschaftlichen Fortschritt der Zukunft bereiten.

Damit Deutschland diese Entwicklung mitgestalten und daran partizipieren kann, sind ambitionierte, mutige und zukunftsweisende Schritte erforderlich. Die Verbindung von Informatik, Mathematik, Statistik, Sensortechnologie, Simulation und datenintensivem Rechnen mit anspruchsvollen Anwendungsfeldern aus dem breiten Spektrum der Natur- und Ingenieurswissenschaften, der Medizin sowie den Geistes- und Sozialwissenschaften wird ein dynamischer Motor des Innovations- und Forschungsstandortes Deutschland sein. Diese innovativen Verbindungen werden völlig neue wissenschaftliche Erkenntnisse mit erheblichen Mehrwerten für Wirtschaft und Gesellschaft hervorbringen.

Deutschland hat im Feld der Hochtechnologien mit großem transformativem Potenzial eine sehr gute Ausgangsposition im weltweiten Vergleich. Um diese Position zu halten und auszubauen, sind neben gesamtgesellschaftlichen Anstrengungen auch völlig neuartige Ansätze im Wissenschaftssystem erforderlich.

Information & Data Science in der Helmholtz-Gemeinschaft

Die Helmholtz-Gemeinschaft Deutscher Forschungszentren leistet Beiträge zur Lösung großer und drängender Fragen von Gesellschaft, Wissenschaft und Wirtschaft durch interdisziplinäre, wissenschaftliche Spitzenleistungen in sechs Forschungsbereichen: Energie, Erde und Umwelt, Gesundheit, Schlüsseltechnologien, Materie sowie Luftfahrt, Raumfahrt und Verkehr. Sie ist mit über 39.000 Mitarbeiterinnen und Mitarbeiter in 18 Forschungszentren die größte Wissenschaftsorganisation Deutschlands.

Als Forschungsorganisation, die sich zum Ziel gesetzt hat große und aktuelle gesellschaftliche Herausforderungen zu adressieren, hat die Helmholtz-Gemeinschaft in den letzten Jahrzehnten ein enormes Kompetenzportfolio im Bereich Information & Data Science aufgebaut: auf Gebieten wie Informationsverarbeitung, Big Data, Datenalyse, Simulation, Modellierung, Bioinformatik, bildgebenden Verfahren, Forschungsdaten-Management, High Performance Computing, Robotik, technischen sowie biologischen Informationssystemen und vielen weiteren zukunftsweisenden Technologien. Wie kaum eine andere Forschungsorganisation verfügt sie über einen exponentiell wachsenden Schatz von Big Data.

Die Helmholtz-Zentren und Forschungsbereiche haben auch eine herausragende Ausgangsposition für eine erfolgreiche, synergetische Verbindung der Kompetenzen: als Betreiber großer Forschungsinfrastrukturen (beispielsweise Satellitenmissionen oder Großanlagen der Kern- und Teilchenphysik), als Anwender von Supercomputing der neuesten Generation sowie als Kompetenzträger für komplexe Simulationen (beispielsweise umfangreicher Erd- und Klimamodelle, virtuelles Materialdesign und Systembiologie). Sie sind daher auch schon seit Langem mit dem gesamten Data-Lifecycle vertraut: der Forschungsplanung, dem Erheben, der Handhabung und Pflege, dem Analysieren, dem Auswerten und der Nutzbarmachung sehr großer und komplexer Datenmengen. An allen Standorten und in allen Einzeldisziplinen gibt es teilweise weltweit führende Ansätze und herausragende Methodenkompetenz – aber gerade auch in ihrem Zusammenspiel ergeben sich ungeahnte Möglichkeiten.

Darauf aufbauend und darüber hinausgehend verstärkt die Helmholtz-Gemeinschaft im hochaktuellen Themenfeld Information & Data Science die eigene Kompetenz, schafft Synergien in der Forschungslandschaft, greift die Entwicklungen im nationalen, europäischen und internationalen Kontext auf und setzt neue disruptive Ansätze um. Neben der Stärkung der Einzeldisziplinen mit modernsten daten- und informationswissenschaftlichen Methoden ist es erklärtes Ziel, das Thema Information & Data Science auf Gemeinschaftsebene disziplinübergreifend voranzutreiben.

Die Helmholtz-Gemeinschaft adressiert das komplexe Themenfeld Information & Data Science auf allen Ebenen:

- Es hat hohe Priorität in der Agenda des Präsidenten.
- Helmholtz-Zentren und Forschungsbereiche berücksichtigen in ihren jeweiligen Strategien das große Potenzial dieses Themenfeldes.
- Im Rahmen der Neuausrichtung der Forschungsbereiche wird der bisherige Forschungsbereich Schlüsseltechnologien in einen neuen Forschungsbereich Information weiterentwickelt.
- Die Gemeinschaft errichtete mehrere neue Institute zu Simulations- und Datentechnologien und Cybersicherheit und plant aktuell die Aufnahme eines neuen Helmholtz-Zentrums für Informationssicherheit am Standort Saarbrücken.
- Wissenschaftlicher Nachwuchs wird in diesem Bereich auf neuen Wegen und in großer Zahl in einem neuen Netzwerk regionaler Helmholtz Information & Data Science Schools (HIDSS) ausgebildet.
- Der von der Helmholtz-Gemeinschaft initiierte Helmholtz-Inkubator Information & Data Science potenziert die einzelnen Initiativen als ein neuartiger, gemeinschaftsweiter Think-Tank und Zukunftsmotor.
- Durch Ihre intensive Interaktion mit nationalen und internationalen Partnern leistet Helmholtz auch entscheidende Beiträge zu Initiativen wie der Nationalen Forschungsdaten Infrastruktur (NFDI) und zu internationalen Allianzen im Forschungsdatenmanagement

Der Helmholtz-Inkubator Information & Data Science

Der Helmholtz-Inkubator Information & Data Science wurde im Juni 2016 vom Präsidenten der Helmholtz-Gemeinschaft ins Leben gerufen, um die vielfältige, dezentrale Expertise der Gemeinschaft im weiten Themenfeld Information & Data Science intelligent zusammenzuführen und zu potenzieren.

Dazu haben alle Helmholtz-Zentren je zwei hochkarätige Wissenschaftlerinnen und Wissenschaftler in den Helmholtz-Inkubator entsandt. Diese 36 Fachleute vertreten zusammen eine enorme fachliche Breite und decken viele innovative Kompetenzen ab. Unterstützt werden sie durch ausgewiesene Expertinnen und Experten aus forschenden Unternehmen und namhaften Forschungseinrichtungen sowie mehreren Beratungsunternehmen. Begleitet wird der Helmholtz-Inkubator von der Geschäftsstelle der Helmholtz-Gemeinschaft.

Der Helmholtz-Inkubator integriert bestehende, zukunftsweisende Initiativen der Helmholtz-Gemeinschaft durch einen gemeinschaftsweiten Bottom-up-Prozess. Die regelmäßige Zusammenführung und Verdichtung der Expertise der Helmholtz-Zentren ermöglicht die visionäre Gestaltung des Themas Information & Data Science über die Grenzen von Zentren und Forschungsbereichen hinaus. Dabei geht der Helmholtz-Inkubator völlig neue Wege, um das Zukunftsfeld dynamisch, umfangreich und fachübergreifend durch Setzung strategischer Schwerpunkte zu gestalten.

Der Helmholtz-Inkubator verfolgt derzeit folgende Ziele:

- die regelmäßige Interaktion kreativer Köpfe aus der gesamten Gemeinschaft,
- die Schaffung von Grundlagen für innovative, interdisziplinäre Netzwerke und Ansätze,
- die Identifizierung zukunftsweisender Themenfelder und disruptiver Pilotprojekte,
- die Planung und Begleitung von langfristig angelegten und gemeinschaftsweiten Plattformen.

Der Helmholtz-Inkubator hat innerhalb der Helmholtz-Gemeinschaft eine hohe Dynamik entfaltet, zahlreiche Impulse mit großer thematischer Breite formuliert, vielfältigen Austausch zwischen Digitalisierungsexpertinnen und -experten aus allen Domänen ermöglicht und so einen tiefgehenden Strategieprozess eingeleitet, der in dieser Form und in diesem Umfang einmalig im deutschen Wissenschaftssystem ist.

Über 150 beteiligte Wissenschaftlerinnen und Wissenschaftler, davon 36 Vertreterinnen und Vertreter des Helmholtz-Inkubators, sowie 10 externe Beraterinnen und Berater (u.a. IBM, SAP, Trumpf, Blue Yonder, Gauß-Allianz) haben sich in den letzten zwei Jahren im Rahmen von über 35 Workshops und AG-Treffen diesem großen Themenkomplex gewidmet. Auch die Vorstände der Helmholtz-Gemeinschaft haben sich in einem dedizierten Workshop mit den strategischen Überlegungen des Helmholtz-Inkubators auseinandergesetzt. Nach Schätzungen der Geschäftsstelle sind bis heute über 25.000 Personenstunden Arbeit in diesen Prozess geflossen.

Der bisherige Prozess

Der Helmholtz-Inkubator trat im Oktober 2016 zu seinem ersten, zweitägigen Workshop zusammen und diskutierte das Thema Information & Data Science offen und uneingeschränkt; jedes Zentrum lieferte Impulse aus seiner jeweiligen Sicht.

Obwohl zu Beginn des Prozesses die Schaffung von Konsortien zur Bearbeitung von Pilotprojekten im Vordergrund stand, formulierten die Expertinnen und Experten die klare Empfehlung, dass die Entwicklung von dauerhaften, strukturellen Aktivitäten im Themenbereich Information & Data Science auf einigen Teilgebieten auf Gemeinschaftsebene notwendig sei – zusätzlich zu neuen Impulsen durch Pilotprojekte.

Die Vertreterinnen und Vertreter erörterten die zentralen Herausforderungen der Helmholtz-Gemeinschaft auf Ebene der gesamten Gemeinschaft. Die identifizierten Themen wurden umfassend mit allgemeinen forschungspolitischen Initiativen der Allianz-Organisationen und Vorstellungen der Zuwendungsgeber sowie internationalen Entwicklungen abgeglichen. Zusätzlich wurde der Helmholtz-Inkubator dabei von führenden externen Expertinnen und Experten im Thema Information & Data Science beraten.

Die Vorschläge zu gemeinschaftsweit zu bearbeitenden Themenfeldern wurden im Frühjahr 2017 in mehreren fokussierten Arbeitsgruppen des Helmholtz-Inkubators konkretisiert. Die Arbeitsgruppen setzen sich aus den Inkubator-Mitgliedern zusammen, die sich spezifisch in diesem Thema einbringen wollen; weitere mit den Themen befasste Expertinnen und Experten der Helmholtz-Gemeinschaft nahmen beratend an den Sitzungen der Arbeitsgruppen teil. Die Ergebnisse der Arbeitsgruppen wurden in einem Inkubator-Workshop mit allen Vertreterinnen und Vertretern des Helmholtz-Inkubators und externen Expertinnen und Experten im Mai 2017 diskutiert und weiter geschärft.

Aus den diskutierten Themenvorschlägen wurden diejenigen Themen weiter verfolgt, von denen gemeinschaftsweite Mehrwerte und ein erhebliches Entwicklungspotenzial erwartet werden konnten. Der Helmholtz-Inkubator identifizierte so fünf Themenkomplexe, die er der Helmholtz-Gemeinschaft zur langfristigen Verfolgung durch die Etablierung von fünf dedizierten Plattformen vorschlug.

Die Vorstände der Helmholtz-Gemeinschaft haben sich in einer außerordentlichen, fachlichen Sitzung im September 2017 eingehend mit diesen fünf Plattform-Ansätzen befasst. Zu allen Themen wurden inhaltliche und strukturelle Leitplanken für eine detaillierte Konzepterstellung formuliert. Auf der Mitgliederversammlung haben sie diese zur detaillierten Ausarbeitung durch den Helmholtz-Inkubator und seiner Arbeitsgruppen empfohlen, um eine potenzielle Umsetzung ab September 2018 vorzubereiten. Die Mitgliederversammlung forderte die Geschäftsstelle dazu auf, die AGs bei der Ausgestaltung von Governance und Finanzierungsfragen zu unterstützen.

Die Ergebnisse des Vorstandsworkshop Information & Data Science und der Mitgliederversammlung wurden anschließend dem Senat der Helmholtz-Gemeinschaft übermittelt.

Die Arbeitsgruppen des Helmholtz-Inkubators haben darauf folgend ab Oktober 2017 die weitere Konkretisierung der Themen vorgenommen. Die Inkubator-Vertreter der Zentren wurden nochmals aufgefordert, spezialisierte Fachleute in die jeweiligen AGs zu entsenden; so wurde themenspezifisch ein noch höheres Maß an Expertise aufgebaut.

Die Arbeitsgruppen haben zur weiteren Ausarbeitung der Konzepte Berichterstatter bestimmt. Zur Unterstützung der Arbeitsgruppen und Berichterstatter wurden pro Themenfeld zwei Referenten eingestellt; hierfür stellte der Präsident Mittel aus dem Impuls- und Vernetzungsfonds bereit. Die AGs bildeten folgende Teams:

- Arbeitsgruppe wissenschaftlicher Nachwuchs: vertreten durch die Berichterstatter Achim Streit (KIT) und Uwe Konrad (HZDR), 28 Mitarbeitende, unterstützt durch die Projektreferentin Susan Trinitz. Erarbeitetes Konzept: Helmholtz Information & Data Science Academy (HIDA).

- Arbeitsgruppe Mehrwerte aus Forschungsdaten durch Metadaten: vertreten durch die Berichterstatter Rainer Stotzka (KIT), Kirsten Elger (GFZ) und Frank Ückert (DKFZ), 27 Mitarbeitende, unterstützt durch die Projektreferentinnen Nanette Rißler-Pipka und Rumyana Proynova. Erarbeitetes Konzept: Helmholtz Metadata Center (HMC).

- Arbeitsgruppe Basistechnologien und grundlegende Dienste: vertreten durch die Berichterstatter Ants Finke (HZB), Volker Gülzow (DESY) und Uwe Konrad (HZDR), 36 Mitarbeitende, unterstützt durch die Projektreferenten Knut Sander und Tobias Frust. Erarbeitetes Konzept: Helmholtz Infrastructure for Federated ICT Services (HIFIS).

- Arbeitsgruppe bildgebende Verfahren (Imaging): vertreten durch die Berichterstatter Christian Schroer (DESY) und Wolfgang zu Castell (HMGU), 44 Mitarbeitende, unterstützt durch die Projektreferenten Alexander Pichler und Murali Sukumaran. Erarbeitetes Konzept: Helmholtz Imaging Platform (HIP).

- Arbeitsgruppe Künstliche Intelligenz und Maschinelles Lernen: vertreten durch die Berichterstatter Fabian Theis (HMGU) und Katrin Amunts (FZJ), 45 Mitarbeitende, unterstützt durch die Projektreferentinnen Susanne Wenzel und Angela Jurik-Zeiller. Erarbeitetes Konzept: Helmholtz Artificial Intelligence Cooperation Unit (HAICU).

Im März 2018 fand der vierte Inkubator-Workshop statt. Hier wurden die bis zu diesem Zeitpunkt erarbeiteten Konzeptentwürfe präsentiert und weiterentwickelt. Dabei wurden die Inkubator-Vertreter erneut von ausgewiesenen externen Expertinnen und Experten unterstützt. Die Ergebnisse des Inkubator-Workshops wurden im Anschluss in den jeweiligen Arbeitsgruppen umgesetzt und die Konzepte von den Arbeitsgruppen finalisiert. Flankierend fanden individuelle Gespräche aller Berichterstatter mit der Geschäftsführerin der Helmholtz-Geschäftsstelle zu Fragen der Governance und Finanzierung statt.

Nach Fertigstellung der Konzepte durch die Arbeitsgruppen und Berichterstatter wurden diese im Juli 2018 allen offiziellen Inkubator-Vertretern übergeben. Der Helmholtz-Inkubator empfiehlt den Vorständen der Helmholtz-Gemeinschaft die vorliegenden fünf Konzepte zur nachhaltigen und gemeinschaftsweiten Umsetzung.

Die Vorstände der Helmholtz-Gemeinschaft können nun im Rahmen der Mitgliederversammlung im September 2018 über die Umsetzung und Finanzierung jedes Plattform-Konzepts befinden. Die Vorstände bestimmen außerdem für jedes genehmigte Konzept, welche Helmholtz-Zentren die Plattformen zum Nutzen der gesamten Helmholtz-Gemeinschaft tragen sollen oder definieren ein Verfahren zur Verortung der Plattformen.

Die wichtigsten Prozessschritte der vergangenen zwei Jahre sind in Abbildung E.1 schematisch dargestellt.

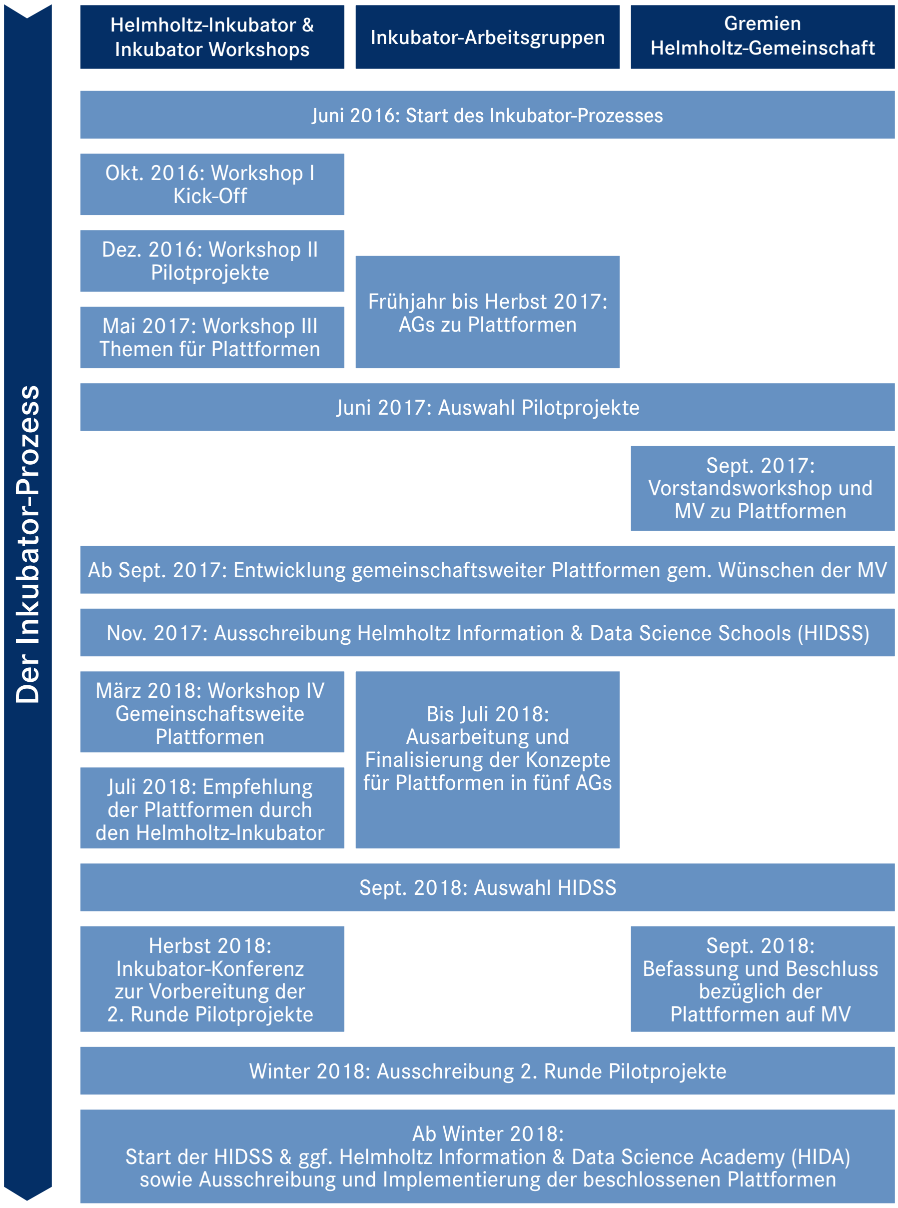

Abbildung E.1: Die wichtigsten Schritte des Inkubator-Prozesses der vergangenen zwei Jahre.

