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D6.1 - REPORT AND SPECIFICATION DOCUMENT OF THE PROTOCOL OF IRA PROCEDURES

BIM 6

OI 6.1 - DESIGN OF THE IRA PROCEDURES

WP 6 - RESEARCH SUPPORT SERVICES: ACCESS PROVISION THROUGH ADVANCED METHODS AND TECHNOLOGY; INTELLECTUAL PROPERTY

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Summary

1. INTRODUCTION

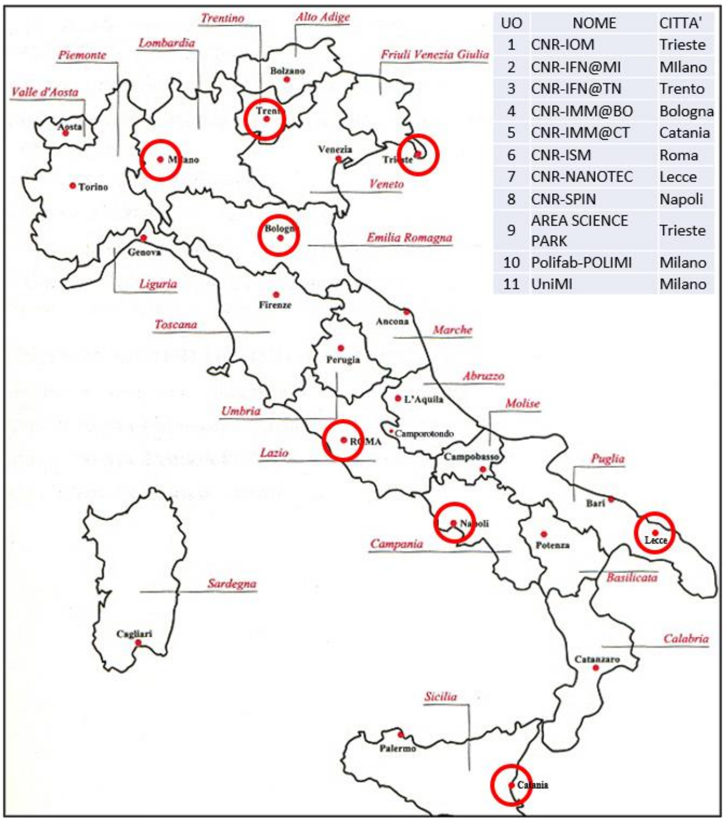
This document constitutes the first deliverable D6.1 of WP6 (Research Support Services: Access provision through advanced methods and technology ; Intellectual Property) within the scope of activity A6.1 "Innovative procedure for interactive remote access". Here, the specifications and proposed protocol for Interactive Remote Access (IRA) to the acquired instrumentation within the NFFA-DI project will be outlined.

As previously detailed in D2.5 "Protocols for Real-time access monitoring, statistics, and analytics", external user access to the infrastructure will occur through the digital Single Entry Point (SEP) portal. This portal allows users to submit access requests to the infrastructure based on a scientific project (proposal), following methods like those used on the NFFA Europe Pilot (NEP) project portal. Each proposal involves a minimum of two or more experimental steps that can be carried out in the Operating Units that provide the required technique and are available to host the external user, after a feasibility and a scientific peer reviewed evaluation of the proposal.

2. OBJECTIVE

The deliverable D6.1 is associated with the Intermediate Objective of defining the terms and conditions for Interactive Remote Access (IRA) to the NFFA-DI infrastructure, including the definition of possible sustainable cost models for the various Operating Units of NFFA-DI.

The definition of this protocol will enable external users to access the NFFA-DI infrastructure remotely, thus positively contributing to the sustainability of the infrastructure and the overall goal of reducing CO2 emissions from travel. In Figure 1, the map of the various Operating Units comprising the distributed NFFA-DI infrastructure across the national territory can be visualized.



UO	NOME	CITTA'
1	CNR-IOM	Trieste
2	CNR-IFN@MI	MIlano
3	CNR-IFN@TN	Trento
4	CNR-IMM@BO	Bologna
5	CNR-IMM@CT	Catania
6	CNR-ISM	Roma
7	CNR-NANOTEC	Lecce
8	CNR-SPIN	Napoli
9	AREA SCIENCE PARK	Trieste
10	Polifab-POLIMI	Milano
11	UniMI	Milano

Figure 1:. Map of the Operating Units (UO) comprising the distributed NFFA-DI infrastructure across the national territory.

3. REMOTE ACCESS IN NFFA-DI

The WP6 of the NFFA-DI project aims to define a comprehensive portfolio of ready-to-use integrative services for our research community. In recent years, the experience of mobility restrictions related to the Covid-19 pandemic has accelerated an ongoing digital transformation, which by its nature is also affecting research and how it will be conducted in the years to come.

