HR4 Project Delivery Report

Authors

Antonio Bonucci,

Jana Pivonkova, Valerio Bellucci, Christian Bressler

Table of Contents

Executive Summary

HR4 is aimed to provide digital tools to the human resources of LEAPS, to foster transversal projects between the LEAPS facilities for development and upgrade, to engage the use of LEAPS facilities, in the enlarged user ecosystem, and to promote the industrial collaboration for the development of innovative technologies.

Objectives

The HR4 program was specifically designed to:

1. Develop a comprehensive digital collaborative platform that would support seamless interaction among researchers across the LEAPS ecosystem.
2. Implement remote training tools that would allow users to perform and engage in complex scientific activities without the need for physical presence. Enhance user engagement through interactive and user-friendly digital tools, aiming to increase participation and improve the user experience at the FELs and in the synchrotrons.
3. Introduce in LEAPS tools based on collective intelligence and large language model to collect a large amount of strategic information about LEAPS technology of interest and user applications in particular in the area of advanced material

Key Findings

- The program successfully deployed VLab, an innovative virtual laboratory environment at a Free Electron Laser Source, which has become a critical component of the facility's training. The same concept will be extended to synchrotron radiation beamlines (in future funding application).
- Digital collaborative platforms have been effectively utilized, collecting from dislocated source, relevant information that can enhance the inspiration for collaboration and participation to funding call, out of the usual European funding scheme.
- Strategic tools for collective intelligence have been leveraged to improve the assessment of technology and user cases and enlarge a more integrated scientific community.

Description

As first important result, HR4 explored remote and hybrid user training methodologies. Remote User Training Tools basing on digital simulation of the facilities were used and investigated in the EU project eRImote, with goal to facilitate the access to FEL. A digital simulation of a synchrotron radiation beamline for training purposes will be developed in future funded project. Results will be shared among the entire LEAPS community. Contacts with other user communities during eRImote, exemplified by partnerships with entities like Euro-BioImaging and Instruct, has proven highly enriching. These connections not only serve to naturally promote remote training tools to potential user consortia but also provide invaluable constructive feedback for further improvements.

As second point, digital tools, mainly based on collaborative and collective intelligence, were introduced and used.

Collaborative and collective intelligence[1] encompass a dynamic framework where diverse agents, whether human or machine, autonomously contribute to problem-solving networks. This collective intelligence is amplified by the rapid dissemination of vast information facilitated by the Internet, enabling comprehensive assessments of technologies, user applications, and predictive technology trends.

To achieve these objectives, HR4 leverages established platforms like LinkedIn for the Innovation Mall[2], supplemented by funding opportunities available through the CALIPSO Plus project.

As third point, the utilization of collective intelligence within HR4 facilitates the acquisition of important insights critical for informing facility development plans and effectively targeting user communities engaged in advanced material science. Noteworthy outputs of this process comprise of comprehensive reports detailing academic and industrial stakeholder engagements, assessments of technology maturity levels, or analyses of investment trends.

Employing public database online has enabled the rapid accumulation of substantial public data and information, empowering the generation of tailor-made reports by leveraging advanced language models. This data will be seamlessly shared via Sync & Share, accompanied by illustrative examples of the reports.

Moreover, the methodology implemented allows for dissemination to other LEAPS facilities. It's imperative to emphasize that while the current commercial tool has been instrumental, its necessity in future iterations is diminished. This is due to the availability of new commercial tools offering similar functionalities. The wealth of data already amassed serves as a robust foundation for future research endeavors utilizing alternative tools.

---

[1] *Collaborative and collective intelligence, distinguished by their nuanced contributions, form the bedrock of HR4's strategic initiatives within the LEAPS facility. Collaborative intelligence entails the orchestrated collaboration of diverse entities, whether human or machine, toward shared problem-solving goals. In contrast, collective intelligence encompasses the aggregation and synthesis of individual contributions within a networked framework, often transcending individual capabilities to achieve greater insights and outcomes.*

[2] *https://hbr.org/2008/12/which-kind-of-collaboration-is-right-for-you*

Achievements of HR4 Program

Digital Collaborative Platforms[3]

A platform has been developed to offer LEAPS members access to a range of valuable resources and opportunities aimed at enhancing their experience and collaboration within the network. https://www.linkedin.com/groups/12579230/

To allow for more tailored topics, and hence better precision of the reach that ensures relevance of the post to the reader and vice versa, a series of personalized hashtags was introduced on the platform.