1 SUMMARY IN GERMAN AND ENGLISH

1.1 SUMMARY

A significant amount of research data produced within the Helmholtz Association are imaging data. In order to obtain such data, the association has a unique collection of imaging modalities at its disposal, ranging from nanoscale to global observations. Imaging science is an enabling technology used in all research fields of the association.

Although being an essential component of research at all centers of the Helmholtz Association, imaging science is not one of the central research topics of the association. Nevertheless, there exists a rich portfolio of expertise covering research on novel imaging modalities, experimental work using large-scale research facilities, expertise in mathematics and computer science related to imaging, as well as research in image analysis within specific fields of application.

The Helmholtz Imaging Platform HIP aims to leverage this potential, enabling synergies across imaging modalities and imaging applications. The platform consists of two components: (i) a HIP Core Team providing scientific support and operating a technological platform supporting imaging science within the Helmholtz Association. The Core Team further organizes the (ii) HIP Imaging Network, comprising experts from all related disciplines within and outside of the Helmholtz Association.

An essential mode of operation of HIP is a funding mechanism for short-term cross-domain projects, which may follow high-risk, cutting edge ideas, or bridge the gap from an early implementation towards a professional software tool. These projects have a seed character and shall develop prototypes solving problems in imaging sciences occurring within the application of imaging at the centers. Following a strategy of agile development, these solutions will further be explored by the imaging community at the Helmholtz Centers.

Overall, HIP aims at establishing the Helmholtz Association as a leading provider, developer and scientific user of cutting-edge imaging technology.

1.2 ZUSAMMENFASSUNG

Ein erheblicher Teil der Forschungsdaten, die innerhalb der Helmholtz-Gemeinschaft produziert werden, besteht aus Bilddaten. Um diese Daten zu erzeugen, verfügt die Gemeinschaft über ein einzigartiges Arsenal an Bildgebungsmodalitäten, das von der Nanoskala bis hin zu globalen Beobachtungssystemen reicht. Imaging Science zählt zu den sogenannten ‚Enabling Technologies', die in allen Forschungsfeldern eingesetzt wird, in denen die Gemeinschaft aktiv ist.

Obwohl Forschung an bildgebenden Verfahren essentielle Komponente der Forschung aller Helmholtz-Zentren ist, zählt sie als eigenständige Wissenschaft nicht zu den zentralen Forschungsgegenständen der Gemeinschaft. Dennoch existiert ein reichhaltiges Repertoire an Expertise, welche sowohl die Forschung an neuen bildgebenden Verfahren umfasst, wie auch experimentelle Forschung an Großforschungseinrichtungen, Expertise in Mathematik und Informatik mit Bezug zu bildgebenden Verfahren, sowie Forschung an Verfahren zur Bildanalyse innerhalb spezifischer Anwendungsdomänen.

Die Helmholtz Imaging Plattform HIP zielt darauf ab, dieses Potenzial zu heben und Synergien zu entfalten, welche die verschiedenen Modalitäten sowie Anwendungen von Imaging Sciences umspannen. Die Plattform besteht aus zwei Komponenten: (i) Ein HIP Core Team stellt wissenschaftliche Unterstützung auf dem Gebiet der Imaging Sciences bereit und betreibt eine technologische Plattform, die diesbezügliche Forschung innerhalb der Helmholtz-Gemeinschaft unterstützt. Darüber hinaus organisiert das HIP Core Team das (ii) HIP Imaging Netzwerk. Letzteres umfasst Experten aller relevanten Disziplinen innerhalb und außerhalb der Helmholtz-Gemeinschaft.

Eine essentielle Funktionsweise von HIP läuft über ein Finanzierungssystem für kurzzeitige, domänenübergreifende Projekte. Diese mögen Hoch-Risiko-Projekte sein, oder einfach die Kluft zwischen einer ersten Implementation hin zu einem professionellen Software-Werkzeug überbrücken. Diese Projekte bieten eine Anschubfinanzierung und sollen damit prototypische Lösungen entwickeln, die Herausforderungen im Bereich des Einsatzes bildgebender Verfahren im Rahmen der Forschung innerhalb der Anwendungsgebiete der Zentren angehen. Einer Strategie agiler Entwicklung folgend, werden derartige Lösungen durch die Gemeinschaft der Wissenschaftlerinnen und Wissenschaftler innerhalb der Helmholtz-Gemeinschaft, die sich mit bildgebenden Verfahren befassen, weiterentwickelt.

Insgesamt gesehen zielt HIP darauf ab, die Helmholtz-Gemeinschaft als einen führenden Anbieter, Entwickler und wissenschaftlichen Nutzer von wegbereitender Technologie im Bereich der wissenschaftlichen Bildgebung zu etablieren.

2 INTRODUCTION

Scientific discovery ever since its early days has made use of images. Images are the most natural form of encoding information for human perception since the human brain is highly adapted to identifying patterns in images (Mattson 2014). It therefore does not come as a surprise that a **large amount of data, if not the largest amount, being produced** at the research centers of the Helmholtz Association is produced as images or is image based. Imaging is present in almost all research fields as a mode of perceiving quantitative information within a (temporal-)spatial context. Hereby, the variety of imaging modalities ranges from the small molecular scale, e.g., being currently pushed beyond traditional limits in ptychography, through the macroscopic scale as represented by medial images of the human body, up to the global scale of satellite images observing the Earth at the planetary scale. Images traditionally result from measurements leading to **two- or three-dimensional digital data representations or data objects with a precise spatial context**, partially with an additional time resolution in the case of videos.

Every image is based on measurements of physical quantities. Even a drawing being produced by a physiologist for morphological description is preceded by the biologist observing the object before capturing it on paper. For many imaging modalities, the quantities being shown in the image cannot be measured directly but result from some form of reconstruction process. For example, classical X-ray tomography measures differences in attenuation of X-ray beams to reconstruct the object being scanned via solving an inverse problem. In either case, **images result from making use of an associated physical model** and as such provide a special class of data objects.

Computing does not stop with the image being produced. In scientific applications, images provide a basis for the quantification of observations. Thus, images have to be analyzed and made suitable to algorithmic quantification. For example, species having to be identified and counted in microscopic images of water samples to quantify life forms (Daims and Wagner 2007). Considering images as data objects, there are specific characteristics sticking out.

- An image is always carrying **inherent spatial information**. Objects on an image are presented within a certain spatial configuration.
- Images provide an outstanding **way to capture complex phenomena**. This is the reason why images are being used in scientific presentation to make complex phenomena accessible to the scientific audience.
- The human brain is particularly well adapted to capture patterns in images. In this sense, images are a very **anthropogenic way of encoding information**.

The latter aspect is of special interest in the context of artificial intelligence. While images are well suited for human perception, an image might not be the most efficient way to provide information for algorithmic processing. On the contrary, in many cases images are a poor way of storing information as they are far away from efficient coding. While on the medium scale, images will persist as an essential part in scientific discovery, keeping the ‚human in the loop‘, we can imagine processing data directly from the measurement source, rather than going through the additional effort to reconstruct an image. This aspect is of particular importance in fields of research, where the high amount of imaging data being produced prohibits any manual step in processing the data. For such applications, the reconstruction of images might still be needed during the development of an **automated processing pipeline** but can later be skipped during standard operational processing.

The Helmholtz Association with its interdisciplinary range of research fields and broad variety of research interests hosts a unique repertoire of imaging modalities. Some of them can be considered standard within a scientific field, such as many medical imaging devices or microscopes in biology. Others are really unique, being linked to large-scale scientific infrastructures being operated by centers of the Helmholtz Association, e.g., the PETRA III facility at DESY (DESY 2018). Last but not least, some imaging modalities are actually the subjects of research on their own, being driven by members of the Helmholtz Association, such as photoacoustic imaging at the Helmholtz Zentrum München (Ntziachristos 2010). Advances in all research areas making use of scientific imaging hereby rely on three crucial factors:

1. **Imaging modalities have to be fully exploited** to use their potential in scientific discovery. In many cases, scientific demand is driving imaging modalities towards the limits of their technical capabilities.
2. **Scientific imaging needs to be based on precise scientific measurements**. Reliable quantification of observables and identification of objects captured through imaging, including quantification of their inherent uncertainties can only be guaranteed if the full imaging pipeline from the source to the analysis of the image is being considered.
3. **The largest potential in using imaging modalities for future research lies in combining modalities of complementary characteristics** in order to overcome limitations inherent in every technical realization of physical measurements.

Overall, **imaging lies at the core of the Helmholtz Association's mission**. Being used in interdisciplinary research, imaging essentially is interdisciplinary itself, relying on expertise in experimental physics and engineering, being processed making use of mathematical algorithms and computing expertise, while being applied and interpreted within a specific domain of application.

Imaging Research at the Helmholtz Association

Due to the organization of research in the Helmholtz Association within thematic research fields and research programs, expertise in scientific imaging is spread over all research fields. Being an **enabling technology**, imaging science is incorporated into interdisciplinary projects within the domain of application. While this is an ideal structure to foster making use of imaging within the specific field of application, such a mode of organization hides the potential which could be raised by making use of **synergies across imaging modalities and imaging applications**. In particular, it ignores the treasure being hidden in the amount of imaging data not being used beyond the domain of research within which it has been created. For example, images being obtained in remote sensing projects within the research field Earth and Environment (Wennrich, Popp, and Hafner 2002) might be of high value for researcher in the research field Health, being interested in human exposure to environmental pollutants or allergens (Wolf et al. 2017). Beyond such hidden treasure, large-scale imaging modalities such as the European XFEL should be exploited towards their full potential. While originally focused on material sciences within the research field Matter, imaging modalities for the nano scale have just started being used in biomedical research, e.g., to explore mechanisms of host-pathogen interactions in bacteria. In a similar way, the same imaging technologies are being used in various research fields without exchanging expertise and technology (Grünberger et al. 2016, Neumann et al. 2010). Software components for automatic detection of microorganisms in fluorescence microscopy could well be adapted to detect cells in medical samples, to give one example. In particular, modern advances in machine learning algorithms such as deep learning techniques can be re-used and re-trained to be applied for similar, though not identical classification tasks (Ravishankar et al. 2016). **Making use of this potential will prevent the association from repeatedly spending resources on similar tasks as well as leverage expertise in the field through cross-fertilization.** Strategically, imaging science on its own will not become a central research focus of the Helmholtz Association. Clearly, cutting-edge research on certain imaging modalities well fits into the Helmholtz research program. Nevertheless, specific examples, such as photoacoustics, can never serve the broad need for expertise in imaging sciences across all fields of research which dominantly lies on intermediate levels of transfer of expertise towards applications rather than purely basic research in imaging. Therefore, from a strategical point of view, **it is self-evident to make every effort to unfold synergies and enable cross-fertilization among the experts in the field.** Therefore, it should be a strategic goal to enable professional research to make use of imaging sciences, rather than solely relying on experts in a domain of application with some additional skills in imaging.

In summary, the following challenges need to be addressed towards leading imaging research within the Helmholtz Association to the next level. (1) The **existing expertise** within the Helmholtz Association which is indeed rich and laid-out complementarily must be pooled to create a unified force of critical mass. (2) **Access to existing imaging modalities** has to be facilitated for all researchers within the association, regardless of their specific domain background or the research field the modality is associated with. In particular, large-scale imaging facilities within the association should be maximally exploited for the benefit of high-level research in all research fields of the association. (3) Uninformed use of cutting-edge measurement devices is a waste of resources. **Knowledge transfer** is therefore an indispensable component of operating such devices. Expertise in imaging research must therefore be made accessible vertically (from the expert to the application) and horizontally (among different domains of application). Note that neither one of these is a one-way road. (4) As imaging data comprises a major part of research data within the Helmholtz Association, procedures and modes of operation must be prepared for **automatic processing** of imaging data spanning from data generation to the analysis of the processed image.

In order to better demonstrate the motivation for the Helmholtz Imaging Platform (HIP) four exemplary **use cases** are described below. All cases presented indicate how an interdisciplinary team of scientist could solve actual challenges by fruitful collaboration and technology transfer. The use cases exemplify how domain specific research in future can profit from potential synergetic projects through HIP. We note that all four cases are backed-up by research challenges existing within the Helmholtz Association and illustrate the mechanisms which are essential to HIP. Presently, there is no organizational structure to foster such kind of collaborative research within the Helmholtz Association beyond the borders of the individual research fields.

Use Case 1: A mathematician working outside of Helmholtz has developed a new algorithm for phase retrieval. On standard simulation data the algorithm outperforms the present gold standard in the field. The scientist approaches HIP, asking for real-world data, since she has learned from the HIP web page that ptychographic tomography, an imaging modality based on phase retrieval, is being used at several Helmholtz centers. Getting in touch with the beamline experts at Helmholtz, the mathematician learns about practical issues of ptychographic measurements, she has not yet considered in her theoretical work. Through joining forces, the new algorithm will be refined and eventually replaces the standard being used at the beamline so far. Partners from the HIP network help to optimize the code such that the algorithm can be provided as a ready to use software package to the international scientific community.

Use case 2: Material scientists working at a Helmholtz beamline aim to quantify precise material composition using photon imaging. For further analysis, it is important to also obtain an estimation of the uncertainty of the measurements. Similar challenges occur in geophysical research, where geologists need to quantify geological layers in order to provide data for modelling and simulation. Again, uncertainty of the measured quantities is an important model input. Both meet with specialists for uncertainty quantification at the HIP core and discuss their problems. The HIP core expert just recently learned at an international conference on uncertainty quantification about a new approach to deal with such issues. The three scientists decide to push this idea further and start exploiting the new techniques within their concrete settings.

Use case 3: Medical imaging scientists dealing with screening of a large cohort are facing the problem of processing their data due to the size of the data. Data processing seems to impose restrictions on the valuable time being used for screening. Earth scientists working in remote sensing based on satellite data have developed efficient processes to directly process raw data and move processed data to a national satellite data archive. Through meeting at the annual HIP Imaging Network workshop, both learn of each other's work. They decide to organize a joint group meeting. As an outcome the biomedical group starts to pick-up the concept being used in satellite imaging and adopt it to their requirements.

Use case 4: Marine scientists have developed a web-based tool getting interested citizens involved in classification of plankton from image snapshots. Through promoting their tool at the HIP's web page, deep learning experts get to know about the dataset and contact the marine group via HIP. Being an interesting dataset for the development of new reinforcement learning techniques, the marine dataset becomes a benchmark dataset for algorithm development. As an outcome, new algorithms for deep reinforcement learning are brought back into the HIP community to be further applied for the similar problem of automatically classifying cells in high-throughput microscopic imaging.

All the aforementioned cases show how to leverage synergies enabled by HIP, benefitting individual scientists and the Helmholtz Associating as a whole. Use case 1 demonstrates, how the HIP network will function as a broker for both, interesting algorithms and cutting-edge modalities, bringing experts from different fields together. For research questions of overarching interest, the HIP Core Team will provide state-of-the-art solutions, advancing the use of imaging in different fields of application. This is exemplified by use case 2. Use case 3 illustrates a model of technology transfer from one research field into another. Currently, scientific activities being organized within research fields and their respective research programs do not provide opportunities for such kind of projects. Finally, use case 4 demonstrates the opportunity to establish imaging within the Helmholtz Association as an internationally visible platform, setting standards for benchmarking in the field. More examples, providing specific ideas for interesting HIP projects are provided in the Appendix.

3 GOALS OF THE HELMHOLTZ IMAGING PLATFORM

The **Helmholtz Imaging Platform** is conceptually designed to address challenges presented in the chapter 2. Being a platform operated by the Helmholtz Association and serving the needs across all centers and research areas, HIP has been designed according to the following guiding principles:

- Research at Helmholtz is set-up in research programs working on clearly defined questions of societal impact. HIP will not seed an additional program or even a topic within a program, Therefore, it will be essential to **reach critical mass** through joining of forces bridging centers, research fields and programs.

- HIP is a platform and not a project. Thus, **long-term synergies** need to be established reaching beyond classical boundaries of research projects and lasting longer than the temporal horizons of common project driven collaboration.
- Research areas such as imaging or data sciences are highly dynamic, evolving with the speed of technological development. Being a platform, HIP must prove a stable framework within which **dynamical research** can evolve. It will be essential for the long-term success of the platform that HIP allows to adapt new developments and pick-up new trends quickly and at an early stage.
- Essentially, imaging sciences are an enabling science within the Helmholtz portfolio. Therefore, research on methods, algorithms and technologies is not self-serving. To overcome traditional, commonly long phases of transfer of knowledge from theory into practice, HIP will be pushing usability through following a strategy of **agile development**.
- Finally, imaging sciences with their modalities and data provide a strategic asset for the Helmholtz Association for bringing data driven science effectively into application for the profit of solving challenging questions of societal impact. HIP will substantially contribute to making research at Helmholtz known beyond Germany and Europe. Therefore, HIP is explicitly targeting international **visibility and leadership** in applied imaging sciences, raising the interest of leading imaging experts to collaborate with Helmholtz.

In order to address the challenges mentioned above and to establish HIP as a leading platform within the Helmholtz Association, the following central goals have been defined.

1. **Develop a network of expertise.** Bridging researchers in imaging sciences and imaging applications together across traditional boundaries (research centers, research fields and organizations) and reaching out into the national and international research community in imaging sciences.
2. **Facilitate access to imaging modalities.** In agreement with the Helmholtz Centers which own the imaging infrastructure, HIP acts as broker for available modalities and supports to make them findable and accessible through defined access processes and transparent modes of operation.
3. **Enhance the use of algorithms.** Fostering vertical knowledge transfer from mathematical/physical modeling via efficient algorithms and advanced optimization all the way to expert knowledge in the domain of applications. In addition, raising synergies through horizontal knowledge transfer across various applications of imaging modalities, thereby enabling multiple use of expertise.
4. **Increase professionalism.** Accelerating applied research using imaging technologies through accessibility of expertise on the modality leading to quicker mastering of algorithms and their use.
5. **Provide conditions for creative ideas and cross-domain development.** Fostering creative ideas and provisioning of seed funding to explore beyond the boundaries of traditional scientific domains, hereby following a strategy of agile development with rapid prototyping, evaluation and refinement.
6. **Increase visibility.** Establishing the Helmholtz Association as a leading provider, developer and user of cutting-edge imaging sciences.
7. **Make imaging data findable.** Providing a metadata portal for imaging data, linking to data repositories at the centers and thus, allowing for search and exploration (in close cooperation with the proposed Helmholtz Metadata Center HMC).

While these goals are directly oriented towards enabling research within the traditional research fields of the Helmholtz Association, there is also intrinsic scientific value for imaging science itself. To be precise, the Helmholtz Imaging Platform will

8. develop **algorithms for the extraction of quantitative information** from measurements using various imaging modalities,
9. explore **methods for uncertainty quantification** in imaging data,
10. provide **technology** opening imaging data **for automatic processing**,
11. identify the abstract core of algorithms being used in imaging to allow for horizontal knowledge transfer and **reuse of algorithms**,
12. incorporate artificial intelligence into the imaging pipeline towards **computer-aided knowledge discovery**.