The objective of WP6 is to develop a class of new services for the use and support of the NFFA-DI infrastructure, which will facilitate access to the infrastructure itself. This deliverable will focus on the development and presentation of a protocol for IRA (Interactive Remote Access), a flexible and interactive method for conducting scientific experiments even without the physical presence of the researcher, breaking down the barrier between the physical and digital worlds.

Remote access, virtualization, in a multi-channel approach, will provide the community with accessibility to facilities and tools without the need to travel physically. This will drastically reduce the distances between resources, contributing to the quality and productivity of many collaborative projects, thus enabling fully participatory research by users even during any restrictions or limitations on mobility of any nature.

Remote access is defined as a process that allows a user to connect to and operate a system or computer device from a physically distant location from where the user is located.

It usually involves a bidirectional Internet connection (LAN, WAN) between two or more online computers located at a distance from each other, where the user can have control (more or less limited) of one of the two machines operating from one on the other. For this to be possible, both devices involved must be equipped with the specific software required to establish the connection.

Examples of remote access include:

- Retrieving files using file transfer protocols (FTP);
- Connecting via SSH (Secure Shell);
- Configuring a VPN connection to access the internal network of a specific entity/institution;
- Remote desktop protocols such as RDP (Remote Desktop Protocol) or VNC (Virtual Network Computing);
- Controlling network devices such as routers.

Remote access is widely used in various IT fields and technical support, allowing system administrators and authorized users to manage and monitor computer resources from any location, improving efficiency and operational flexibility. However, it is important to implement robust security measures to protect systems from potential threats during remote connections.

In the realm of scientific research, the use of remote access procedures to instrumentation is crucial for optimizing experiment times and mitigating potential mobility restrictions or limitations, especially in scenarios such as pandemics. Here are some reasons that highlight the importance of this practice:

- *Operational efficiency:*
  Remote access allows scientists and operators to conduct experiments without needing to be physically present in the laboratory. This reduces waiting times and optimizes resource utilization, as more people can access the instrumentation in shorter timeframes.

- *Reduction in instrumentation booking times (scheduling):*
  Remote access enables the planning and execution of experiments even outside conventional working hours. This can reduce waiting times to access shared equipment, improving efficiency and allowing greater flexibility in experiment scheduling.

- *Global collaboration:*
  Remote access facilitates collaboration among researchers and scientific teams distributed across geographically distant locations. Experts can contribute and participate in experiments without the need for physical travel, promoting quicker knowledge sharing and more efficient scientific progress.

- *Risk reduction in emergency situations:*
  In emergencies such as pandemics or other crises, remote access reduces the need for physical travel and, consequently, the risk of exposure to contagion. This is particularly important for ensuring the safety of laboratory operators.

- *Business continuity in adverse conditions:*
  In the event of mobility restrictions, remote access allows research activities to continue without significant interruptions. This flexibility is essential to ensure that scientific research can proceed even in adverse conditions.

- *Resource optimization:*
  Remote access enables the optimization of scientific equipment usage, reducing downtime and maximizing overall laboratory productivity.

- *Environmental sustainability:*
  By reducing the need for physical travel, remote access also contributes to environmental sustainability by decreasing transportation impact and greenhouse gas emissions associated with travel.

In summary, remote access to scientific instrumentation not only optimizes efficiency and resource utilization but also serves as a key strategy for addressing unforeseen challenges, ensuring continuity and safety in scientific research activities.

4. INTERACTIVE REMOTE ACCESS IN NFFA-DI

The specificity of the instrumentation available in the catalog of the NFFA-DI infrastructure and the expertise required for its use make it very challenging to authorize full and autonomous remote access by external users to the infrastructure. Additionally, many experimental techniques still require an on-site operator for instrument calibration or sample positioning.

The possibility of using interactive remote access allows overcoming all the aforementioned difficulties. In activity 6.1 of WP6, the concept of Interactive Remote Access is introduced, defined as a set of the best communication protocols and interactive modes to ensure continuity in the research flow even in the case of mobility restrictions.

In the NFFA Europe Pilot (NEP) project, there was already provision for the possibility of remote access to the infrastructure laboratories, where feasible and available, as described in public deliverable D2.1 "Detailed procedures for integrated Transnational Access" (10.5281/zenodo.7056994). The request for remote access could be made at the time of scheduling the experimental measurement at the hosting laboratory and could be defined with different levels of interactivity based on the specific needs of the technique to be performed. As of February 2024, the data on remote access are encouraging: out of 162 proposals submitted and concluded, 51 were conducted remotely (31%), 79 with physical access to the laboratories (49%), and 32 with mixed access (remote/presence, 20%) in the different experimental steps outlined in the proposal.