- #LEAPStechnologynews: Share any groundbreaking technological results or advancements.

LEAPS members have access to the latest groundbreaking technological results and advancements. Members can stay informed about cutting-edge developments in their respective fields, including new discoveries, innovative technologies, and research breakthroughs. This platform tab serves as a valuable resource for staying ahead of the curve and driving innovation within the community.

- #LEAPSprojectupdate: Update the group on the progress of your facility projects

LEAPS facility representatives have the opportunity to update the group on the progress of their facility projects using the designated hashtag. This enables members to stay informed about ongoing projects, milestones achieved, and upcoming initiatives. By sharing project updates, representatives can foster transparency, collaboration, and engagement within the community.

- #LEAPScallforsolution: Challenges are collected that look for solutions, by funding schemes, coming from industry, private sector or other public institutions.

Members who encounter challenges in their technology development can use the #LEAPScallforsolution hashtag to seek unique solutions within the community.

From the other side, members can leverage the collective expertise and resources of the LEAPS network to find innovative solutions to challenges from private sector. This hashtag facilitates collaboration and problem-solving among members.

---

[3] *https://www.leaps-initiative.eu/hr4-platform-connecting-leaps-specialists-and-industry-professionals/*

- #LEAPScallforpartnership: Typical case is when a niche partner with specific competencies is sought, also during multipartners project.

For members already engaged in collaborations with multiple partners but seeking a niche partner with specific competencies, the #LEAPScallforpartnership hashtag provides a platform to connect with potential partners within the community. By sharing details about their projects and identifying the expertise they require, members can attract suitable partners and enhance the success of their collaborations.

From the other side, members can leverage the collective expertise and resources of the LEAPS network to participate as partner to projects both from public and private sector.

This hashtag promotes networking and collaboration among members with complementary skills and capabilities.

- #LEAPScallforexpert: This hashtag is used to promote your search for experts to fill open job positions.

Members seeking experts to fill open job positions can use the #LEAPScallforexpert hashtag to promote their job postings within the community. Whether recruiting for research positions, technical roles, or leadership positions, members can leverage the platform to reach qualified candidates with the necessary expertise and experience. This hashtag facilitates talent acquisition and recruitment efforts within the LEAPS network.

Through these targeted hashtags, members can access a range of resources and opportunities to stay informed, collaborate, solve challenges, form partnerships, and recruit talent within the LEAPS community.

Remote User Training Tools

One of the project's major goals was the development of remote training tools, which were realized through the following initiatives:

- **Virtual Laboratory (VLab):** VLab has been instrumental in providing extremely realistic, immersive training experiences. It allows users to conduct experiments and learn complex instrumentation and work procedures in its virtual setting, thus reducing the learning curve and preparation time for actual experiments.

- **Training Modules:** A comprehensive training module was developed, which effectively covers the operational and scientific procedures relevant to the FEL's user base. It also serves to train prospective new users at these large-scale research infrastructures, and is already being used in the university curriculum for physics students.

The tool was promoted by the eRimote project in the main clusters of potential user (EURObioimaging, Instruct-ERIC). The positive feedback was not limited to the tool, but to LEAPS that was engaged with a pilot project in this training domain.

The forward step was to look for funding to extend the virtual simulation to a synchrotron line.

These activities have been conceived, developed and implemented by Prof. Christian Bressler, and within LEAPS/eRImote was strongly supported by colleagues Annika Thiel, Ulla Laechele, Ute Krell, Elke Plönjes, and Julia Hauk. This support allowed implementing significant upgrades to VLab, which have been constantly tested at different occasions including schools, workshops and science exhibitions.