3.1 HIP OPERATING WITHIN THE CYCLE OF AGILE DEVELOPMENT

Agile development has been introduced around the turn of the century as an approach to increase transparency and flexibility in software development and hereby minimize risks of the traditional development process (Moran 2014, Coldewey 2002). The core of the agile principles (Beck et al. 2010) is a fully user centric orientation. Development is then characterized by working in self-organizing teams following an incremental, iterative strategy.

HIP is realizing agile development through enabling HIP projects. The full process is depicted in Figure 1. Starting with ideas for new development and promising collaboration, the HIP network will enable scientists to get in touch with each other, exchange ideas and develop first plans. Through applying for HIP projects, such teams will be able to follow their idea, prototype solutions, test, evaluate and refine them. The **HIP project realization process** is purposely designed to allow maximum freedom of development and nevertheless guide towards value for the end user. For example, each project necessarily must have a 'customer' willing to adopt the solution in case the idea works out. Depending on the actual work to be done, the customer not necessarily needs to be a member of the project team. Both, developmental aspects as well as the user perspective will be represented by a **Project Support Team** (PST) which serves as a counterpart to monitor and adapt milestones and final deliveries.

Within the project timeline, several loops of the agile process might be passed through. It will be important that users and developers operate in an interactive way to collect early feedback and incorporate it into design and development (Kent et al. 2001).

Towards the end of the project, the project team together with the PST will agree on the final deliveries of the project. Since high-risk projects should be possible as well as technological/methodological refinement of existing solutions, the outcome of a project cannot be fixed universally or a priori. A successful solution might lead to a **new collaboration** (e.g. with external partners) and then be further proceeded based on third-party resources. Likewise, a high-risk idea might have been proven to be non-feasible. Nevertheless, following an idea will at least lead to new insight which should be preserved in a **lessons-learned document**. Ideally, the project will develop a useful solution which can then be **adopted by the user community** acting within the POF framework. Another typical HIP project might be to **professionalize an existing solution**, making it run on multiple platforms, scale towards larger use or increase accessibility. Thus, professional software development belongs to the essential skills which need to be provided by the HIP platform. Knowledge in professional software development is just one example of skills which HIP will take an action on being delivered within the Helmholtz Association, preferably through cooperating with other Helmholtz platforms and well-established facilities.

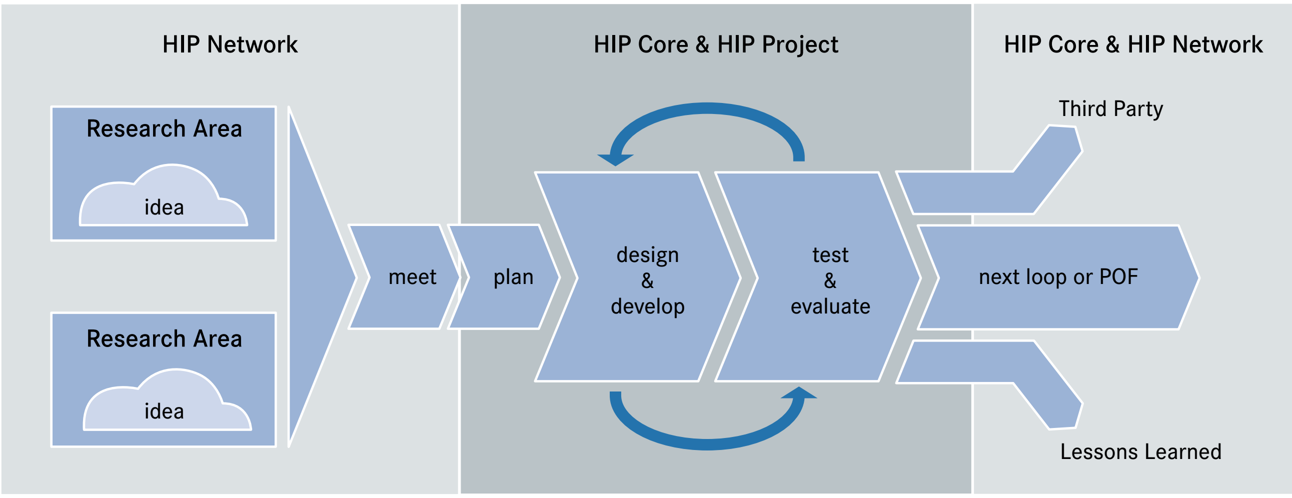

Figure 1: Schematic representation of the HIP agile development process

To guarantee long-term benefit of solutions being developed within HIP, the Core Team will facilitate a **software repository** and an **interface to imaging data**. Beyond these technological facilities, HIP will also define **minimal standards for software development**, documentation and maintenance of solutions.

As a side effect, the HIP agile development process also allows to develop **new criteria for accessing performance** and outcome of interdisciplinary collaboration. It is a commonly accepted fact, that neither co-authorship on publications, nor the classical citation based performance indicators are suited to value expertise and work being done to enable and support domain scientists to reach better results (Ledford 2015). This is one of the reasons, why highly-skilled young people in data sciences find it difficult to work in a classically, research-driven environment. HIP opens-up the opportunity to value enabling research in new ways and contribute to making Helmholtz become attractive to the next generation of data scientists. Performance indicators can be suggested and evaluated on HIP projects following the agile development process.

4 PROPOSED ORGANIZATION

The Helmholtz Imaging Platform comprises two major components:

- the **HIP Imaging Network** is bringing together experts in imaging science, facilities operation, and domain applications, including external partners;
- the **HIP Core Team** is driving imaging sciences at the Helmholtz Association, providing scientific expertise, organizational and administrative support, and running the networking and outreach program;

All those components will be explained in the following sections and their interplay is sketched in Figure 2.

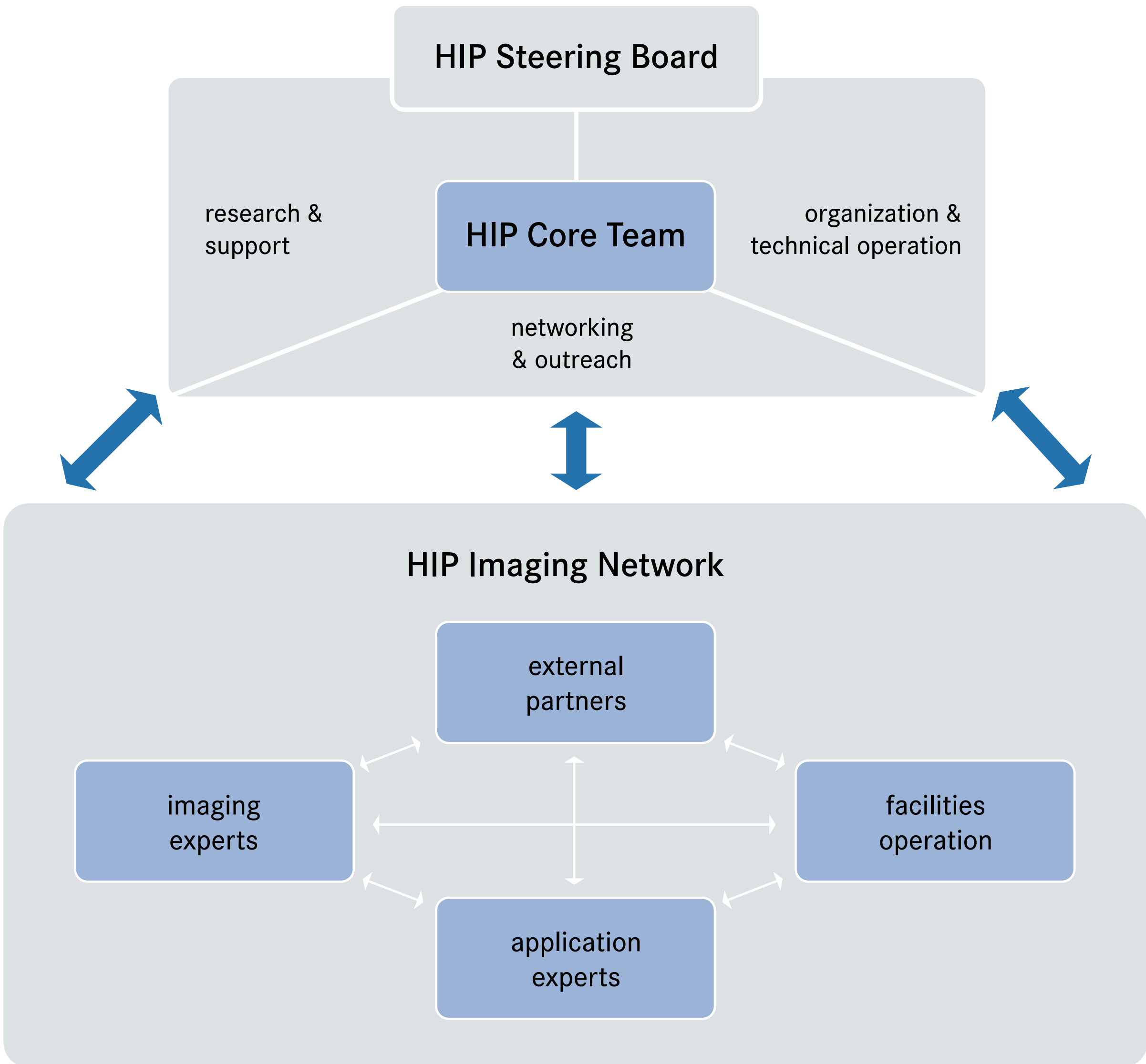

Figure 2: Organization Scheme of HIP

The essential instruments for running HIP are (i) the technical platform for collaboration and exchange and (ii) HIP projects. The projects follow the HIP project realization process providing a framework for agile development within a precisely defined framework. In the following sections, the proposed structure of HIP is discussed in detail.

To enforce international scientific standards and prevent HIP from being dominated by its internal perspective, a **Scientific Advisory Committee** (SAC) consisting of external experts will be appointed.

4.1 HIP IMAGING NETWORK

To enable synergies across research fields and exploit scattered potential in imaging sciences an Imaging Network is of vital importance. The aim is to connect domain experts using imaging technologies at the centers and other institutions, experts in imaging sciences and related fields, as well as core personnel operating large scale imaging modalities at the Helmholtz Centers. The HIP network intends to comprise experts from all imaging modalities within the Helmholtz Association, as well as experts in mathematics and computer science, including high-performance computing. Hence, one main responsibility of HIP will be the outreach to the community of imaging scientists and other stakeholders within and outside of Helmholtz Association. This includes the **organization of periodic events**, such as workshops, meetings, hackathons, or ‘datathons’, etc. The experts can collaborate in joint projects that are the central instrument of HIP (cf. HIP projects in Section 4.4).

Scientists can join the network by creating a profile of their expertise and participating in community activities. The HIP Core Team will provide technology for supporting the network, maintaining and operating services, accordingly, and organize events for knowledge exchange and community building. International experts from universities and other non-Helmholtz institutions shall also be part of the network. One way of getting external experts involved is by invitation as a **guest scientist** for visits of up to half a year at one of the participating Helmholtz Centers.

As an incentive to actively get involved and contribute in the network, fast and non-bureaucratic help to domain scientists at Helmholtz Centers will be provided for small problems. For example, PhDs with a concrete problem in imaging sciences can consult the HIP Core Team. In addition, the HIP can provide funds for a short-term stay at the host institute of experts from the HIP network. As the scientific branch of the Core Team is involved in many different projects from different research domains, it serves to promote and strengthen the network of experts at the Helmholtz Centers, bridging the gap to other Helmholtz platforms, and to external partners within the national and international context.

In order to expand the network beyond academia HIP will furthermore **build bridges into industry** and establish and maintain contacts to companies working in the field of imaging or showing interest in imaging modalities and methods.

4.2 HIP CORE TEAM

The main driver for HIP is the **HIP Core Team**. One of the key tasks is establish, maintain and expand the HIP Imaging Network. In order to build a strong network and generate general benefit, the Core Team has to reach a certain critical size. The mission of the Core Team is to leverage imaging sciences within the Helmholtz Association and actively drive HIP. Consequently, the responsibilities of the HIP Core Team can be categorized into three main tasks:

- building and maintaining an internationally visible network of experts and enable synergies (Network & Synergies),
- driving and fostering imaging sciences in the Helmholtz Association (Science & Support),
- running the platform (Operation & Organization).

The scientific part of the platform will be led by two PIs that each heads a scientific group. Both groups constitute the **HIP Scientific Team** (see below). Furthermore, a HIP manager will be hired by the Host Lab of HIP who administratively manages the platform. Together with the scientific PIs the HIP manager forms the **HIP Coordination Team**. HIP has to expand and maintain the Imaging Network within and outside the Helmholtz Association. To manage outreach and dissemination two full time equivalents (FTEs) – namely a **scientific** and an **industrial relation officer** – will be responsible to achieve outreach activities such as to

- establish and keep contacts within the scientific and industrial environment,
- act as a scout and broker for interesting imaging datasets in the Helmholtz Association and
- organize community events.

Building bridges into industry has great potential and the cutting-edge scientific infrastructure at Helmholtz Association could give a competitive edge to German industry.

Speaking of imaging science today usually implies scientific computing and data science. Consequently, algorithm and software development is of utmost importance. To support this, a **technical team** of five people will be set-up as part of the HIP Core Team. The tasks are to

- ensure standards in SW development (together with the proposed platform HIFIS),
- suggest and improve widely used imaging SW frameworks and toolboxes,
- leverage SW modules of general interest and make them available, and
- consult on specific SW challenges such as code structure or efficiency.

In order to provide and maintain software solutions being developed within the projects, the Core Team will operate a **repository for software** and facilitate access to imaging data by providing an **imaging data portal**. Note that the imaging data itself should stay with the scientific groups who produced them. The goal thus is to make imaging data findable and accessible (following the **FAIR data principles**, (Wilkinson et al. 2016)). Similarly, the software repository can also include links to local software repositories at the centers. In this sense, the repository will be set up in a distributed way. Beyond making software available, the repository should contain curated software that meets certain quality standards. The latter have to be defined at the early stage of implementing the platform and then be adopted by all projects. Furthermore, expertise in software quality, standards for managing imaging data and corresponding metadata should be provided by the HIP Core Team in cooperation with the proposed technology services platform HIFIS and the metadata center HMC.

The technical team will further run a **platform for networking**, community building and dissemination. In addition, the technical basis for the **proposal system** will be provided.

To monitor and control cash flow within the framework of HIP, in particular the HIP projects, a **controller** will be employed. The controller will be in close cooperation with the Head Office of the Helmholtz Association.

Beyond Helmholtz context, other activities, such as preparing for relevant EU projects and large-scale international cooperation need to be established and supported. Since teaching is of crucial importance in order to foster imaging science within the whole Helmholtz Association, specific courses on imaging sciences will be offered by the HIP scientists within the context of the proposed Helmholtz Information & Data Science Academy HIDA.

The HIP Core Team will be located at the HIP headquarters. The latter will provide an attractive working environment for imaging scientists and administrative/technical staff making up the Core Team, as well as for short-term visits of scientists working in imaging projects.

HIP SCIENTIFIC TEAM

To leverage the scientific impact of HIP and foster imaging sciences in the Helmholtz Association, the Core Team shall comprise two Scientific Teams. Each team is headed by a principal investigator (PI), who is aimed to have an affiliation with a local university. The field of expertise should be located within computational sciences, data science or applied mathematics. The PIs should also possess methodological expertise in some of the imaging modalities relevant to HIP. Besides the PI, each of the groups includes two postdocs and 3 fully funded PhD positions. The scientific emphasis of the two teams has to accord to major challenges for imaging sciences within the Helmholtz Association and could potentially lie in the following fields:

- Efficient algorithms for big data imaging;
- Uncertainty quantification in multi-modal imaging;
- Knowledge discovery in imaging;
- Advanced methods for inverse problems in imaging.

The PIs pursue their own research as well as contribute to the HIP community in a 70/30 split, i.e., 70% of their time shall be devoted following their own research. For the remaining 30% of their time they are expected to contribute to HIP projects and provide general support within the HIP network. It is important to note that the Scientific Team can play an active role in the finding and selection of project partners. In this sense, the Scientific Team can be seen as a broker for project partners. Furthermore, the scientific staff advises HIP network members in the preparation of HIP project proposals, e. g., to refine project ideas. For scientific exchange HIP will also connect with other Helmholtz platforms, in particular the machine-learning platform HAICU, to incorporate AI in imaging.

To further expand the expertise of the Scientific Team and foster international exchange guest scientist can stay with the Core Team or at a participating Helmholtz Center up to half a year. This is an important feature to support transfer knowledge into the Helmholtz Association and in playing a leading role in imaging sciences. Funds for short term visits and invitations are centrally allocated with the HIP core.

In general, the fact that the scientific PIs of the HIP Core Team pursue their own research in imaging sciences guarantees that

- the Core Team drives methodological research in imaging topics of interest to the Helmholtz Association,
- the expertise provided to the HIP network is making use of latest developments in the field at the cutting-edge level,
- the scientists in the Core Team attract third-party funding to advance imaging research.

ROLES IN THE HIP CORE TEAM

The organization, administrative support, and outreach of the core group is estimated to consist of five FTE. Another five FTE are foreseen in the technical team. The two scientific groups together comprise another twelve FTE. The overview of all positions with brief description is shown in Table 1.

Table 1: Positions and their respective functions in the HIP Core Team

Position	Function
Administrative Manager	Managing the HIP Core Team, part of the HIP Coordination Team
Assistance	Team assistance (1½ FTE)
Controller	Controlling of the HIP projects (½ FTE)
Scientific Relation Officer	Maintaining & expanding the academic Imaging network in- and outside the Helmholtz Association
Industrial Relation Officer	Promoting all Imaging modalities & establishing/deepening contacts in industry
Staff SW Developer	Highly qualified SW developer for professional SW and code optimization (2 FTE)
Staff Programmer	Professional SW and code optimization (2 FTE)
IT Expert & Programmer	In charge of IT in the Core Team (1 FTE)
Principal Investigators	2 Professor positions (joint appointment with a local university) in the field of Imaging Sciences with relevance to research in the Helmholtz Association, part of the HIP Coordination Team
Postdocs	Work in the respective research groups & support HIP (4 FTE)
PhD Students	Work in the respective research groups (6 FTE)

4.3 HIP STEERING BOARD

Supervision of the HIP Core Team will be provided by the **HIP Steering Board**. The board will further consult the platform in decisions relevant for HIP as a whole. The members of the Steering Board can either represent imaging methods or imaging modalities, i.e., members are expected to have expertise in the field of imaging sciences. The Steering Board will be concerned with

- assessing timelines and resources for HIP projects,
- recommend HIP projects for funding to the IVF,
- defining and refining the HIP project criteria,
- supervision of the HIP Core Team – monitoring and controlling the activities,
- observe strategic direction of the HIP Core Team.

Thus, it is essential that the board meets face to face regularly, for example on a quarterly basis. A representative of the HIP Coordination Team shall be guest in the meetings of the Steering Board.

4.4 HIP PROJECTS

A strong incentive to enable interdisciplinary collaboration across Helmholtz Association and ultimately leverage the HIP network is given by **HIP projects**. Each Helmholtz Center should have a contact point, who closely works with the HIP Core Team, helping scientists at the center to engage themselves in the platform.

Projects are established following the **HIP project realization process**. HIP projects typically belong to one of the following categories:

- knowledge transfer between different domains of expertise,
- raising professionalism for existing initial prototypes,
- early prototyping of high-risk ideas.

Helmholtz scientists pursue their research within the scientific programs of the center. In addition, they will be able to **apply for HIP projects**, making use of the HIP proposal system described in the next Section.