In the NFFA-DI project, we conducted a census of the techniques that will be included in the infrastructure catalog and that involve a remote access system. Table 1 provides details of the Operating Units, instruments, techniques, and expected modes of remote access to the instrumentation. We can observe that currently, 15 instruments offer the possibility of connection for remote control of the instrument.

Operating Unit	Instrument	Experimental Technique for NFFA-DI Catalog	Software for remote access
Area-Science-Park	Dual beam Tescan	FIB-SEM	to be defined
Area-Science-Park	Jeol 200 kV	TEM	to be defined
Area-Science-Park	Jeol 300 kV	TEM	to be defined
CNR-IOM	LT-STM	STM	remote.iom.cnr.it
CNR-IOM	VT-STM	STM	remote.iom.cnr.it
CNR-ISM	femtosecond laser source-optical paramentric amplifier	Ultrafast-Spectroscopy	VPN
CNR-ISM	Photoluminescence Spectrometer	Optical-luminescence	VPN
CNR-SPIN	MODA - Modular system for Oxides Deposition and Analysis	PLD	TeamViewer
IMM-Catania	Computing center UO@IMM-CT	Theory-and-simulation	secure connection via vpn (terminal only)
Polifab	RF probe station	RF measurements	Team viewer (to be evaluated)
UniMi-Fisica	MLMS (Milan Lab for Materials Simulation)	Theory-and-simulation	ssh, scp
UniMi-Fisica	MLMS (Milan Lab for Materials Simulation)	Theory-and-simulation	ssh, scp
UniMi-Fisica	MLMS (Milan Lab for Materials Simulation)	Theory-and-simulation	ssh, scp
UniMi-Fisica	MLMS (Milan Lab for Materials Simulation)	Theory-and-simulation	ssh, scp
UniMi-Fisica	MLMS (Milan Lab for Materials Simulation)	Theory-and-simulation	ssh, scp

Table 1: Details of the Operating Units, instruments, techniques, and expected modes of remote access to the instrumentation of NFFA-DI.

Given the definition of Interactive Remote Access considered in activity 6.1, it is not essential for the instrument to be remotely controllable to foresee this type of interactive remote access. In fact, IRA involves a remote connection with the on-site operator who directly operates the instrumentation. Whether the external user is connected remotely to the instrumentation or not is an additional level that we can consider.

In this document, we propose a protocol for IRA access that could potentially be used with all instrumentation in the NFFA-DI catalog to further increase the percentage of interactive remote access recorded in the NEP project.

5. REMOTE ACCESS ENABLEMENT

In the NEP portal, laboratories available to grant remote access include this possibility in the description of their facility. For example, the Karlsruhe Institute of Technology (KIT) laboratory for the Scanning Probe Lithography (SPL) Setups (Dip-pen Nanolithography – DPN technique, Lithography & Patterning installation) already offers the possibility of IRA, as seen in Figure 2.

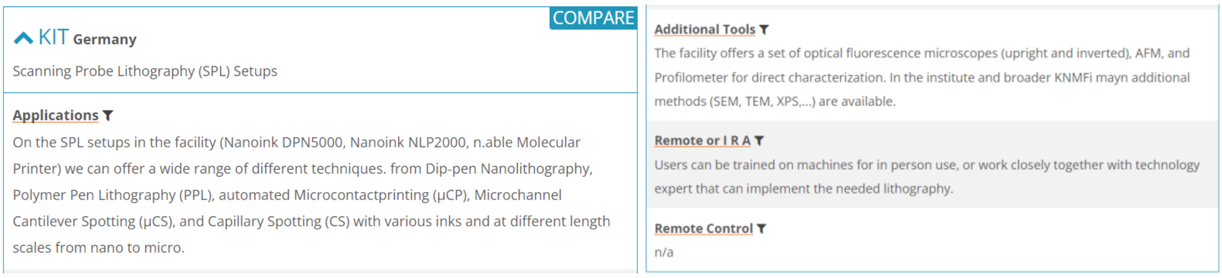


Figure 2 :Screenshot from the NEP portal ((Dip-pen Nanolithography (DPN) | NFFA.eu) showing some of the specifications of the services offered by the Karlsruhe Institute of Technology (KIT) laboratory for the Scanning Probe Lithography (SPL) Setups (Dip-pen Nanolithography – DPN technique, Lithography & Patterning installation).

According to the access procedure for the NFFA Europe Pilot (NEP) infrastructure, as described in D2.1 Detailed Procedures for Integrated Transnational Access (10.5281/zenodo.7056994), after scheduling the proposal, the external user receives an official document signed by the Project Coordinator authorizing access to the selected laboratory. The request for remote access, if needed, and the specific mode are defined later.

In NFFA-DI, it is desired for the possibility of IRA to be available in all infrastructure laboratories and proposed in the laboratory specifications exactly as shown in Figure 2. Furthermore, to facilitate the IRA request, it is desirable for it to be selectable during the proposal submission phase on the NFFA-DI portal.