Strategic Use of Collective Intelligence Tools

The HR4 project has leveraged collective intelligence tools to enhance decision-making and project management within the European XFEL.

Based on the technology roadmap and the general interest of the LEAPS facility, a list of technology of interest and field of user case has been identified in the list below and data downloaded to for different online databases:

Technology of interest	User fields
Data as Excel sheets and graphics	
Beam splitter (diffractive)	Catalysis
Beryllium	Catalysis (enzyme)
Bulk compressor	Catalysis (H and H)
Detector (X-ray)	Catalysis (photo-)
Diamond	Diamond
Diamond (synthetic)	Diamond (synthetic)
Femtosecond	Lithium battery
Laser	Nondestructive testing
Laser (detection)	Nondestructive testing (chip)
Laser (femtosecond)	Nondestructive testing (microprocessor)
Laser (infrared)	Nondestructive testing (semiconductor)
Lens (diffractive)	Nondestructive testing (wafer)
Lens (optics)	*Total: 12 topics*
Lens (refractive)	
Optics	
Optics (crystalline)	
Optics (diamond)	
Optics (X-ray, silicon)	
Optics (X-ray)	
Transmission grating	
Transmission grating (compressor)	
Total: 21 topics	
Data as graphics only	

Alignment	3D Wafer inspection
Artificial Intelligence	Aluminium
Attophotonics	Aluminum
Attosecond	Amorphous
Attosecond laser	Amorphous cell
Attosecond optics	Amorphous solar cell
Attosecond spectroscopy	Attosecond spectroscopy
Beam	Battery
Beam splitter	Battery pack
Bellow	Beryllium detector
Beryllium	Beryllium imaging
Beryllium detector	Beryllium inspection
Beryllium lens	Blood
Bulk compressor	Blood circulation
Chemical vapor deposition diamond	Cancer
Compound lens	Carbon
Compound refractive lens	Carbon nanotube
Compressor	catalysis
Crystalline optics	Cavitation
Crystal optics	Cell
CVD diamond	Chemical vapor deposition
Detector	Chemical vapor deposition diamond
Diamond detector	Chip
Diamond imaging	Chip inspection
Diamond laser	Circulation
Diamond microprocessor	Coal
Diamond optics	Composite
Diamond X-ray optics	Compressor
Diffracted beam	Crystal
Diffraction	CVD diamond
Diffraction splitter	Degradation
Diffractive beam splitter	Detector
Diffractive lens	Diamond
Diffractive lenses	Diamond battery
Dirraction grating	Diamond detector
Electron imaging	Diamond inspection
Electron spectroscopy	Diamond laser
Femtosecond	Diamond microprocessor
Femtosecond laser	Diamond Nanostructure
Femtosecond optics	Diamond optics
Femtosecond spectroscopy	Diamond phononics
Grating	Diamond photonics
Grating compressor	Diamond semiconductor
High Pressure	Dust
High Pressure High Temperature	Elasticity

High Pressure High Temperature diamond	Electron spectroscopy
High Temperature	Energy
High velocity	Femtosecond spectroscopy
HPHT diamond	Fission
Imaging	Fracture
Infrared	Fusion
Infrared imaging	Gold nanoparticle
Infrared inspection	Heart
Infrared laser	Heart attack
Infrared lens	High Pressure
Infrared spectroscopy	High Pressure High Temperature
Laser	High Pressure High Temperature diamond
Laser detection	High Temperature
Laser detector	High velocity
Laser Grating	High velocity impact
Laser imaging	HPHT diamond
Laser inspection	Hydrogen
Laser spectroscopy	Imaging for chip inspection
Lens	Impact
Manipulator	Industry
Microphotonics	Infrared spectroscopy
Microsecond laser	Inspection
Microsecond optics	Interface
Monochromator	Interstellar
Multilayer imaging	Iron
Multilayer mirror	Iron ore
Multilayer optics	Kidney
Multiplayer	Lithium-ion battery
Nanophotonics	Lithium battery
Nanoprobe	Lungs
Nanosecond laser	Magnetic nanoparticles
Nanosecond optics	Medicine
Nanosecond spectroscopy	Mems
Optics	Mems imaging
Phase grating	Mems inspection
Phase lens	Microcomposite
Phonon imaging	Microfabrication
Picosecond	Microphotonics
Picosecond laser	Microporous
Picosecond optics	Microprocessor
Picosecond spectroscopy	Microprocessor imaging
Refractive lens	Microprocessor inspection
Shutter	Microsecond spectroscopy
Silicon detector	Microtechnology
Silicon optics	Multilayer inspection