Based on a peer-reviewed proposal system, scientists from the Helmholtz Centers can initiate collaborative projects. The blueprint of a HIP project shall be funded with approximately 300 k€ in total. Following the strategy of agile development, projects are expected to last roughly two years and typically lead to early prototypes/software, which can then be further expanded and refined. Deviations from this blueprint are possible. The HIP Core Team can be involved in HIP projects as project partner if the content fits their expertise. Thereby the HIP Core Team contributes to the Imaging Network by direct involvement into the projects. In this case no project funds will be allocated to the Core Team in order to avoid double funding. Another way of involvement of the Core Team is via the so-called **Project Support Team** (PST), which is explained in detail in Section 2.

Special emphasis for HIP projects is laid on developing innovative approaches, which tackle imaging problems that are not covered within POF programs. Such projects often are characterized by higher risk, and will therefore have demonstration character. Thus, HIP will provide seed funding for new ideas. Emphasizing the fact that funds will be reserved for projects which cannot be funded within existing Helmholtz funding schemes, a HIP project has to be submitted by at least two different centers and representing at least two different research fields. Note that this scheme does not imply a similar structure for the funds being provided, although this will typically be the case. Nevertheless, it might also be possible that a center serves as customer within a project proposal without receiving extra funding out of HIP.

HIP PROJECT PROPOSAL

For establishing a HIP project proposal system, HIP can rely on existing expertise, for example, coming from handling beamtime proposals for research using synchrotron radiation. As for HIP, there will be continuous submission of project proposals, which will then be externally reviewed by the SAC or PRP. The decision to recommend a project for funding will be taken once a year by the Steering Board, following project prioritization and availability of resources. HIP projects will typically start in the first quarter of the year. Criteria for selection of the projects are (these criteria can be further refined by the Steering Board and the SAC):

- *Interdisciplinary in nature:* HIP seeks to foster collaborative work across Helmholtz Research Centers and research fields. Hence, only projects from partners of different Helmholtz centers and at least two different research fields will be eligible. Of course, expertise to conduct the project must be available within the project consortium.

- *Added value in the Helmholtz community:* The results of the project are intended to benefit as many researchers as possible within the Helmholtz Association. For the proposal there has to be at least one determined 'user', being willing to adopt the solution provided by the project and assess its usability.
- *Scientific merit:* Projects need to reflect scientific excellence and show scientific impact.
- *Matching with the blueprint project:* Match in terms of cost and time with the blueprint project will have a positive impact on the project's priority.

PROJECT SUPPORT TEAM

Each accepted HIP project will be advised by an appointed **Project Support Team** (PST) that comprises a domain scientist of the respective field of application, a representative of the methodology in question, and a HIP Core Team member. The PST advises the project partners. The final deliverables will be jointly determined with the PST, in accordance with the general objectives of the projects. Therefore, the PST will be part of project kick-off as well as the milestone meetings.

HIP PROJECT REALIZATION PROCESS

The HIP project proposal has to address the criteria above. Furthermore, the approval process is intended to be short and efficient. A schematic view on a possible HIP project flow is depicted in figure 3. After submission of a proposal (see a draft proposal form in the Appendix), the project will be formally checked by the HIP Core Team and then proceeded to external peer review. The review is then supervised by the Scientific Advisory Committee (SAC) or the Project Review Panel (PRP). Based on the scientific review, a prioritized list of projects will be prepared by the SAC or PRP. This list is submitted to the Steering Board, which will finally recommend the projects to the President of the Helmholtz Association.

Details, technicalities for the quality assurance and documentations will be determined with the Initiative & Networking Fund.

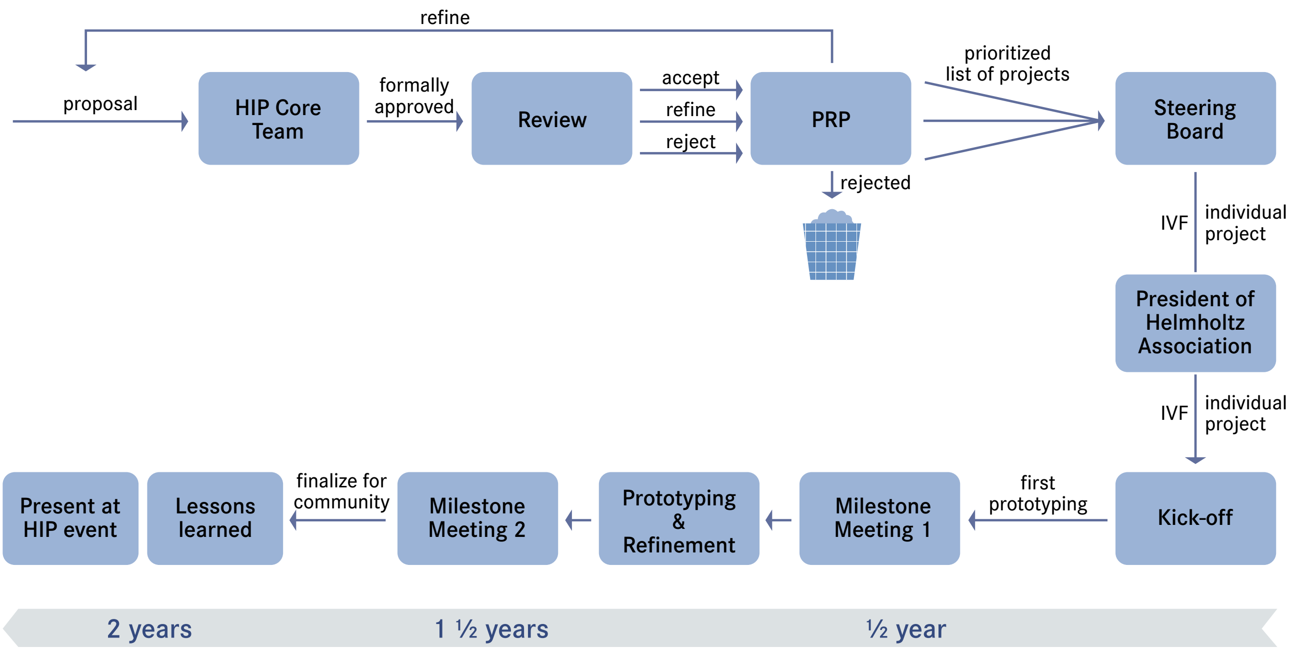

Figure 3: Flow of a project proposal from initial to final stages

Once the project is started, the time until the **first milestone meeting** is expected to be used for first prototyping and further refinement of the actual project deliverable. At the milestone meeting, the deliverables must be specified in detail. In particular, this flexible approach allows for high risk projects, which are often defined more broadly and uncertain in nature.

As mentioned earlier, the project partners are expected to follow an **agile development cycle**. Towards the end of the project, the emphasis of the **second milestone meeting** will be on the finalization and delivery of project results to the HIP community. In order for the community to benefit, the **project outcome and "lessons learned"** need to be prepared and communicated. For example, this can be a report and/or a presentation at one of the HIP events such as the annual conference.

In terms of software, **quality** and **documentation of the generated code** are vital for reuse. All of this will be reviewed in the second milestone meeting, which will need to cover points such as

- discussion of the actual outcome,
- explanation of deviation (if any) from intended deliverables,
- discussion on lessons learned,
- impact/benefit for imaging community, and
- work steps/preparation to make outcome available to the broader community.

Beyond the end of the project, management and maintenance of the resulting imaging data as well as further refinement of software will remain in responsibility of the respective research group at the Helmholtz Center. In case of general interest, however, the HIP Core Team can decide to take over responsibility in order to ensure optimal visibility and accessibility to the imaging community. Another possibility for HIP project partners is to apply for a follow-up project in the framework of HIP that will be reviewed in the HIP proposal process.

FINAL PROJECT ASSESSMENT

After finishing the project, the SAC or PST will provide a final assessment of the project. Part of the assessment will be some kind of user feedback. Since every HIP project needs to have at least one 'user' (beneficiary), the user feedback will be part of the project evaluation. Successful projects are then expected to be further pursued within the existing POF structures.

The HIP Core Team will compile an annual report including all finished HIP projects, which will be provided to the Steering Board and the Initiative and Networking Fund.

An important aspect of evaluation of HIP projects is the development of suitable performance indicators for interdisciplinary projects in data and information sciences. HIP will establish such KPIs, monitor them on its own activities and refine the indicators over time – in accordance with the Steering Board.

5 WORK PROGRAM

Establishing HIP also follows the idea of agile development. To be precise, **first projects can already be started while the platform itself is being set-up**. For this purpose the Kick-off Team can serve as a preliminary Steering Board and the Head Office of the Helmholtz Association can conduct the scientific review process. This is possible, because there have been several overarching activities within the Helmholtz Association with imaging sciences playing a role. For example, the Helmholtz Think Tank has initiated a bottom-up initiative on imaging with two workshops being organized in the sequel. Second, a proposal for a Future Project Helmholtz Image Computing Partnership (H-ICP) has been submitted with suggestions for teams crossing research fields which are able to submit a proposal within short notice. Finally, Imaging at the Limit, being one of the Helmholtz Incubator Pilot Projects is currently delivering the prototype for a HIP style project, comprising four partners working on two use cases.

Consequently, the **HIP roadmap towards operation** naturally comprises two lines of activity running in parallel. On the one hand, necessary steps will be initiated and undertaken to get HIP running in its full operational mode. The various components have to be set-up and modes of operation have to be defined. On the other hand, work on scientific projects can start immediately, building on the pool of expertise in imaging sciences which is already part of the Helmholtz Incubator and its working group on imaging.

5.1 ROADMAP TOWARDS OPERATION

The Helmholtz Imaging Platform will be installed in two phases and then continuously operated in phase 3. During the **initialization phase** a Kick-off Team will support the Host Lab of HIP to initiate first steps, e.g. recruiting the administrative HIP manager being the most important one. An initial technological platform will be established, building on existing services provided by participating centers.

To get science to work as quickly as possible, initial project sketches have been collected (a selection of which can be found in the Appendix).

The Kick-off Team is suggested to consist of 11 people, being recruited from both, the Helmholtz Incubator and the working group on imaging. The Kick-off Team will be elected by the Assembly of Members of the Helmholtz Association. With the end of the initialization phase, the Kick-off Team will have accomplished its mission and will be released. By then the Steering Board should be established.

The main tasks of the initialization phase are to

- organize the **HIP kick-off workshop** constituting the basis for the HIP network,
- get an **initial HIP technology platform** running,
- set-up the HIP Core Team, and
- start initial HIP projects.

Following initialization, there will be a **pilot phase**. Within this period, the HIP core will leverage its full operational size. The main executive body being responsible for this phase is the HIP Coordination Team which can be supervised by the Steering Board. The Coordination Team will coordinate the technology platform to be established on a sustainable basis and all administrational processes to be finalized and put into action. Experiences from the first round of HIP projects will allow the Steering Board and the SAC to define early criteria of measuring performance and also refinement of the HIP project realization process.

At high priority, HIP has to be made visible to the outside world, and the network of external relationships has to be built. Thus, HIP will start dissemination and outreach already by this early stage.

With the end of the pilot phase, a **first evaluation of the processes and working procedures** can be done, leading to a second round of refinement. Finally, it is expected that HIP will be **fully operational early in the first quarter of 2022**.

In the following, the work program leading to HIP being fully operational is split-up into working packages.

5.2 WORK PACKAGES

The work packages, which contain their respective tasks and milestones, are graphically represented by a Gantt chart in 9.3 of the Appendix.

WP1: PRELIMINARY SETUP

Duration: Q4 2018 – Q2 2019

Responsible: Kick-off Team

Kick off workshop

To provide the basis for the HIP network and establish the liaison with each of the Helmholtz Centers, a HIP kick-off workshop will be organized soon after approval (Q4 2018). This meeting will formally establish the HIP community, getting it on track towards the common goal and allow for an early discussion of ideas, expectations and common plans. The workshop will thus constitute the HIP network. Envisioned candidates for the Scientific Advisory Committee will also be invited.

Setting up Scientific Core Team

In order to get the HIP Core Team started, an administrative HIP manager has to be recruited as soon as possible. Therefore, the Kick-off Team supports the Host Lab in working out an explicit job description for the position, scouting for suitable candidates and starting the recruiting process. The administrational support needed for recruiting and hiring will be provided by the hosting Helmholtz Center.

Establishing the HIP Steering Board

To be able to supervise the following pilot phase, the Kick-off Team can support the establishment of the Steering Board. As a first step, the modes of operation for the Steering Board have to be defined and adopted. Then candidates for the Steering Board will be suggested. Naturally, members of the Kick-off Team may also serve on the Steering Board, ensuring continuity in setting up the platform. The Assembly of Members of the Helmholtz Association elects the HIP Steering Board and supervises the development of all Helmholtz platforms.

Quick start of pilot projects

The second part of this work package comprises activities necessary for the execution of the first round of HIP projects. Based on the project sketches foreseen during the planning phase, candidates for early projects have to be selected and invited to submit a full proposal. Towards this aim, the formalities for HIP project proposals have to be revised and finalized for the initial stage. In case the SAC or the PRP are not yet in operation, the Head Office of the Helmholtz Association will organize a scientific review process. Note that with the initial projects to be selected, the project realization process can be initialized. Following the agile principles, details of the process will be defined and adopted along the way.

WP2: ADMINISTRATIONAL SETUP

Duration: Q4 2018 – Q2 2020

Responsible: Kick-off Team / HIP Coordination Team taking over after being hired

Recruitment

Once the HIP manager is hired, job requirements and responsibilities for other positions of the HIP core need to be finalized. In order to get the recruitment process running, a HIP recruitment team might be established at the Host Lab. The team will scout for candidates for the PI positions, scan for possible university affiliations and publish job offers. Likewise, job descriptions for the other HIP positions have to be finalized and the hiring process has to be initiated.

Formation of SAC and PRP

In parallel, the other bodies of HIP need to be established. A list of candidates for the SAC has to be compiled and presented to the President of the Helmholtz Association for selection. Candidates have to be contacted and asked for their willingness to serve on the board. As a next step, the PRP can be appointed by the SAC. For both panels, modes of operation have to be defined and finally being adopted by the Steering Board.

Project Management

Being an essential component of HIP, projects need to be run on a professional level. Therefore, proper project management has to be set-up and criteria for project quality control have to be adopted with the Steering Board. In particular, processes for financial control and reporting have to be defined. Again, following agile principles, initial criteria will be adopted quickly, with refinement and addition of other criteria following over time. Keeping the focus on the scientific value, processes and deliverables have to be selected carefully reflecting administrational load coming along with such measures. Digitalization and automatization will have to be considered and utilized right from the beginning.

Development of contract portfolio

Due to the legal set-up of the Helmholtz Association with all its members being legal entities on their own, every project needs to be run within a proper legal framework. To reduce the administrational overload coming along with such necessities, templates for the various contracts required for projects have to be formulated and cross-checked in accordance with the rules and regulations of the Helmholtz funding procedures.

WP3: TECHNOLOGICAL SETUP

Duration: Q4 2018 – Q3 2021

Responsible: Kick-off Team / HIP Coordination Team taking over after being hired

Setting up a website

The HIP technological platform can be initialized using services provided by the participating Helmholtz Centers. Among the first priorities will be the set-up of the HIP website to make HIP become visible in the digital world and to serve as a portal for collaboration and internal processes. This website contains detailed information on HIP, members being involved, expertise being provided and events being organized. In addition, the website will help the community of researchers to get informed about imaging modalities at respective Helmholtz Centers as well as interesting datasets and software being provided by the Helmholtz imaging community.

Initializing the HIP communication platform

To allow for communication within HIP and with the platform, email lists will serve as an initial tool. The more HIP is becoming operational, the further will be the advancement of the HIP technological platform. A workflow management will be needed as well as an electronic proposal system for HIP project realization process. In addition, interfaces for the HIP software repository have to be developed as well as the HIP data portal. The latter is assumed to operate as data broker rather than a data repository itself. Nevertheless, interesting showcase datasets may also be provided as well as stimulating data challenges being published. In particular, the latter can help to increase the visibility of HIP very quickly.

Evaluation, selection, installation of collaborative tools

To facilitate collaboration within HIP, online web-based tools are necessary. These tools will be realized based on cloud technology. Since HIP is not special concerning its needs for collaboration tools, selection and adoption of tools will be done in close interaction with the Helmholtz technology platform HIFIS.

Provide software repository

Since the aim of HIP is to develop prototypes or algorithms in conjunction with imaging modalities, there is a necessity of software repository for HIP community and other researchers working in the imaging domain. This repository will help in storing developed code within the project framework at one place, and offer possibilities for later access. Together with the other Incubator platform HIFIS, HIP will facilitate the access to the software repository. Note that making use of a proper software repository is part of professional software development with versioning and documentation being essential components. Thus, in addition to providing a technological platform, the HIP Core Team will define and supervise minimal standards of quality for software development within HIP. Being aligned with the developmental goals of the HIP projects, software standards might reflect varying Technology Readiness Levels (European Commission 2014).

Provide frontend to data repositories

With imaging data being one of the essential assets of the Helmholtz imaging community, access to imaging data has to be facilitated and promoted. Following the FAIR principles, one of the major goals will be to make imaging data findable and accessible. With HIP being internationally visible, the HIP Core Team will provide a HIP data portal, comprising links to various resources of imaging data and repositories within the association. In addition to providing a comprised interface to imaging data, the HIP data portal will also highlight data sets of particular interest, acknowledging the fact that challenging datasets may serve as promoter of making research at Helmholtz visible for the larger data science community worldwide. An important aspect of data handling is its preparation for automatization. Therefore, proper metadata standards for imaging data are indispensable. HIP will adopt such standards if existing and develop new ones in other cases. This will be done in close collaboration with the proposed Helmholtz Metadata Center (HMC). The rights of the Helmholtz Centers as data owners remains untouched by these offers.

WP4: QUALITY MANAGEMENT

Duration: Q2 2019 – Q1 2022

Responsible: HIP Coordination Team / HIP Core Team

In order to check and maintain quality management right from the beginning, measures have to be planned and implemented guaranteeing quality control. In particular, criteria for project proposals, project development and project evaluation have to be defined and continuously monitored in accordance with the rules and regulations of the IVF. Analogously, suitable performance indicators have to be adopted for the HIP Core Team, its services to the HIP community and its own development. HIP will develop, monitor and evaluate a set of key performance indicators with the Steering Board, which eventually are envisaged to become part of a new scientific reporting scheme which better honors the work of enabling scientists. In order for such criteria to be tested and evaluated, processes of monitoring have to be established. Needless to say, quality control will also be of utmost importance in the selection and evaluation of HIP projects. HIP will profit from experience of large-scale research facilities, for example, synchrotron facilities in establishing efficient processes of application and evaluation minimizing efforts on both sides, project applicants and reviewers. Again, following agile principles HIP will start with early adoptions which will then be refined and improved as experience increases.

WP5: INTEGRATION, DISSEMINATION AND OUTREACH

Duration: Q3 2019 – Q1 2022

Responsible: HIP Coordination Team / HIP Core Team

Integration

HIP is just one out of five proposed Helmholtz data science platforms. From a high-level point of view, HIP also promotes information and data science within the Helmholtz Association. Therefore, HIP needs to integrate with other data science activities, such as the Helmholtz Incubator pilot projects, Helmholtz data science schools, Helmholtz future projects and the other incubator platforms. Cooperation will start as soon as the platforms begin to develop, aiming at leveraging synergies at a very early stage. Therefore, relations and modes of collaboration with relevant existing activities have to be established as soon as HIP is operating.