The specific modes of IRA according to the availability of each laboratory will be defined following the protocol described in the next paragraph.

5.1. IRA PROTOCOL

The level of autonomy granted to the external user accessing the laboratory instrumentation remotely can be defined by addressing the following questions:

1) Is all the instrumentation necessary for the technique controlled by software installed on one or more PCs?
   a) If not, indicate the percentage of instrumentation not controlled by PCs.
2) Do the PCs controlling the instrumentation possess remote control software (e.g., TeamViewer)?
   a) If yes, indicate the usage methods of such software (e.g., static ID with temporary password).
   b) If no, indicate whether there is an intention to acquire such software.
3) Are the experimental chambers equipped with cameras connected to software installed on the PCs, ensuring nearly complete visualization of the setup?
   a) If yes, indicate the percentage of visual coverage guaranteed.
   b) If no, indicate whether there is an intention to acquire such support.
4) Is sample preparation carried out exclusively automatically?
   a) If no, indicate the percentage contribution of a human operator.
5) Is sample positioning carried out exclusively automatically?
   a) If no, indicate the percentage contribution of a human operator.
6) Is fine-tuning of position following calibrations, focusing, etc., completely controlled by software installed on the PCs?
   a) If no, indicate the percentage contribution of a human operator.
7) Is it necessary to reposition the sample during the experiment?
   a) If yes, indicate the percentage of repositioning that must be done by a human operator.
8) Is sample removal at the end of the experiment carried out exclusively automatically?
   a) If no, indicate the percentage contribution of a human operator.
9) Does the laboratory have personnel available to perform all operations requiring a human operator? (from sending credentials, to sample positioning and removal)
   a) If yes, indicate:
      i) The total duration of a measurement set and the average number of measurements per experiment.
      ii) Whether continuous presence of the human operator is necessary.

6. COST MODEL

The NFFA-DI project, and consequently the NFFA-DI infrastructure, currently does not plan to provide a contribution for travel expenses to researchers submitting a proposal. Consequently, access to the infrastructure via IRA allows the external user to save on travel expenses and corresponding CO2 emissions.

Regarding the execution of the experiment, the NFFA-DI infrastructure, in line with the NEP project, will cover the expenses necessary to ensure access to the infrastructure by external users who have submitted a positively evaluated proposal. The infrastructure will also enter an access contract with the external user, similar to that defined in the NEP project. This contract does not distinguish between in-person or remote access.

Following the completion of the proposed protocol by a laboratory, the levels of remote access can be defined, summarized in the following classes:

a) IRA with continuous assistance from laboratory personnel connected live with the external user throughout the experiment duration.
b) IRA with partial assistance (percentage defined by the protocol) from laboratory personnel connected with the user only when necessary (training, instrument calibration, sample positioning, initial testing, etc.).
    i. Subsequent direct and autonomous use of equipment by remotely connected external users (subject to the availability of software and compatible instrumentation for remote access, see Table 1).
    ii. The external user disconnects and interacts only at specific moments with the operator on-site conducting the experiment (image acquisition, etc.) in synchronous (chat) or asynchronous (email) mode.

We do not consider in the remote access scenarios the possibility of laboratory personnel conducting the experiment without any connection with the external user, as this falls under the services provided by the laboratory for standard experiments.

Considering that the cost of an experiment/measurement of the laboratory can be composed of:

- Instrument depreciation;
- Consumables cost;
- Measurement duration (defined in terms of Unity of Access);

Option a) is potentially achievable for all NFFA-DI instrumentation and does not offer any economic savings compared to physical access to the infrastructure, except for travel expenses, which are not covered by the NFFA-DI infrastructure.

Option b) offers potential savings related to the defined percentage of necessary operator presence and the qualification of the operator. This percentage can be defined using the questions in the protocol outlined in this document.

7. CONCLUSIONS

This document defines, within the scope of the NFFA-DI project, what is meant by Interactive Remote Access (IRA) to the project infrastructure and provides an overview of the project-affiliated laboratories that offer the possibility of remote access and control of instrumentation, as detailed in Table 1.

Furthermore, a protocol is presented to precisely define the level of interaction necessary/desired for conducting an experiment remotely. This protocol will be shared with all project partners and used to outline the guidelines for IRA access to the NFFA-DI infrastructure, which will be presented in the upcoming deliverable D6.5.

Additionally, cost comparisons have been made between physical access and remote access to the infrastructure. It follows that in the case of continuous connection IRA with a local operator, there is potentially no cost difference compared to physical access. However, in the case of partial IRA, there may be savings in remote access compared to physical access due to a decrease in the percentage of the operator's presence on-site. The proposed protocol will help define the specific percentage of operator presence in each laboratory.