Silicon X-ray optics
Splitter
Synthetic diamond
Transmission
Transmission compressor
Transmission grating
Transmission grating compressor
Ultraviolet
Ultraviolet lens
Ultraviolet spectroscopy
Vacuum alignment
Vacuum bellows
Vacuum chamber
Vacuum interface
Vacuum manipulator
Vacuum motor
Vacuum pump
Vacuum shutter
X-ray
X-ray attenuator
X-ray crystalline optics
X-ray crystal optics
X-ray detection
X-ray detector
X-ray grating
X-ray laser
X-ray lens
X-ray nanoprobe
X-ray optics
X-ray spectroscopy
X-ray windows

Total: 119 topics

Nanocomposite
Nanofabrication
Nanoparticle
Nanophotonics
Nanoporous
Nanoprobe
Nanoprocess
Nanosecond spectroscopy
Nanostructure
Nanostructure imaging
Nanostructure inspection
Nanotechnology
Nano processor
Natural diamond
Nondestructive
Nondestructive testing
Nuclear battery
Nuclear fission
Ore
Painkiller
Perovskite
Phonon
Phononic crystal
Phonon imaging
Photonics
Photonic crystal
Picosecond spectroscopy
Plant
Redox
Renewable
Rock
Rubber
Rubber elasticity
Ruby
Salt
Sapphire
Semiconductor
Silicon imaging
Silicon inspection
Silicon Nanostructure
Silicon photonics
Silver nanoparticle
Solar
Solar Cell
Space

	Space dust Star Steel Stroke Synthetic diamond Tire Tire degradation Transmission Tree Ultraviolet spectroscopy Wafer Wafer inspection X-ray X-ray inspection *Total: 148 topics*

For each topic, data were downloaded in the form of Excel files and graphics regarding the following analysis:

- **Main stakeholder organizations (mainly companies)**

A total of 429 Graphics and 49 Excel files, encompassing 14,980 entries. For each entry, the following data were collected:

- Company Name
- Company Description
- Website
- Employees
- Location
- Founded Date
- Organization Type
- Tech Topic
- Total Patents
- Patent Portfolio Value
- Revenue
- Market cap

- **Patents**

A total of 209 Graphics and 37 Excel files, encompassing 405,190 entries. For each entry, the following data were collected:

- Application Date

- Application Number
- Publication Date
- Publication Number
- Issue Date
- Title
- Standard Original Assignee
- Original Assignee
- Standard Current Assignee
- Authority
- Simple Legal Status
- Legal Status & Event
- Inventor Name
- Main IPC

- **<u>Literature</u>**

A total of 409 Graphics and 40 Excel files, encompassing 883,496 entries. For each entry, the following data were collected:

- Publication Date
- Title
- Authors
- Institutions
- Journal
- Source
- Citations
- DOI
- Abstract
- PDF Link

- **<u>News</u>**

A total of 168 Graphics and 46 Excel files, encompassing 81,906 entries. For each entry, the following data were collected:

  - Date
  - Title
  - Source
  - Abstract
  - Companies
  - Business Type

- **Market report**

A total of 375 Graphics and 27 Excel files, encompassing 11,935 entries. For each entry, the following data were collected:

- Report Name
- Publish Date
- Publisher
- Sector Name
- Start Year
- Start Year Size(USD)
- End Year
- End Year Size(USD)
- CAGR (%)
- Region
- Abstract
- Category