Scouting for interesting collaborations can start as early as the kick-off workshop. Nevertheless, internal set-up and getting HIP running on its own will have higher priority at the beginning. With HIP operating in its initial state, integration will be started. One particular focus of integration will be laid on the selection of certain imaging modalities at participating Helmholtz Centers, serving as test beds for various HIP services. These modalities will be selected being aligned with the research focus of the initial projects.

Dissemination

In order to foster exchange, dissemination activities will be started within the pilot phase. Among these are

- organization of an annual HIP meeting including presentations of the initial projects,
- creation of posters, flyers etc. presenting HIP,
- presentation of HIP at national/international scientific conferences,
- organization of regular seminars for the participating scientists,
- incorporation of national and international expertise through invitation of guest scientists and guest speakers at HIP events,
- reaching out to other imaging consortia both, within the national and international level, and
- establishment of courses related to imaging sciences within the framework of HIDA.

6 GOVERNANCE

A proper embedding of HIP into the Helmholtz Association is necessary to guide the HIP network along with the HIP Core Team and coordinate its development. To implement HIP, it will be located at a Helmholtz Center (host lab). The host lab should fulfill certain criteria which can be found in A4 in the Appendix. The host lab has the disciplinary responsibility for the personnel of HIP. It operates HIP in accordance with the goals and services agreed to by the host lab with the Helmholtz Association. To this end and in line with the general considerations to embed the platforms into the Helmholtz Association (these principles are described for all platforms in the general opening chapter), the following structure is proposed (see Figure 4).

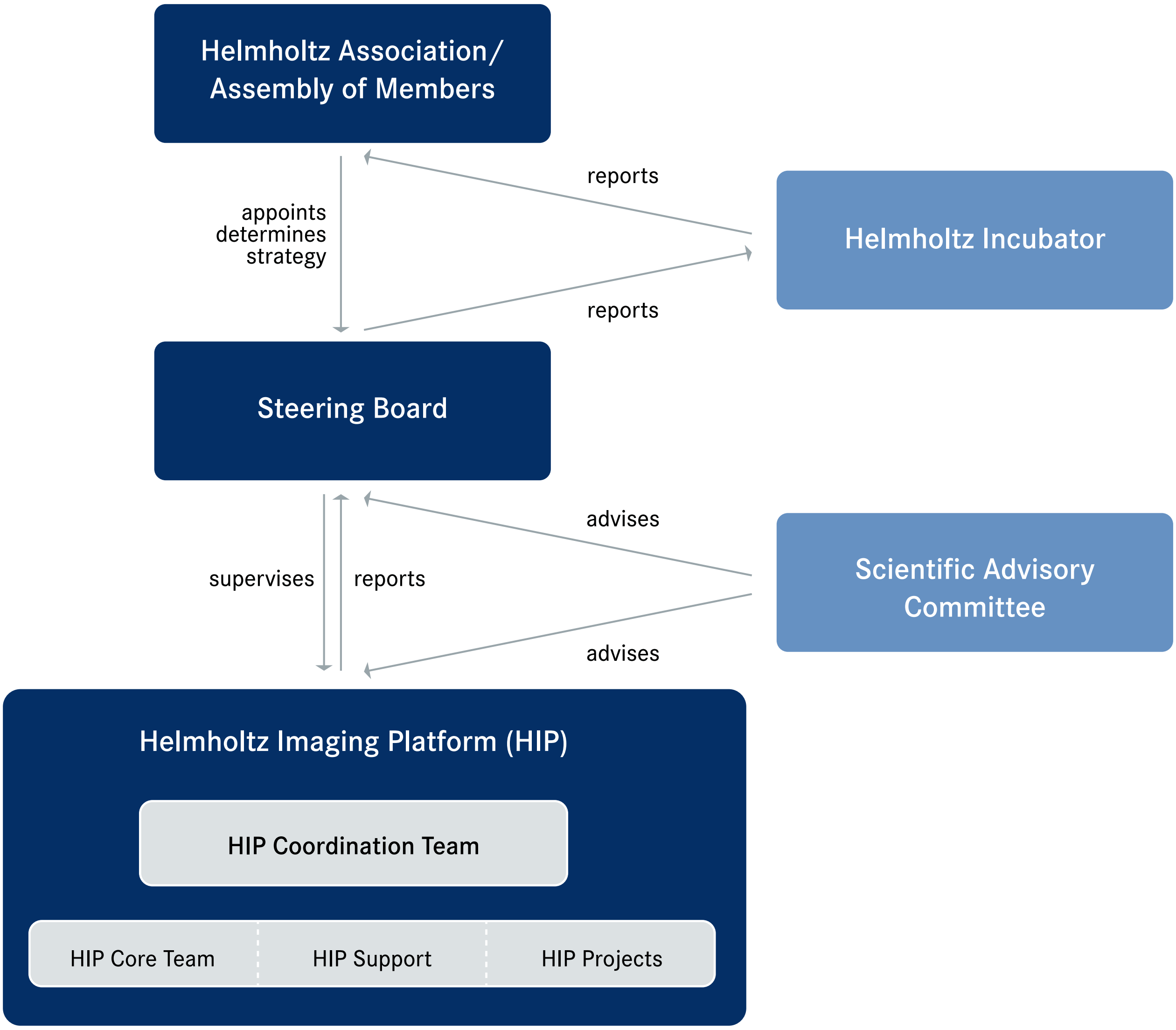

Figure 4: Schematic illustration of the integration of HIP into the Helmholtz Association. The platform is integrated into the operational and disciplinary authority of the Helmholtz Centers that host HIP (not shown in the illustration).

6.1 THE HIP STEERING BOARD

The **Steering Board** supervises the HIP Core Team and monitors the HIP project realization process. The Steering Board shall consist of 7 members. Every Steering Board member shall have a direct affiliation with one of the Helmholtz Centers and shall represent the research fields of the Helmholtz Association. The board assesses matters regarding the overall financial plan, steering and supervision of the HIP Core Team, and it accounts for observance of the strategic direction within the strategic guidelines defined by the Assembly of Members of the Helmholtz Association. It recommends projects for funding after a review by the SAC or PRP. It reports to the Helmholtz Incubator which then reports to the Assembly of Members of the Helmholtz Association. One representative of the HIP Coordination Team and the Head Office of the Helmholtz Association shall be guests of the meetings of the Steering Board.

The Steering Board shall be consulted in case of conflicts of interest regarding the HIP network or the HIP Core Team.

The Steering Board is constituted by the Assembly of Members of the Helmholtz Association. External scientific advice will be provided by the SAC.

6.2 COORDINATION OF THE HIP CORE TEAM

The general management of the platform shall be jointly taken by the two scientific PIs and the administrative HIP manager, the HIP Coordination Team. Together they can take decisions concerning scientific direction, supervision of the HIP core personnel, organization of processes and steering of the HIP Core Team. The administrational issues of the platform are managed by the HIP manager, who is accountable for resource planning, financial performance, and personnel matters within the rights and duties delegated by the directors of the host lab. The members Coordination Team will elect among themselves a representative who will be guest in the meetings of the Steering Board and represent HIP externally.

6.3 THE SCIENTIFIC ADVISORY COMMITTEE

External scientific advice for the development of HIP will be provided by the Scientific Advisory Committee (SAC). The committee’s central mission is to prevent HIP from being dominated by its internal perspective.

The SAC shall be comprised of 5 national and international experts outside of the Helmholtz Association and advises the HIP Steering Board on all scientific aspects and the overall development of the platform. In addition, the SAC can advise on standards for software development and management of imaging data as well as suitable metadata standards. The members of the SAC shall be appointed by the President of the Helmholtz Association. Meetings of the Steering Board and SAC are envisaged at least once a year, being aligned with the HIP annual event.

6.4 THE PROJECT REVIEW PANEL

The SAC can appoint a subcommittee to evaluate project proposals. The Project Review Panel (PRP) shall be recruited from the HIP network and shall have 5 members. It shall assess the scientific quality of HIP project proposals. Therefore, it can drive the project review process and assign priorities to the project proposals. Criteria for project review are defined by the HIP Steering Board, which is advised in these matters by the SAC and the Initiative and Networking Fund. The PRP could meet once a year in order to work out a prioritized list of projects, which will then be submitted to the HIP Steering Board. The decision on recommending a project for funding stays with the Steering Board – being subject to availability of resources. The final decision regarding projects funded by the Initiative and Networking Fund (IVF) lies with the President of the Helmholtz Association.

6.5 HIP WITHIN THE IMAGING COMMUNITY

At a glance HIP cannot be seen as a monolithic, self-contained unit but rather as an embedded structure in an already existing landscape, which is visualized in Figure 5. HIP will build on this established network of experts and further strengthens it with its activities, especially with the projects. The network is a core feature of HIP to attain the described goals for the benefit of the whole association.

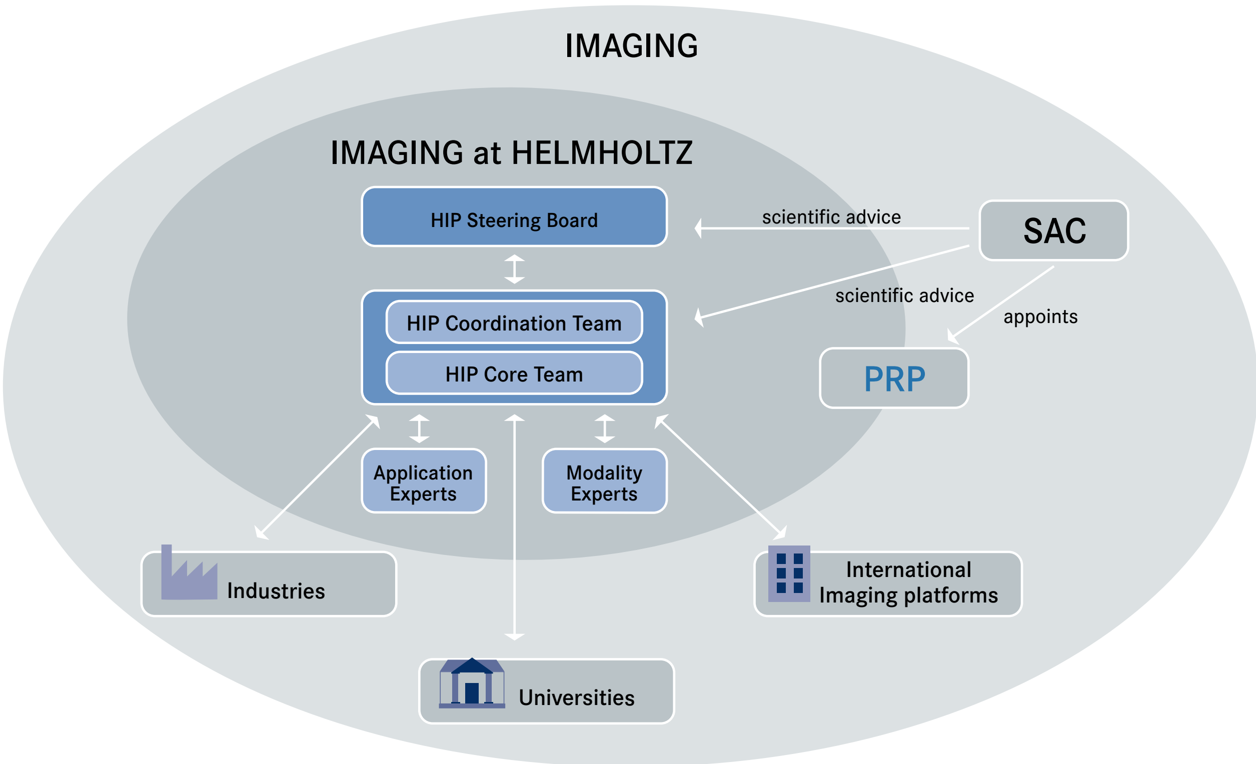

Figure 5: HIP and the interplay in the imaging community

The HIP components have been selected to make best possible use of this interdisciplinary scientific environment. Further openings and adjustments are subject to the future development of the platform.

6.6 ASSESSMENT OF HIP

The success of Helmholtz Incubator platforms such as HIP depends on several factors. Here, we summarize reports and the key performance indicators (KPIs), which are deemed to be essential to the evaluation of HIP.

REPORT

The HIP Steering Board will periodically report to the Helmholtz Incubator. Then the Incubator reports to the Assembly of Members of the Helmholtz Association. Furthermore, an annual HIP report will be published highlighting HIP projects and other achievements of HIP.

As mentioned before, performance indicators should cover all the activities of HIP as a platform for imaging sciences within the Helmholtz Association.

KEY PERFORMANCE INDICATORS

It is essential to make the impact of HIP measurable. To capture all aspects of interdisciplinary, enabling research a suitable set of Key Performance Indicators (KPIs) will be needed. In addition to established KPIs to measure scientific output such as publications, citations, etc., we suggest to use more refined KPIs, in order to monitor the impact of the platform in terms of networking and its use as driver of interdisciplinary research. First ideas for such KPIs have been collected:

- number of projects realized and the satisfaction of the beneficiaries,
- number of Helmholtz Centers being involved,
- number of guest researchers participating in HIP projects,
- feedback from Helmholtz Centers,
- visibility of HIP platform as being measured by usage of its internet representation,
- number of prototypes and/or software products and their utilization,
- number of HIP community events and participation, and
- active promotions of HIP in international events.

HIP will further develop and refine these KPIs together with the Steering Board and the SAC. This is an opportunity to derive new KPIs being ultimately able to better reflect different facets of research on enabling technologies, its visibility, user satisfaction and adoption of solutions by the scientific community. This is essential in order to assess the full added value of HIP to the Helmholtz Association and the imaging community as a whole.

7 LONG-TERM POTENTIAL

7.1 INTERNAL

Imaging is omnipresent within all the research fields of the Helmholtz Association. There is a vast imaging expertise scattered over different research domains. Currently, there are many independent developments, leading to many doubled efforts and inefficient use of resources. The HIP network lies at the heart of the platform and will bring together researchers from imaging science, operation facilities and various applications. This will create awareness for imaging developments within the Helmholtz Association and enable quick and efficient transfer of knowledge to all research fields. HIP provides a forum to join forces addressing imaging needs by combining expertise from different fields of science. The HIP projects provide an essential instrument to enable such synergetic collaborations in a flexible and application oriented way, providing imaging solutions beyond the particular use case. In addition, the HIP Core Team serves as a focal point of the network, reaching out to all scientists guiding and advising in imaging related matters and defining standards for imaging software and imaging data.

On the long run, the Helmholtz Imaging Platform will leverage the synergies in imaging science within the Helmholtz Association, promote interdisciplinary research, broker imaging solutions and data, and educate scientists on all levels. Doing so, imaging technologies will become available on a routine basis, allowing scientists in fields of application to focus on their specific expertise. At the same time, the Helmholtz Association will be able to leverage imaging research at the level of the association without the need to establish a new research field.

HIP will provide one of the first examples of a scientific platform being operated by the Helmholtz Association as a whole and serving the needs of all centers. It will provide a research environment, which does not challenge the current organization of science at the centers. On the contrary, the dynamic character of research driven by HIP paves new ways of collaboration across traditional boundaries. As such, HIP reflects the overall trend in science towards interdisciplinary collaboration.

7.2 EXTERNAL

By comprising imaging activities within the Helmholtz Association into a joint platform, HIP will significantly enhance international visibility of these activities. In addition, special outreach activities are foreseen. In particular, international visibility of HIP will be realized by making imaging data available to the international scientific community, thereby enhancing the visibility of Helmholtz Association in the domain of 'Information and Data Science'. In addition, the HIP Platform will be internationally visible by collaborating with other imaging experts from academia and industries. The outreach activities of HIP will be strengthened by presenting the HIP platform at international conferences, summer schools, workshops, as well as organization of dedicated events such as hackathons, 'datathons' and other scientific events.

Imaging sciences is not driven by academic research only. Industries, as providers of technology, adopters of standards and developers of software, play an important role in driving imaging technology. Scientific applications often push existing technology towards its limit, providing the basis for future development. Furthermore, unique imaging modalities being operated by the Helmholtz Association are of high interest for industrial partners. Therefore, on a longer perspective, HIP should also strengthen its interaction with partners from outside academia. In particular, this will be of high interest within the context of digitalization and artificial intelligence.

Imaging at Helmholtz is not just methods or data – **Imaging at Helmholtz is data and methods embedded within fascinating applications!**

8 FINANCIAL PLAN

We expect HIP to be working at full cost in 2020. By then the personnel will be fully hired and all board members will be engaged.

The total annual cost planned is 4,376 k€ and can be split into static cost of 2,876 k€ and dynamic cost of 1,500 k€. The static part will be permanently needed to run the HIP platform and can be further split into personnel and nonpersonnel costs, 1,868 k€ and 1,008 k€, respectively. See Table 2 for an overview. Dynamic costs are used to fund HIP projects. Those project funds are IVF funds which can change on a long-term perspective. The envisaged initial set-up of 5 projects per year represents a lower estimate. IVF funds require matching which shall be kept reasonably low in order to as well allow HIP projects with higher risk. The details in this regard, however, will be then settled in accordance with the IVF.

A major part of the HIP budget is directly redistributed to the Helmholtz Centers. This is achieved by allocating HIP project funds, scientific support of the HIP Core Team or external scientific input of HIP funded visiting scientists. For a more detailed financial plan of HIP in full operation please see section 9.9. Furthermore information on the finances required for the ramp-up of HIP can be found in section 9.10.

Table 2: Grouped annual cost in k€ of the Helmholtz Imaging Platform. Here, the aggregated cost representation according to the formal specification of the Head Office of the Helmholtz Association. It shows the expected costs per year for the fully established platform, broken down into personnel (with overhead) and material costs (basic funded) and project costs (IVF-funded). Estimates of the working group underlying this presentation are found in section 9.9.

HIP FINANCIAL PLAN

platform part field of engagement *cost type*	**costs p.a. in k€**
Administration	
Management, Controlling etc	
nonpersonnel costs	30
personnel costs	228
Outreach, Communication	
nonpersonnel costs	108
personnel costs	175
subtotal	**541**
HIP Core Team, Project Support Team	
Technical Staff, Software Development	
nonpersonnel costs	180
personnel costs	378
Scientific Staff	
nonpersonnel costs	300
personnel costs	1,087
subtotal	**1,945**
Projects & Scientific Exchange	
Guest Scientists	
nonpersonnel costs	240
HIP Projects (#5 per annum)	
Project funds	1,500
subtotal	**1,740**
Events	
HIP events	
nonpersonnel costs	120
External events	
nonpersonnel costs	30
subtotal	**150**
total p.a.	**4,376**
therof:	
nonpersonnel costs (basic funding)	1,008
personnel costs (basic funding)	1,868
project funds (IVF funding)	1,500

9 APPENDICES

9.1 ABBREVIATIONS

AI	Artificial Intelligence
AWI	Alfred-Wegener-Institut
DESY	Deutsches Elektronen-Synchotron
DFG	Deutsche Forschungsgemeinschaft
DKFZ	Deutsches Krebsforschungszentrum
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DZNE	Deutsches Zentrum für Neurodegenerative Erkrankungen
FAIR	Findable, Accessible, Interoperable, and Re-usable
FTE	Full-Time Equivalent
FZJ	Forschungszentrum Jülich
GEOMAR	Helmholtz-Zentrum für Ozeanforschung Kiel
GFZ	Helmholtz-Zentrum Potsdam – Deutsches GeoForschungsZentrum
GSI	Helmholtzzentrum für Schwerionenforschung
HAICU	Helmholtz Artificial Intelligence Cooperation Unit
HIDA	Helmholtz Information & Data Science Academy
HIFIS	Helmholtz Infrastructure for Federated ICT Services
HMC	Helmholtz Metadata Center
HMGU	Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt
HZB	Helmholtz-Zentrum Berlin für Materialien und Energie
HZDR	Helmholtz-Zentrum Dresden-Rossendorf
HZG	Helmholtz-Zentrum Geesthacht
HZI	Helmholtz-Zentrum für Infektionsforschung
IPP	Max-Planck-Institut für Plasmaphysik
IVF	Impuls- und Vernetzungsfonds
KPI	Key Performance Indicators
KIT	Karlsruher Institut für Technologie
MDC	Max-Delbrück-Centrum für Molekulare Medizin
PETRA	Positron-Elektron-Tandem-Ring-Anlage

PI	Principal Investigator
POF	Program Oriented Funding
PRP	Project Review Panel
PST	Project Support Team
SAC	Scientific Advisory Committee
SW	Software
UFZ	Helmholtz-Zentrum für Umweltforschung
XEFL	X-Ray Free-Electron Laser Facility

9.2 POTENTIAL PROJECTS

IMPROVED REGULARIZATION FOR SPECTRAL ELECTRICAL IMPEDANCE TOMOGRAPHY DATA

J.A. Huisman[1], E. Zimmermann[1] and R. Griesmaier[2], F. Hettlich[2]

[1] FZJ, Earth and Enviroment

[2] KIT, Key Technologies

Project idea and its background

Spectral electrical impedance tomography (EIT) is an imaging method to obtain the subsurface distribution of the complex electrical conductivity in the mHz to kHz frequency range. It can be used to characterize subsurface structures and to monitor subsurface water flow and solute transport. However, the ill-posed electrical inverse problem requires appropriate regularization for meaningful results. Typically, a smoothness-based constraint is used to find the smoothest model that accurately describes the measured data (see Figure, [1]), but this may lead to an overly smooth subsurface representation especially in the presence of distinct layering or cavities. In addition, spectral regularization may also be required because of frequency-dependent measurement errors that affect the imaging results differently for each considered frequency.

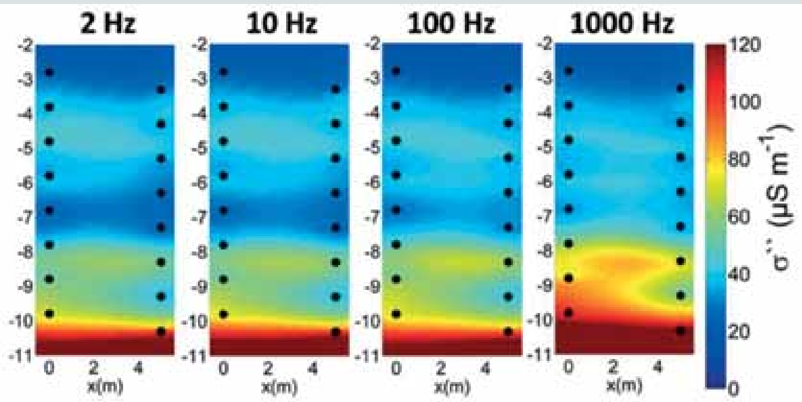

Figure: Imaging results for the imaginary part of the complex electrical conductivity at frequencies of 2, 10, 100 and 1000 Hz using a smoothness based inversion approach.

Scientific impact of the project

Within this context, the aim of this project is to **develop improved regularization strategies for tomographic reconstruction** of complex electrical conductivity distributions in soils and aquifers. Three different strategies of increasing complexity will be explored. In the first strategy, an edge detection method will be developed in order to derive models of subsurface structures during post-processing of spectral EIT images. In the second strategy, different approaches to manipulate the regularization matrix will be used in order to obtain models that closely mimic subsurface structure directly from the imaging process. In particular, methods that penalize smoothing across boundaries and image-guided inversion will be extended to spectral EIT data. In the third and final strategy, model-based inversion with a reduced amount of model parameters will be implemented. A detailed evaluation of these regularization strategies is essential for the establishment of spectral EIT as a viable method for subsurface characterization.

References

[1] M. Kelter, J.A. Huisman, E. Zimmermann, A. Kemna, H. Vereecken, J. Appl. Geophys. (2015), 333-344

ACCURATE BRAIN MYELIN MAPPING BY GEOPHYSICAL JOINT INVERSION CONCEPTS

Tony Stöcker[1], Hendrik Paasche[2]

[1] DZNE, Health

[2] UFZ, Earth and Environment

Project Idea and Background

Magnetic Resonance Imaging (MRI) is a routine tool in clinical diagnostics. In the past MRI was mainly used for subjective image reading by experienced radiologists, but the technology can be extended to quantitative biophysical tissue parameter mapping. The MRI signal depends on many biophysical processes. Sensitizing the acquisition to the process of interest enables parameter estimation by subsequent model fitting of the MRI data. An important example is the estimation of myelin content. Myelin is a major factor for brain structure and function and brain demyelination is a consequence of many neurological diseases, e.g., multiple sclerosis. Since myelin affects many physical processes, there are different MRI-based approaches for myelin quantification. Currently, the most promising methods are: 1) the trapped water in the myelin sheet gives rise to a second component in relaxation spectra, 2) the large myelin molecules are in constant chemical exchange of protons with surrounding free water, affecting the MRI magnetization transfer contrast, 3) thickness of the myelin sheet affects diffusion of water, 4) myelin is diamagnetic and therefore affects measurements of magnetic susceptibility in tissue. These approaches are based on model simplifications and assumptions, which result in biased estimates of myelin content. The idea of the proposed project is to simultaneously fit two or more of these models by utilizing joint inversion approaches well-known from geophysical imaging. Due to the inherently ill-posed nature of geophysical inverse problems, there exist long experience and a variety of mathematical tools to combine data of different physical nature to fit a single (e.g., [1]) or even different (e.g., [2]) material parameter. Such methodology was not yet applied in medical imaging applications. A massive improvement with respect to accuracy and reproducibility of myelin mapping is expected by combining complementary information drawn from several MRI acquisitions.

Scientific Impact

Accurate mapping of brain myelin content is a promising biomarker for early detection of many neurological diseases and of high diagnostic value. Myelin mapping with high sensitivity can play an important role for future personalized precision medicine. Realization of accurate brain myelin mapping by combining complementary information from several MRI acquisitions may open new opportunities for reduced sampling efforts, since different methods mutually support each other in parameter fitting and high-resolution imaging. **Transfer of geophysical joint inversion techniques to relatively better-determined medical imaging problems** may help to better understand potential and flexibility of different linkage concepts in use and their impact on the search space of the joint fitting problem.

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DATA BASED INVERSION OF THE ELASTIC WAVE EQUATION – ALGORITHMS FOR PLANETARY SEISMOLOGY AND PHOTOACOUSTIC IMAGING

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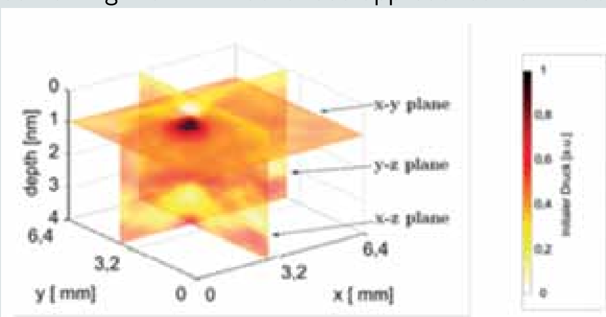
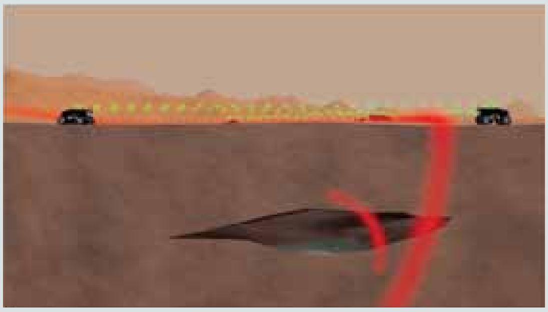
Explain the project idea and its background

Rooted in the elastic wave equation, imaging modalities such as seismic tomography or photoacoustic imaging have been developed, which allow to visualize internal structures in a non-destructive way. These methods are based on reconstructing the initial state displacement field from measurements on the boundary of the region of interest. In seismic tomography, the so-called full waveform inversion has been suggested in order to overcome limitations of the common ray theory. In photoacoustic tomography, a new experimental setup has recently been proposed, based on the induction of elastic waves by thermal expansion. Formally, both approaches rely on the same mathematical model. This opens possibilities for potential synergies and cross-fertilization of scientific and technical methods. The algorithmic challenge for both application domains lies in estimating the parameters of the model in an efficient and reliable fashion. Using methods being developed in the field of inverse problems and combining them with advanced approaches from machine learning allows us to address these challenges.





Describe the scientific impact of the project

The project aims at combining insights from mathematical modelling of inverse problems with methods from machine learning, Bayesian estimation theory, and compressive sensing. The resulting techniques will enable an intelligent, information-driven approach towards model-based data acquisition and analysis. Through such an 'informed' way of learning, the algorithms make use of the physical model underlying the process of data acquisition. Combining technological insights from both, seismic tomography for future space exploration missions and photoacoustic imaging for in vivo bioimaging, will create potentials for innovation in both fields. Being quite universal, it is expected that the developed techniques can further be transferred to other imaging modalities.

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ROBUST CNN-BASED IMAGE ANALYSIS

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Project idea and its background

Image analysis solutions in the context of the Helmholtz mission have to be understood as reliable scientific measurement tools. Thus, uncertainties of results do not only need to be quantified, but also should be minimized as much as possible. Current Convolutional Neural Network (CNN) solutions do not deliver such information and are not optimized w.r.t. minimal errors or maximum reliability. A well-known example of such behavior is, that a small amount of well-designed noise, clutter or patterns, unnoticeable or irrelevant to a human observer, can shift classification results dramatically (usually called adversarial noise, digital dodging, fooling etc.). Similar effects can be caused by small image rotations, image scaling and illumination effects. First tools [1-3] allowing to measure model robustness, harden CNN models and meanwhile are even available for runtime detection of adversarial attacks. While these tools are a promising step towards more reliable CNNs, they do not systematically ensure well-balanced and robust CNN-based analysis tools. E.g. for classification, class labels should be assigned due to a rich set of features for each and every class. Current solutions may jump on a distinct feature for a certain class, just because this feature is singular for the used training set – e.g. every green thing would be a frog, just because the only green thing in a training set was a frog. In this project we will analyze how balanced CNNs perform, investigate balancing strategies, and develop algorithms for uncertainty estimation, thereby increasing reliability of CNNs and minimizing results' variances.

Scientific impact of the project

The project will deliver tools allowing to **analyze and balance available CNN-based imaging solutions, such that their reliability is increased**. Thus, it has the potential for a significant impact on all deep learning solutions used in scientific applications.

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IMAGING INFECTION PATHWAYS BY LOW-DOSE 3D X-RAY PTYCHOGRAPHY

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Project idea and its background

Infectious diseases are one of the major leading causes of death worldwide. The situation is growing more acute with the emergence of antibiotic resistant bacteria that threaten the effective prevention and treatment of infections. Bacterial pathogens specifically sense and manipulate host cells during infection. Identifying the source of the infection in a timely fashion ahead of the morphological changes induced by the pathogen on 3D imaging of volumetric samples will allow us to map the extent and severity of the disease and evaluate the success of the therapy response. We aim to use 3D X-ray microscopy, for visualizing host-pathogen interactions in cells and tissues during the course of an infection.

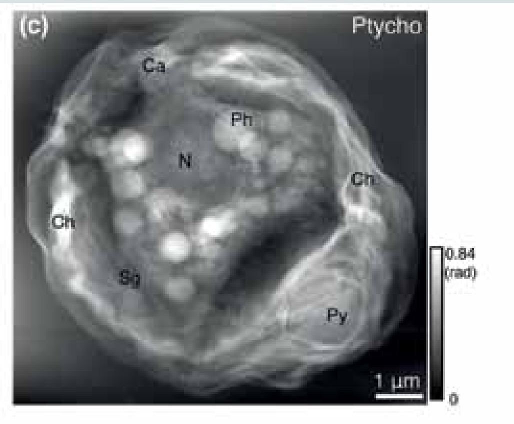

Figure: Ptychographic projection image of a frozen hydrated cell [2]

In biological tissues, hard X-ray absorption contrast is weak. At the same time, it is the tolerable dose that is limiting the contrast in X-ray micrographs of biological specimens [1]. Ptychography is a hard X-ray phase contrast microscopy technique that provides highest spatial resolution and sensitivity at comparatively low dose [3,4]. To obtain a 3D image of the specimen, currently, individual projection images are independently reconstructed, subsequently serving as input for tomographic reconstruction. In this scheme, the minimal dose is given by that needed to obtain convergence of the ptychographic reconstruction algorithm for a single projection, not taking into account the additional information about the sample available from the other projections.

Here, we propose to develop a full 3D combined ptychographic reconstruction algorithm that allows one to take full advantage of dose fractionation [5] that in the current approach cannot be applied due to the comparatively high dose requirements needed to obtain convergence of the ptychographic algorithm in 2D projections.

Describe the scientific impact of the project

By solving this algorithmic problem, we expect to reduce the required dose in 3D X-ray microscopy by more than one order of magnitude, making high-resolution 3D imaging of whole cells and tissues with spatial resolutions in the 10 nm range possible.

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DATA SCIENCE FOR REAL-TIME DIAGNOSTIC AND CONTROL OF PLASMAS

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Explain the project idea and its background

One of the outstanding opportunities for data science to have an enormous impact on next-generation, large-scale plasma experiments is to enable their real-time diagnostic and control. This is illustrated beautifully in experiments like ITER and XFEL. Entering the era of self-heated ("burning") plasmas, fusion research is characterized by large and expensive experimental devices like ITER, and there there is now a need to develop tools for real-time plasma control. In this context, simulation-based and data-based approaches have started to merge, and a recent study [1] has identified the use of AI for this purpose as a "First Tier Transformative Enabling Capability." A prerequisite towards this ambitious goal is the extremely fast inversion of tomographic data, e.g., from soft X-ray diagnostics, which allows for the determination of spatial characteristics of the plasma such as its shape and position [2]. Current methods to solve the tomographic inversion problem are way too complex and slow, but it was recently shown [3] how it can be reformulated within the mathematical framework of Bayesian statistics, also allowing for the use of machine-learning based approaches and the quantification of uncertainties. Based on these preparatory studies, we will investigate how deep neural networks can be combined with current classical inversion schemes to obtain robust and real-time capable inversion methods for plasma control applications. With the capabilities of high-brightness, ultra-short X-ray sources like the European XFEL (in combination with ultra-short, high-intensity infrared lasers) studying high energy density science [4] can now transition from looking at equilibrium states to studying transient processes such as fundamental plasma instabilities under extreme conditions [5]. In order to understand the complex dynamics of these processes, **the scarce and expensive experimental time available at such machines calls for real-time feedback to optimize experimental conditions on the fly.** To this goal, iterative inversion of imaging data to extract the fundamental plasma properties should ideally be replaced by single-step inference methods such as machine learning trained on synthetic data. Real-time feedback then heavily relies on fast parallel yet portable algorithms optimized for modern computing hardware and the flexibility to adapt to unforeseen situations on the fly. While cooperating on machine learning inversion approaches, we will focus on providing performance portable many-core computing capabilities with the flexibility of on-the-fly adaption of analysis algorithms.

Describe the scientific impact of the project

Real-time capable inversion techniques would lead to a breakthrough in our ability to analyze and control fusion and high energy density plasmas, with various spin-offs as an added value. Performance portable solutions exploiting modern hardware with the flexibility to adapt to user needs on-the-fly will dramatically change the analysis of high rate image data streams.

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SHIP – A SELF-LEARNING HELMHOLTZ IMAGING PIPELINE

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Explain the project idea and its background

Here we propose the **self-learning Helmholtz Imaging Pipeline (sHIP) for collaborative online processing of biological, medical, oceanographic and remote sensing imagery**. Image processing often consists of three basic processing steps: 1) segmentation of one or several regions of interest (ROI) from the remaining image, 2) quantification of certain characteristics such as the size, shape, color or texture of a given ROI and 3) classification of a given ROI (e.g.[1,2,3]). Collaborative online tools allow for faster and more reproduceable assessments of image datasets (e.g. http://ecotaxa.obs-vlfr.fr/ or http://catmaid.readthedocs.io/en/stable/#) and can be developed into Citizen Science projects (e.g. https://planktonid.geomar.de). These techniques are developed in different fields in parallel and it often takes a long time for optimal solutions to spread. Here we propose the development of an online pipeline to streamline image processing and to allow the simple test of novel processing techniques on a set of benchmark image datasets. The entire pipeline should finally be hosted at the HIP and be accessible via online access points, but also via Application Programming Interfaces (APIs). The pipeline will consist of three major online facilities: 1) an Online Formatting Platform (OFP) that allows different input image formats (e.g TIF, jpg, HDF5) and sizes (kByte to Terabyte) to be fed into the pipeline; 2) an Online Segmentation Platform (OSP) that allows for collaborative manual and automated segmentation of the images and 3) an Online Classification Platform (OCP) that allows for collaborative manual and automated classification of ROIs. A modular design using microservices will allow for an agile development of the pipeline.

Describe the scientific impact of the project

sHIP will be designed for two user-types: 1) experts in image processing that would like to apply novel techniques to different benchmark image datasets and make these techniques available to the Helmholtz Imaging community via additions to the pipeline and 2) domain scientists that require image processing tools for small to large image datasets. sHIP will therefore cater to the needs of all levels of image processing expertise of domain scientists. In each domain specific instance or use case, the pipeline will become more “intelligent” through the growth of the validated training sets and the subsequent improvements of the involved deep and machine learning components. It could also represent the IT backbone for further Citizen Science microservice project development in HIP. sHIP will be developed with a plankton image dataset obtained at GEOMAR (> 10000 scanned zooplankton samples with > 5 Million ROIs), an electron microscopy image dataset of a C. elegans larvae at nanometer resolution from the MDC acquired at HHMI Janelia and a multi modal image dataset aggregated at the DKFZ-led Joint Imaging Platform (https://www.dkfz.de/en/mic/research/MICO/mico_projects.html#section5). For these datasets disrupted processing and annotation pipelines are available, making them perfect use cases for the development of sHIP. sHIP will be designed for the simple integration of further datasets later on.

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INSTANCE- AND SIGNIFICANCE-DEPENDENT DEEP LEARNING ALGORITHMS FOR TIME SERIES MULTISPECTRAL IMAGE ANALYSIS OF EARTH SURFACE ANOMALIES

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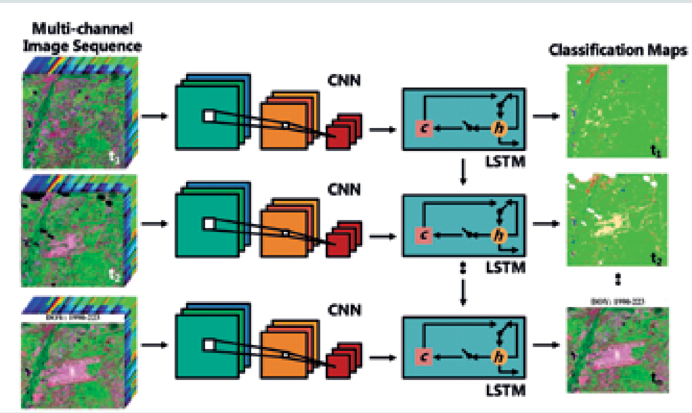
[2] GFZ, Earth and Environment

Project idea and its background

The upcoming decade is a golden era for Earth observation (EO), particularly due to the new Copernicus Earth observation programme. Several Sentinel satellites employing novel sensor technologies and mission concepts are already in service or will be launched in the next few years. In the Copernicus era, we have access to very large and ever-growing data volumes on a global scale, which enables tackling global applications at an unprecedented spatial resolution and revisit time. It allows the observation of small-scale and rapid change dynamics at the Earth surface that are often caused by natural or man-made hazards such as landslides, dam breaks, pollution events or waste deposits. These anomalies can be distinguished from long-term and seasonal dynamics making use of a combination of spectral information (Sentinel-2) and texture information (Sentinel-1) Algorithms must be fast enough and sufficiently transferrable to be applied for the whole Earth surface.