- **Venture capitalist investment**

A total of 484 Graphics

The following data were listed:

- Amount of funding (USD)
- Announced Year
- Investor
- Industry
- Series round
- Investment type
- Country

- **Experts**

A total of 403 Graphics and 36 Excel files, encompassing 267,517 entries. For each entry, the following data were collected:

- Expert
- Publications
- Citations
- Institutions
- Related Topics

- **Research fundings**

A total of 38 Excel files, encompassing 65,488 entries. For each entry, the following data were collected:

- Open Time
- Close Time
- Title
- Award To
- Award By
- Amount (USD)
- Award Country
- Source
- Abstract

- **Grant**

A total of 36 Excel files, encompassing 33,916 entries. For each entry, the following data were collected:

- Date
- Title
- Amount (USD)
- Close Time
- Award Time
- Award To
- Award By
- Status
- Award Country
- Source
- Abstract

The information for each topic was presented as trends and highlights, fast-growing innovations, and main investments. The topics were analyzed using a research methodology that included and excluded synchrotron radiation. This allowed us to identify organizations and experts not in the LEAPS network who may be of interest.

Not all data for every topic and subcategory was downloaded. Instead, a selection of relevant data was made, particularly focusing on the European landscape.

The amount of downloaded data, categorized by topics, subtopics, general data, or data specifically with synchrotron radiation, is as follows:

- 2.1 GB
- 11,565 Files
- 796 Folders
- 399 Excel files
- 1,788,313 Excel entries

- 11,111 Graphics
- 140 technologies of interest
- 160 user applications of interest

Since the amount of data was not easily manageable with our limited resources, a script that uses Large Language Models was developed for automated technology exploration and report production. The author, Dr. Valerio Bellucci, has also worked on the main download of the database. This system enables connecting commercial large language models with a user database and desktop resources for intelligence exploration and document production. The system was successfully tested in our database, producing reports for technology trends including LEAPS facilities' development and user experiments (examples attached). The system can be used for writing any type of document and answering open-ended and open-topic questions via the information in a database. In the framework of LEAPS, it can be used for writing reports about the search for technology providers, target users, in particular industrial users, supply chain, positioning in the competition landscape, evaluation of the impact of technologies, and application for funds. The system can be used to effectively simplify the work of LEAPS officers and cut down the required time for producing topical studies. In our tests, the time required to write a pre-determined report was reduced from 3 days to 3 hours using the developed system.

By now the following reports have been created:

Technology of interest	**User fields**
Technical Study on 'lensless imaging' - 'Improve accuracy'	Catalysis experiments synchrotrons XFELs report
X-ray optics	Lithium Battery Technology Report
X-ray detectors literature analysis	Lithium Batteries Report Synchrotron Experiments
X-ray Detectors Patents Landscape Analysis	Lithium Battery Comparative Analysis
X-ray detectors report	Chip Inspection Synchrotron Experiments Report
Diffractive Beam Splitters Report	Nondestructive Testing in Electronics Synchrotrons XFELs
Refractive Lens Technologies Synchrotrons XFELs	Technical Study on '3D wafer inspection' - 'Improve resolution'
Diffractive Beam Splitters Report	
Refractive Lens Technologies Synchrotrons XFELs	
Total: 9 reports	*Total: 8 reports*

The main uses of the database, LLM system, and the reports are as follows:

- Searching for technology providers.
- Targeting potential users, particularly industrial users.
- Drafting supply chains for missing components and materials in Europe.

- Positioning relative to other competing analytical technologies (e.g., cryomicroscopes, nanoFTIR, etc.).
- Evaluating impact, particularly for writing applications for funds.
- Finding academic and industrial experts outside the LEAPS network to expand our pool of experts.
- Searching for companies interested in knowledge and technology transfer.

A special acknowledgment for the support of Eva Crosas (DESY) that downloaded the relevant data on the Beryllium technology, Frei-Hardt Markus (PSI) and EL-MANSOURI Jamal (SOLEIL) for the useful feedback and suggestions.

Contact: ilo@xfel.eu