Scientific impact of the project

We develop advanced deep learning models which shall enable anomaly detection on a global scale, mainly using Sentinel-2 and Sentinel-1 time series image data. To make full use of the spectral-spatial-temporal information, we will start with ReCNN networks [1] – deep networks combining a CNN, which exploits the spectral-spatial correlation in a neighbourhood, and a recurrent neural network (RNN), that is particularly powerful for processing sequential data. Furthermore, the level of detail depends on appropriate definitions for anomalies that take type and character of the hazardous event, i.e. instance, adequately into account. Furthermore, depending on the acquisition conditions, images taken at different places and time possess different quality, i.e., significance. We will thus specifically focus on developing instance- and significance-dependent learning algorithms, e.g. based on the recently proposed graphic networks (GN) [2].



The transferability of the data-driven methods is a general issue for all large scale applications. Therefore, the developed instance- and significance-dependent deep learning algorithms shall be highly relevant for other involved HGF centres.

Figure: A ReCNN architecture for the classification of time series multi-channel images.

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9.3 SCHEDULE OF WORK PLAN AND MILESTONES

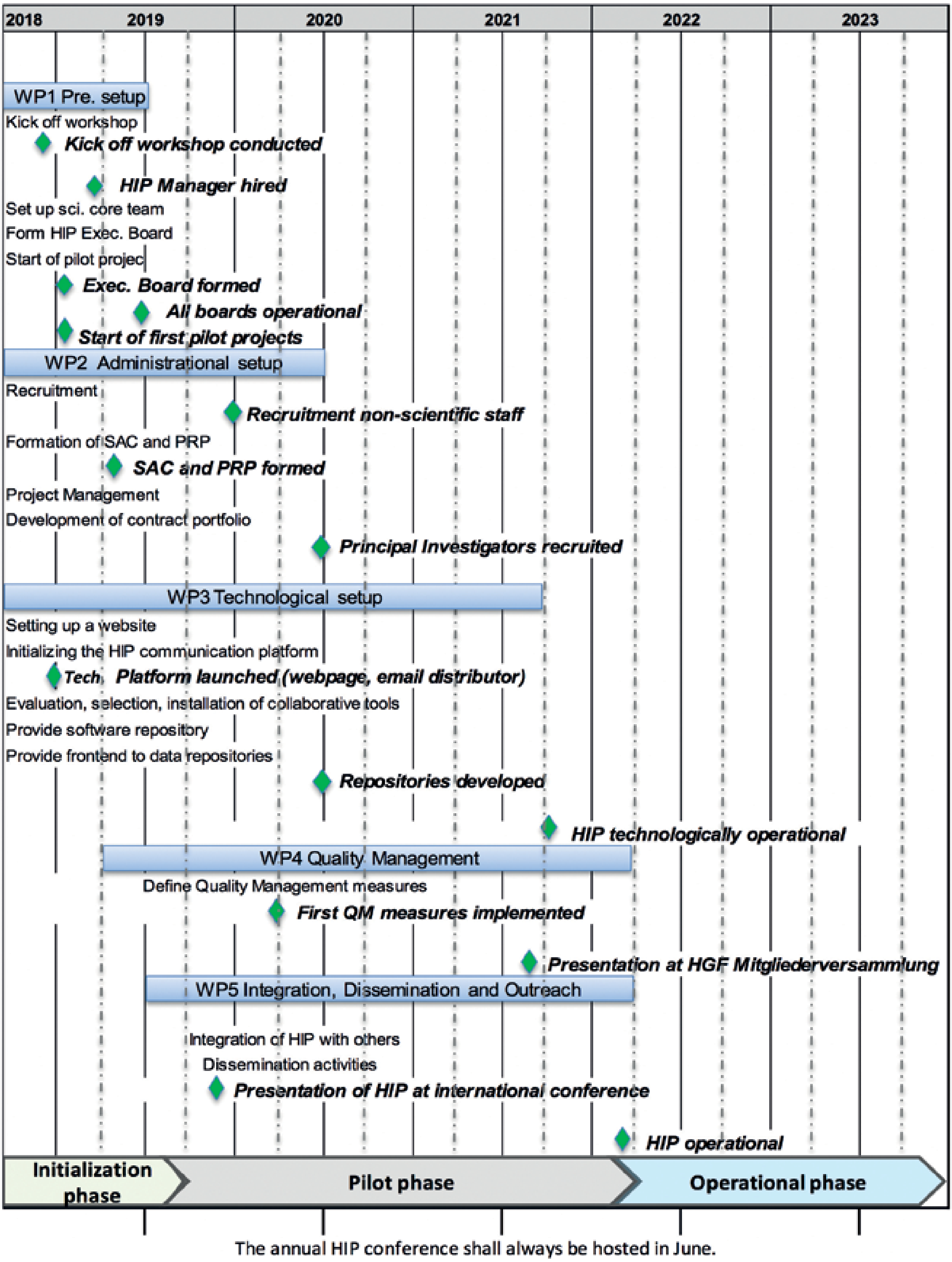


Figure 6: Schedule of work packages, tasks and milestones in various phases under the framework of HIP.

9.4 CRITERIA FOR THE HIP HOST CENTER

The hosting Helmholtz Center should possess the following features in order to drive the HIP (points in no particular order):

- strong international visibility of the center in imaging sciences
- reputation of the center with respect to research in imaging sciences
- established network of competence in imaging sciences in the local area
- established network of cooperation with local universities and / or research facilities in areas of relevance for imaging sciences
- degree of alignment of the HIP goals with the strategy of the center
- strong commitment of the leading board of the center
- overall reputation of the center as an active agent in scientific research
- potential to access cutting edge imaging facilities (at least in the local area)
- cutting edge applications for applying methods on imaging sciences
- strong potential for active collaboration of researchers working on complementary imaging modalities
- access to students in imaging sciences and related fields
- strong computational support and access to appropriate IT infrastructure and data
- methodological competences available on campus
- strong support for career development on the PhD and the Postdoc level
- attractive location for both nationally and internationally working scientists
- provide attractive work place and working conditions

9.5 ENVIRONMENT ANALYSIS

IMAGING MODALITIES BEING OPERATED BY THE HELMHOLTZ CENTERS

After having visited Helmholtz Research Centers and discussed with researchers at respective centers in imaging areas, the necessity of having HIP as a research platform has been strengthened. Besides, the benefit of having HIP was also evidenced by lively discussions with Helmholtz researchers at respective centers. Below, the table is listing some of the imaging modalities at various Helmholtz Centers and their descriptions in terms of measurement. This table is far from being complete, and merely gives an insight into the variety of modalities being operated within the Helmholtz Association.

Table 3: Examples of Imaging Modalities

Imaging Modality	Center	Description of (physical) measurement
Radar imaging of glaciers & sea ice	AWI	multi-channel ultra-wide band airborne radar for polar applications; along-track and across-track SAR
Multi-/hyperspectral imaging	AWI	multi- and hyper-spectral ocean backscattered satellite data exploited by analytical bio-optical techniques; Imaging via video camera systems mounted on towed and lander based platforms; high resolution acoustic imaging and topographic mapping
X-ray-microfocus computer tomography	AWI	x-ray tomography on micro-scale for ice measurements
Microscopy	AWI	research on micro- and nanostructures of diatom silica, its properties as composite materials and their transfer to technical products
X-ray full-field microscopy	DESY	Projection microscopy in absorption and near-field phase contrast, parallel and magnified projection
Coherent x-ray diffraction	DESY	Coherent x-ray diffraction microscopy based on far-field diffraction patterns and scanning coherent diffraction micro-scopy combined with tomographic scanning modality (spatial resolution < 10 nm)
X-ray scanning microscopy	DESY	x-ray scanning microscopy with various x-ray analytical con-trasts, such as x-ray fluorescence, diffraction, and absorption as contrast, giving access to (trace-)elemental distribution, local atomic structure, and local chemical states of a given element (spatial resolution < 100 nm)
X-ray imaging of ultrafast processes	DESY	Single-shot near-field imaging of ultrafast processes, e. g., shock physics with XFEL radiation. This activity is part of the Helmholtz International Beamline for Extreme Fields am XFEL (HIBEF)
Dynamic nuclear polarization (DNP)	DKFZ	dynamic nuclear polarization of substrates marked with MR-active isotopes such as ^{13}C and ^{15}N
CT / photon-counting CT	DKFZ	computed tomography with conventional and photon-counting detectors
PET & CT/PET & MR	DKFZ	positron-emission tomography with various radiotracers based on radioisotopes such as ^{18}F and ^{68}Ga and combined with morphological correlates provided by CT or MRI

Photoacoustic imaging	DKFZ	tissue excitation with laser light and imaging readout of induced ultrasound waves
Synthetic aperture radar SAR imaging	DLR	a coherent active microwave imaging method, in our case usually mounted on satellites or airplanes
SAR tomography	DLR	SAR tomography uses a stack of 2D SAR satellite images of the same scene taken from slightly different positions and times to extend the 2D SAR images to 3D or even 4D. It is equivalent to a multi-dimensional spectral estimation problem with small and irregular samples
Hyperspectral sensor	DLR	a passive imager, characterized by hundreds of narrow and continuous bands ranging from visible to short wavelength infrared
Seismic tomography	DLR	tomographic imaging using seismic waves for model inversion
Structural magnetic resonance imaging	DZNE	T1, T2-weighted MRI of the brain (spatial resolution)
Diffusion magnetic resonance	DZNE	compressed Sensing Diffusion Spectrum Imaging (CS-DSI) (spatial resolution)
Functional magnetic resonance imaging	DZNE	blood oxygenation level dependent (BOLD) contrast imaging with fast 3D- Echo-Planar Imaging (EPI; spatial resolution , time resolution)
Quantitative magnetic resonance imaging	DZNE	susceptibility-weighted magnitude and phase images (spatial resolution)
Electrical impedance tomography	FZJ	measuring the electrical impedance as a function of positi-on in space with a set of electrodes with applications in soil science
Transmission electron microscopy	FZJ	high-resolution transmission electron microscopy at the Ernst-Ruska Center.
Scanning-probe microscopy (STM, AFM)	FZJ	atomic resolution scanning tunneling and scanning force microscopy on solid-state surfaces
Time-lapse microscopy coup-led with time-lapse imaging	FZJ	visible light imaging and microscopy as a function of time: Following biological processes, e. g., growth of plants.
Deep sea camera	GEOMAR	Optical imaging systems for deep sea applications
Grey/RGB cameras on auto-nomous robots	GEOMAR	optical camera systems on autonomous robots for ocean sciences

Imaging flow-cytometers	GEOMAR	combination of flow cytometry and fluorescent microscopy for morphological analysis of events on cellular level
Acoustic imaging (sonar, seismic, …)	GEOMAR	single- and multibeam echosounder systems
Remote sensing: NEO HyS-pex imaging spectrometer	GFZ Potsdam	hyperspectral imaging spectroscopy
Remote sensing: Telops HyperCam FTIR imaging spectrometer	GFZ Potsdam	Fourier transform infrared spectrometer
Remote rensing: thermal cameras	GFZ Potsdam	high resolution thermal camera for remote sensing applications
Seismic tomography	GFZ Potsdam	tomographic imaging using seismic waves for model inversion
Live cell microscopy	GSI	time-lapse microscopy system to analyze cellular dynamics
Computer tomography	GSI	classical x-ray computer tomography
Molecular radiobiological imaging	GSI	Single particle heavy-ion microbeam for fluorescence lifetime imaging
High throughput confocal microscopy	HMGU	lightsheet-, laserscanning-, 2-photon-, superresolution microscopy
Photoacoustic imaging	HMGU	combination of acoustic tomography with light based induction of pressure waves
X-ray fluorescence imaging (PET-CT, SPECT-CT)	HMGU	novel modalities for molecular imaging based on x-ray fluorescence
Mass spectrometry imaging	HMGU	Spatially resolved measurements of proteome and active substances
Soft-X-ray microscopy	HZB	Soft X-ray full-field microscopy, e. g., of cells and tissues, based on magnified imaging with a Fresnel zone-plate objec-tive.
Neutron-Tomography	HZB	Neutron tomography allows investigations of the interior of large samples (up to hundreds of cubic centimeters) with a spatial resolution of hundreds of micrometers.
High-resolution transmission electron microscopy (TEM)	HZB	combined microscopic imaging for quantitative analysis
Scanning electron microscopy (SEM)	HZB	nano-scale microscopy

X-ray imaging of ultrafast processes	HZDR	single-shot near- and far-field imaging of ultrafast processes, e. g., shock physics and plasmas with XFEL radiation. This activity is part of the Helmholtz International Beamline for Extreme Fields am XFEL (HIBEF)
Small-Angle X-ray Scattering (SAXS)	HZDR	scattering of a high intensity, ultra-short, spatially and temporally coherent pulse of X-ray photons from free and bound electrons in a partially ionized solid density plasma
Computer tomography	HZDR	x-ray computer tomography
Positron emission tomography	HZDR	positron-emission tomography with various radiotracers based on radioisotopes
X-ray full-field microscopy	HZG	x-ray projection microscopy with absorption and near-field phase contrast. Magnified full-field microscopy with Fresnel zone-plate objective.
X-ray full-field tomography	HZG	tomographic imaging based on x-ray full-field microscopy
Ptychography	HZI	scanning coherent x-ray diffraction microscopy on whole cells and tissues.
X-ray fluorescence	HZI	scanning x-ray fluorescence microscopy to locate physiologically relevant ions in cells and tissues.
High-content imaging and fluorescence microscopy	HZI	combination of protein modification and fluorescence micro-scopy for theranostic imaging
Field emission scanning electron microscopy	HZI	field emission SEM-microscopy for high resolution nano-scale investigation
Plasma tomography	IPP	reconstruct poloidal cross sections of various plasma parameters from a limited number of radiation integrals along lines of sight
Plasma thermography	IPP	measure photon flux with visible/NIR/IR cameras
Single-molecule localization microscopy for live cell superresolution imaging and single-particle tracking	KIT	Highly sensitive detection of individual molecules and locali-zation in 3D with nanometric precision and millisecond time resolution.
Atom Probe Tomography (APT)	KIT	A needle shaped tip with a diameter around 100 nm is exposed to a high electric field. With an additional voltage or laser pulse single atoms are evaporated and accelerated to a 2D-Detector, where their time of flight is measured. Form the obtained data a 3D representation of the tip is reconstructed.

Light sheet microscopy	KIT	high-resolution 3D+t imaging of fluorescent samples with dimensions up to 1 mm.
Infrared thermography of high-temperature processes	KIT	Infrared cameras with cooling systems for the visualization of combustion processes
Fluorescence Microscopy	MDC	Photons emitted by fluorescent molecules, scattered by the media
2-Photon microscopy for in vivo deep tissue imaging	MDC	Deep tissue and organ imaging is possible due to the high penetration depth of the infrared radiation in 2-Photon microscopy.
Experimental Ultrahigh-Field MR	MDC	Development of MR-methodology and MR technology with a focus on new ways of mapping and probing morphology, function, physiology and metabolism together with explorations of the benefits and challenges of ultrahigh-field imaging to advance cardiovascular, neurovascular, molecular and other MRI applications.
Advanced light microscopy	MDC	High quality microscopy based on various modalities (confocal laser scanning-, 2-photon-, light-sheet-, wide-field-, fluorescence lifetime-microscopy)
Electrical resistivity tomography (ERT)	UFZ	Injection of DC current by galvanic coupling in the object of interest, measurement of electrical potential differences, tomographic setup, e.g., multiple source positions and multiple receiver positions along one side of the object (earth surface)
Radar tomography	UFZ	Transmission of high-frequency electromagnetic wave propagating through the object of interest to one or more receivers recording the incoming wave energy over time, tomographic setup
Quantitative Time-lapse Epifluorescence Microscopy	UFZ	Monofocal, sequential imaging of live cells with transmitted and reflected light. Fluorescence excitation in visible light range (385nm – 650 nm) and quantitative recording of emitted light at longer wavelengths via photomultiplier detectors.
Helium ion microscopy	UFZ	Helium ion microscopy (SHIM, HeIM or HIM) is an imaging modality based on a scanning helium ion beam. Similar to other focused ion beam techniques, it allows to combine milling and cutting of samples with their observation at sub-nanometer resolution.

An important initiative of Helmholtz Centers is the joint proposal between FZJ and DKFZ to establish a **National Biomedical Imaging Facility (NIF)**. The proposal has been very positively evaluated by the Wissenschaftsrat (German Council of Science and Humanities) as part of the BMBF (German Federal Ministry of Education and Research) effort to formulate a National Roadmap for Research Infrastructures. The NIF aims to create an open facility for research in, and application of, biomedical imaging. The two founding Helmholtz partners will create the NIF infrastructure to advance basic research as well as technology development and clinical applications. For the implementation of NIF, new instruments will be purchased and installed and the next generation of imaging equipment will be developed. NIF will provide access to important diagnostic imaging technologies such as MRI, PET, MEG, EEG, hybrid MR-PET and multimodal, multi-dimensional imaging (MR-PET-EEG). NIF will in particular focus on technology and methodology for whole-body exams at extremely high magnetic fields. In the current stage, the world's first 14 T human MRI is targeted. To implement and maintain such a high-level imaging infrastructure, a concerted, national effort coordinated by Helmholtz is needed. A funding decision is expected by the end of 2018.

IMAGING PLATFORMS AND NETWORKS OUTSIDE OF THE HELMHOLTZ ASSOCIATION

Existing imaging platforms and consortia

Since image reconstruction and analysis is fundamental for scientific research in almost all research fields, many research institutions have made efforts to strengthen their imaging capabilities. The vast majority of these efforts are rather local, small-scale, and limited in their scientific scope and serve only a specific research institution or a particular domain of application. The existence of such small-scale units is usually either motivated by interest in a specific domain of application, e.g., high-end microscopy at the Nikon Imaging Center at Heidelberg University, or directly oriented towards applied mathematics and computation with no particular connection to applications and/or modalities. The latter, theoretically oriented units strive to advance algorithmic tools for imaging in a general methodological manner. One example is the **Center for Advanced Mathematics for Energy Research Applications (CAMERA)** at Lawrence Berkeley National Laboratory. CAMERA had been established in 2010 and is directly funded by the Department of Energy (DOE) with 3.5 Mio Dollar annually and shall work on imaging challenges in collaboration with DOE labs in the US. CAMERA is strongly driven by a few people and collaboration is strongly steered from the side of CAMERA. All people working at CAMERA are located in Berkeley and are 50% funded by CAMERA and 50% from other institutes. The general feedback in the respective DOE labs is very positive and most of the US synchrotron facilities collaborate with CAMERA.

Another example, the Argonne National Laboratory is a multidisciplinary science and engineering research center with 3200 employees located in Chicago. Argonne's Integrated Imaging Institute (AII) provides an interdisciplinary bridge across Argonne's imaging capabilities and communities. It brings together expertise and capabilities in instrument development, data analysis, simulation and modeling, and visualization from across the laboratory with own research directed towards the development of methods and computational resources for the integration and analysis of multi-modal image data. This effort is backed by a Mathematics and Computer Science Research Division supporting science and engineering applications with algorithm design, numerical libraries, collaborative middleware, data analysis and visualization. AII is oriented towards the specific research community of high energy physics and matter. Similar activities can be found at Brookhaven National Lab (BNL) where the DAMA group (Data Acquisition, Management and Analysis) had been established. In addition another center at Brookhaven Lab – the Computational Science Initiative (CSI) - is working in the field of data science for imaging, particle physics and others. All of those groups within DOE facilities (CAMERA, DAMA, AII, CSI) seek – have to seek – collaboration with each other. One interesting aspect to mention is that especially groups at BNL but others too increasingly outsource programming work to external companies. To sum up, the current situation in the US regarding imaging sciences can be described as organically grown. DOE, however, is currently seeking to better join efforts. CAMERA is such a joint and currently most evolved and comprehensive structure. The common programming language used across all DOE labs is Python, most scientists involved follow the open-source philosophy and GitHub is the commonly used and open software repository.

There are also other, smaller-scale research groups sharing the mindset of HIP. Those groups also consider image data as a specific source of information and are thus seeking to combine engineering, computational sciences and mathematics towards a better acquisition and exploitation of imaging data. One example is the Computational Photography Lab at Northwestern University, which is closely linked to the AII at Argonne Lab. The **Cambridge Image Analysis (CIA)** group at Cambridge University in the UK is specializing in the mathematics of digital image and video processing. Their research ranges from the modeling and analysis of such methods to their computational realization and application.

The **Australian National Imaging Facility (NIF)** is a project (130 Mio AUD) organized as an Australia-wide collaborative network that provides state-of-the-art imaging capability for humans, animals, plants, and materials to the Australian research community. Established in 2007, NIF now comprises eleven centers across Australia, which offer instrumentation and expertise for different imaging modalities. NIF is a networking platform since one key mission is to connect interested domain scientist with imaging modalities and respective methods. The approach being followed by NIF is closely in line with the HIP goals. In particular, the aims to reduce uninformed utilization of cutting-edge measurement devices and enable access to existing imaging modalities for all researchers regardless of their specific domain background are identical with the respective HIP goals. Consequently, exchange of experience and strategic collaboration appears to be highly promising for HIP.

A similar structure had been initiated 2010 in Europe, the Euro BioImaging platform with its twin-structure, the German BioImaging community. Those communities are strongly driven by the European Molecular Biology Laboratory (EMBL) and shall enable access to imaging infrastructure and expertise for biological and medical sciences. In addition, a new imaging facility will be set up in Heidelberg, the EMBL Imaging Center, accommodating cutting-edge cryo-EM and light sheet fluorescence microscopy. This center just had groundbreaking and shall be completed and in full operation by 2021. The total cost of 50 M€ is split between public hand and industry.

Another network HIP will strive to settle long-term collaboration with is the Cyber Valley Research Network established 2016 and located in the region Tübingen-Stuttgart. The Cyber Valley initiative brings together international key players from science and industry to concentrate their research in the field of artificial intelligence. Among others, the research of this cluster is expected to address imaging issues within their use cases and advance algorithmic techniques at the edge between imaging and AI. Therefore, CVRN provides a natural partner for solutions in machine learning and artificial intelligence.

An example of industrial research is given by IBM Research with a branch in Haifa dedicated to research in medical imaging. It is the largest lab of the IBM Research Division outside the United States with strong interests in image and video analytics, particular in health informatics. Their medical imaging analytics research includes advanced computer vision and machine learning techniques to analyze medical images and combine this data with information from the patient's medical records to allow automatic extraction of diagnostically relevant features. Other companies such as IBM or Google also maintain strong expertise in various aspects of imaging sciences.

Other large-scale international and national institutions exist at the level of governmental agencies. In particular, NASA, ESA, US Geological Survey (USGS) and National Oceanic Atmospheric Administration (NOAA) have to be mentioned here. These agencies are running projects producing huge amounts of Earth imagery, serving the scientific community. While infrastructure maintenance and data curation is one of their key tasks, these institutions are specialized on imagery related to remote sensing of the Earth's (near) surface. In addition to raw data, derived imaging products are provided and developed, partly enabled by utilizing domain-specific process understanding. These latter aspects make the image reconstruction and analysis research at these agencies largely specific to their respective domains.

9.6 SWOT ANALYSIS

The **strengths** of HIP result from connecting scattered potential in the Helmholtz Association. The variety of imaging modalities and hence imaging data is unique at the Helmholtz Association. Now, modalities and respective domain-driven methods are poorly connected across different research fields. This apparent weakness will be turned in one of the strengths of HIP. HIP is set-up to leverage synergies and enable collaboration across Helmholtz research fields and Helmholtz Centers at the benefit of all. The framework of HIP will foster interdisciplinary research and furthermore allow for high risk projects. In addition, HIP ensures technology transfer into the Helmholtz Association by funded visits of key scientists and open imaging events.

There is hardly any research association, which is home to such a rich portfolio of imaging modalities ranging from earth observation and health sciences to oceanology to materials and fundamental physical research. The Helmholtz Association is in possession of a vast imaging data treasure and wide methodological expertise is spread in different domains. Taking advantage of this is the strength of HIP: Strength in terms of potential international visibility and strength in terms of attractiveness for pioneer imaging and data experts. Such people are in high demand but the abundance of imaging at the Helmholtz Association is a strong point for HIP.

To address the **weakness** of a possible domination of HIP by just a few research domains or Helmholtz Centers, structure and governance of HIP is set-up in a transparent and open way. Another weakness is the current lack of suitable KPIs to measure the overall impact of HIP. As mentioned above (section 6.6) the idea is to use further-reaching performance indicator and actively develop new approaches to better assess platform activities such as HIP. Imaging sciences are by nature differently evolved and of different importance in different research fields. Consequently, the benefit of HIP might not be spread homogenously. This shall be taken into account and can be actively out-balanced by HIP to a certain level.

A potential external **threat** for the success of HIP is complex legal agreements. Project-by-project negotiated agreements certainly counteract with the idea of a quick and comparably low effort application procedure for projects which shall as well allow high risk content. HIP indents to solve this by blue-print contracts, which shall be standardized and reused. This will alleviate collaboration of research centers.

Another important point to mention is that the science case of HIP includes AI, but many HIP projects will not have AI content. From the perspective of AI, however, the strength of the comprehensive imaging data treasure is a key advantage and competitive edge for the Helmholtz Association.

A great **opportunity** is that Imaging Sciences are a growing value within the international science community. HIP fits excellently into the international landscape and will boost the international visibility of the Helmholtz Association in imaging sciences. HIP is aiming for strong visibility and wants to provide cutting-edge example imaging data, attracting renowned guest scientists and drive imaging sciences. This is perfectly in line with the inherent potential of the Helmholtz Association. Next to HIP the other Helmholtz Incubator Platforms are complementary (see A.6) have high potential for cross-fertilization.

Strengths

- HIP leverages synergies across research fields
- Enable collaboration across imaging modalities
- Interdiscipinary high-risk projects will be possible
- Strong visibilty outside Helmholtz Association
- Attractive environment for cutting-edge scientists
- Pooling of imaging resources across research centers
- Foster technology transfer into HGF

Weaknesses

- HIP potentially dominated by a few Helmholtz centers
- Performance: Evaluation of impact with standard KPIs is not possible
- Unbalanced status-quo in imaging sciences at HGF: Some research domains will profit more from HIP than others

HIP

Opportunities

- Imaging is a growing field
- Unique variety of modalities and methods in HGF
- Vast imaging data "treasure" in HGF
- Broad domain expertise at Helmholtz centers
- Other incubator activities are complementary

Threats

- Complex legal & bureaucratic aspects counteract with small or high risk projects
- Imaging sciences reduced to a part of AI
- Experts in Data science are in high demand
- Potentially slow ramp-up: Network needs to be established almost from scratch

Figure 7: Scheme of SWOT in the HIP

9.7 COLLABORATIONS / INTERFACES TO OTHER HELMHOLTZ INCUBATOR PLATFORMS

HIP will focus on providing world-leading expertise in imaging methods and naturally also includes interfaces to other Helmholtz Incubator platforms whenever synergies can be created. Among all platforms, HIP is in the unique position to provide access to one of the largest, most versatile and complex collections of data in the Helmholtz Association. The platform can thus be seen as an ideal partner to test, apply and evaluate new methods developed in the platforms. HIP will clearly benefit from progress in machine learning methods (Goals 10, 12; Chapter 3) and make use of the services provided by the HIFIS (Goal 2, 7). Likewise, metadata becomes important for tasks such as quality assessment, classification and knowledge extraction (Goal 2, 10). HIP will adopt solutions provided by the incubator platforms to serve scientific imaging workflows. In turn, HIP will provide valuable feedback for further development and create new links between the platforms (Goal 5). HIP will thereby foster strategically integrated developments between incubator platforms rooted in a co-design approach with domain scientists. The Helmholtz Imaging Platform will profit strongly from excellent PhD students and Postdocs and thus ensure connecting to the Helmholtz Information and Data Science Academy. To foster imaging sciences within the Helmholtz Association, HIP will provide modules related to imaging sciences to be incorporated within the HIDA program. At the same time, courses on software engineering or quality assurance as well as machine learning and knowledge discovery will complement the development of expertise within HIP.

HIP

HIDA

- Modules on Imaging Sciences
- Courses on Machine learning, knowledge discovery, software engingeering and quality assurance
- Courses on Demand
- Complementary courses for HIP researchers

HIFIS

- Integrated IT infrastructure
- Storing and accessing large image data (Backbone services)
- Software development and testing (Software services)
- Collaboration tools (Cloud services)

HMC

- Research data management
- Data repositories including search and exploration
- Interoperability of imaging data
- Knowledge systems across imaging modalities

HAICU

- Incorporating Artifical Intelligence (AI) in knowledge discovery across imaging analysis
- Machine learning methods in imaging domain
- Deep Learning will be used in image analysis of various modalities
- Algorithm Developments for imaging problems

Figure 8: Interplay of the Incubator platforms.

With the inception of HIP platform, the synergies will be established with other associated Helmholtz platforms such as HIDA, HAICU, HIFIS and HMC, benefitting Helmholtz Research Centers in their focused areas. The interaction and collaboration of HIP with other platforms, particularly in terms of teaching, IT support, data management, state-of-the-art methods is shown in figure 8.

9.8 ROUGH DRAFT OF A PROJECT PROPOSAL TEMPLATE FOR HIP PLATFORM

Title of your proposal for a Helmholtz Imaging Platform project
(maximum 4 pages A4 excl. front page, running text in 10pt size, upload limit 4MB)

Front Page

Standard fill-in form for key information such as:

Main applicant (must have direct Helmholtz Association affiliation)
Other applicants (at least one required, different center, different research field)

Page 1

1. **Brief description of the project idea and its scientific merit**
   Please give a concise and clear description of the project including a brief general and scientific background. Furthermore explain the overall aim of the project and its scientific impact.
2. **Benefit for the Imaging community in and outside Helmholtz**
   What would be the scientific relevance of the result for Helmholtz and how will it be accessible for others.
3. **Description of the deliverable expected and critical aspects**
   Clearly describe which deliverable you expect to obtain and what are critical aspects for the project.
4. **Sketch of the work plan and required resources**
   The timeframe should not exceed two years and two milestone meetings shall be addressed – one 6 months after project start and the second 6 months before project end. Therefore please define the essential steps for project realization.

Page 2–4

5. **Detailed description of the proposed HIP project**

a) Give a deeper insight into the project
   - Summarize previous own work which is relevant to this proposal.
   - describe synergies generated
   - justify the scientific relevance and the claimed benefit for the community

b) Describe the expected deliverables
   - give a brief description of the prototype to be developed
   - provide risk assessment

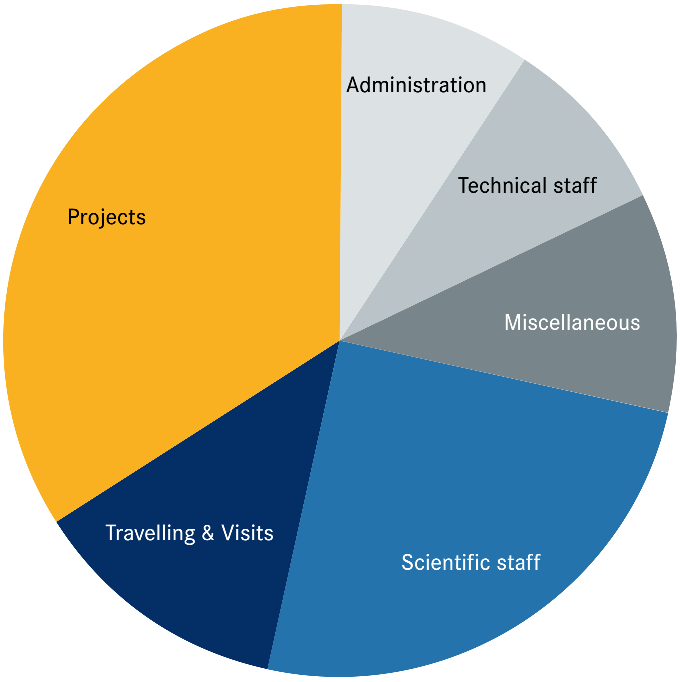
c) Show the intended way of realization
   - give a brief description of methods/tools
   - explain the idea to realize the first prototype
   - justify the planned resources

6. **References and own publications (max 5 in total)**
   References should only appear here. If citations are being used in the body of the proposal, they should refer to references listed here. References (incl. DOI), underline own publications.

   References should be consecutively numbered using this format:
   [1] A. Author, B. Author, and C. Author, Title, Phys. Rev. B **50**, 1234 (2000)(DOI.....)

9.9 FINANCIAL PLAN FOR HIP IN FULL OPERATION

The total annual cost planned is 4,376 k€ and can be split into static cost of 2,876 k€ and dynamic cost of 1,500 k€. Figure 9 gives an overview of the different contributions.



Static Cost

Administration	403 k€
Technical staff	378 k€
Scientific staff	1087 k€
Miscellaneous expenses	468 k€
Travelling & Visits	540 k€

Dynamic Cost

Project budget	1500 k€
Annual Total Cost HIP	***4376 k€***

Figure 9: The HIP cost distribution represented by a pie-chart

Wages of the Core Team personnel are categorized according to guidelines of DFG. See Table 4 –Table 6 for all the positions in the HIP Core Team and their respective wages. The overhead cost of 25% has been calculated in accordance with DFG regulations. The total cost for personnel incl. overhead is 1,869 k€ and can be grouped into personnel cost for administration (Table 4), technical staff (Table 5) and the expenses for the HIP Scientific Core Team (Table 6). Funds required for scientific exchange including guest scientist visits and traveling are shown in Table 7. Finally, Table 8 depicts miscellaneous costs such as costs for SW licenses, marketing, etc. Finally, the dynamic costs of the HIP projects are described in Table 9.

Fixed costs such as IT infrastructure, basic equipment etc are considered in the ramp-up and do not contribute to temporary costs.

Table 4: Personnel costs for administration

#	Position	Monthly [€]	Yearly [€]	Details
1	Manager	6,950	83,400	Managing HIP administratively, member of the HIP Coordination Team
2	Assistance	4,000	48,000	Team assistance
3	Assistance	2,000	24,000	Team assistance, 1/2 FTE
4	Controller	2,263	27,150	Controls and monitors the projects, 1/2 FTE
5	Scientific Relation Offic	5,825	69,900	Maintaining & expanding the academic network within and outside Helmholtz
6	Industrial Relation Offic	5,825	69,900	Establishing/deepening contacts in industry
	Total	**26,863**	**322,356**	
	Total plus Overhead	**33,579**	**402,945**	

Table 5: Personnel costs for the technical staff at the HIP Core Team

#	Description	Monthly [€]	Yearly [€]	Details
7	Staff SW Developer	5,825	69,900	Highly qualified SW developer for professional SW and code optimization
8	Staff SW Developer	5,825	69,900	Highly qualified SW developer for professional SW and code optimization
9	Staff Programmer	4,525	54,300	Professional SW and code optimization
10	Staff Programmer	4,525	54,300	Professional SW and code optimization
11	IT Expert	4,525	54,300	Professional SW and code optimization, responsible for IT in the HIP Core Team
	Total	**25,225**	**302,700**	
	Total plus Overhead	**31,531**	**378,375**	

Table 6: Expenses for the HIP Scientific Core Team

12	Principal Investigator 1	8,467	10,1600	HIP Scientist, group leader 1, PIs will have cross-affiliation with a local university
13	PostDoc	5,825	69,900	PostDoc level scientist, research group 1
14	PostDoc	5,825	69,900	PostDoc level scientist, research group 1

15	Principal Investigator 2	8,467	101,600	HIP Scientist, group leader 2, PIs will have cross-affiliation with a local university
16	PostDoc	5,825	69,900	PostDoc level scientist, research group 2
17	PostDoc	5,825	69,900	PostDoc level scientist, research group 2
18	PhD Student	5,375	64,500	PhD candidate in research group 1
19	PhD Student	5,375	64,500	PhD candidate in research group 1
20	PhD Student	5,375	64,500	PhD candidate in research group 1
21	PhD Student	5,375	64,500	PhD candidate in research group 2
22	PhD Student	5,375	64,500	PhD candidate in research group 2
23	PhD Student	5,375	64,500	PhD candidate in research group 2
	Total	**72,484**	**869,808**	
	Total plus Overhead	**90,605**	**1,087,260**	

Table 7: Expenses for scientific exchange

#	Description	Monthly [€]	Yearly [€]	Details
1	Guest Scientist	20,000	240,000	Scientific visitors
2	Traveling	25,000	300,000	Traveling costs of Core Team
	Total	**45,000**	**540,000**	

Table 8: Miscellaneous costs

#	Description	Monthly [€]	Yearly [€]	Details
1	Misc	4,000	48,000	Homepage, hospitality expenses, office equipment, etc
2	Marketing	5,000	60,000	brochures, reports, flyers
3	SW Licences	15,000	180,000	
4	Platform Events	10,000	120,000	Annual conference, workshops, meetings
5	conferences, fairs	2,500	30,000	admission fees, costs for a conference booth
6	SAC board (trip & allowance)	2500	30,000	min. 1 meeting per annum
	Total	**39,000**	**468,000**	

Table 9: Dynamic project funds

		Monthly [€]	Yearly [€]	Details
1	Projects (#5)	125,000	1,500,000	HIP projects
	Total	**125,000**	**1,500,000**	

9.10 FINANCIAL PLAN FOR THE RAMP-UP

The implementation of HIP can start right after getting approval. The Kick-off Team can support the Host Lab to initiate the recruitment process, and first positions shall be already filled in by Q1 2019. Expenses in 2018 will arise through a kick-off event and setting-up of an initial homepage. In 2019 the recruitment process will be continued and the non-scientific staff is expected to be fully hired by the middle of the year. Furthermore, funds of 100 k€ will be reserved to properly equip the office with, for example, IT infrastructure and additional furniture. The dynamic project funds of 1,500 k€ shall be fully allocated to HIP projects from Q1 2019 onwards. And finally, the second scientific senior group leader shall take her/his position by Q2 2020. See in Table 10 below the cost distribution for the years 2018, 2019 and 2020.

Table 10: Ramp-up costs

#	Costs/Year	2018 [€]	2019 [€]	2020 [€]
1	Administration	0	341,000	403,000
2	Technical staff	0	277,000	378,000
3	Scientific staff	0	313,000	786,000
4	Scientific exchange	0	330,000	495,000
5	Misc.	45,000	400,000	468,000
6	Dynamic	0	1,500,000	1,500,000
	Total	**45,000**	**3,161,000**	**4,030,000**

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