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NFFA

Nanoscience Foundries and Fine Analysis

D4.6

Analysis of Financial Issues related to the Construction of NFFA-RI

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Deliverable D4.6: Analysis of Financial Issues related to the Construction of NFFA-RI

1. INTRODUCTION

1.1. Purpose of the document

The purpose of this document is an analysis of the financial issues related to the NFFA-RI construction and exploitation, taking into account the possibilities of different sites and the number of NFFA centres to be started according to the NFFA roadmap (Deliverable 2.3).

1.2. Application Area

The targets of this document are the members of the NFFA Project, the EC Project Officers, and the general public.

1.3. References

Description of Work (DoW). See at web site:
http://www.nffa.eu/ResearchActivityData.aspx?IdRACT=14&idTypeRACT=1
The cost analysis is based on information acquired in WP2 (user flow assessment) and WP3 (design study of the NFFA-RI) and on values provided by reference DoE facilities and NFFA partner institutions.

1.3.1. Objective of Work Package 4

The objective of Work Package 4 is the development of management structure and format of user access for NFFA-RI centres, the design of the NFFA Data Repository and the intellectual property issue.

1.3.2. Description of work broken down into tasks

The following tasks are defined in WP4:

- T4.1) Definition of the mission of NFFA
- T4.2) Design of the governance of a Research Infrastructure operating several Centres
- T4.3) Design of a scientific management of NFFA
- T4.4) Development of a robust scheme for user access to NFFA centres and to the NFFA Data Repository
- T4.5) Assessment of the possible contribution of existing facilities that could be integrated in NFFA centres
- T4.6) Analysis of the financial issues related to the NFFA-RI construction and exploitation
- T4.7) Cost analysis of the operation of NFFA and of a prototypical reference centre located nearby a LSF
- T4.8) Definition of the quality standard for NFFA products and service
- T4.9) Design of a NFFA Data Repository

2. EXECUTIVE SUMMARY

Deliverable 4.6 describes the financial issues related to NFFA-RI construction and exploitation, taking into account the possibilities of different sites. According with the NFFA roadmap (Deliverable 2.3), the implementation of the NFFA-RI will take place in two phases – firstly two or three centres will be funded and set-up, while additional sites will be installed later and will profit from the experiences of the phase 1 centres. Both, phase 1 and phase 2 centres could be an adaptation of an existing centre or a new centre, although the adaptation of existing facilities will have advantages particularly in phase 1. Both scenarios and the associated costs are analysed in Section 3 of this document.

The preliminary construction layout (Deliverable 3.1) includes a total area of 7300m², of which 700m² will be dedicated to the cleanroom; current construction costs of cleanroom area are around 8 k€/m^2, building costs for 'general use area' and standard laboratories are around 4-6 k€/m² (€ value 2010). According to these numbers, this would require ~ 35 M€ investment for construction cost of one NFFA centre.

Besides the construction costs, additional 22 M€ for common infrastructure including support labs, technical infrastructure, basic scientific equipment should be considered. A sum of 5 M€ was budgeted for additional costs during the installation phase of equipment.

Costs for specialized computing and for the whole IT infrastructure at one NFFA centre are estimated around 2 M€. All centres will have similar basic activities but they will differ in their particular specialisation. The average investment cost for advanced instrumentation, related to the specialisation of the particular centre, is estimated to be 6 – 8 M€.

The specialisations are likely to be driven by activities of already existing facilities and by national and regional interests. Duplication should be avoided to ensure that the NFFA network covers the best possible range of techniques.

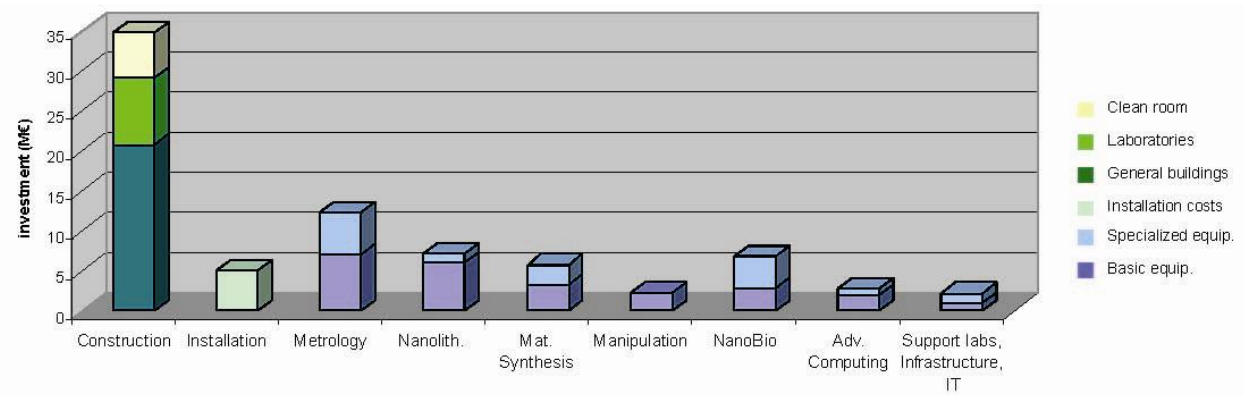

Fig.1. Investment averaged costs for facilities, installation and supplementary infrastructure for one NFFA centre. Light blue areas represent the additional investment foreseen for the advanced equipment for each facility.

3. FINANCIAL ISSUES RELATED TO THE CONSTRUCTION OF THE NFFA-RI

The national policies will determine whether new buildings or upgrade/reconvertion of existing infrastructures will be implemented. Construction funds may be obtained from local governments. Instrumentation will also represent a major part of the investment and the related cost will also depend partly on the decision for adaptation or construction of a new facility. Financing of instrumentation may be directly addressed to national science institutions, but also to private foundations or industry. The intended legal status as ERIC (European Research Infrastructure Consortium) will also have a strong impact on the costs due to excise and VAT exemptions' (see Deliverable 4.2).

For the choice of equipment, the knowledge and experience of staff and user experts will be vital for identifying the best option. Such expertise would be present when an existing facility is adapted. 'Bulk procurement' of equipment for the common activities (as outlined in Deliverable 2.3) could not only provide a good basis for the NFFA goal of comparability and internal standardisation, but could also help to reduce the investment costs significantly.

3.1 Integration of existing facilities

Particularly in phase 1 of the set up of the NFFA-RI, the adaptation of existing facilities (becoming part of the NFFA infrastructure) as NFFA-centres will have several advantages:

- Existing facilities with an NFFA-like infrastructure can begin immediately to provide user support.
- Skilled staff that is familiar with the scientific site and the adaptation requirements is available to take responsibility for necessary upgrades of the infrastructure. Additional staff can be recruited according to needs (technical and administrative user support) as they become apparent.
- An existing facility will have a specialisation and will be embedded in the respective user community.
- The facility (resp. its lab space and equipment) can grow and develop together with the user community, responding to user requirements and ongoing strategic considerations.

Initial investment costs of this scenario will include i) new staff for the service desk and the liaison office as well as additional technical staff to support user access and ii) the upgrade of the existing infrastructure and necessary additional techniques. This second part of the costs will strongly depend on the scientific and methodical specialisation of the existing facility. It will also be attractive to install closely linked new facilities with complementary specialisations at the same site. Examples of existing facilities with strong LSF/fine analysis activity are described in Deliverable D3.7 and D4.5.

3.2 Construction of new facilities

A realistic cost estimate of a new NFFA-centre will strongly depend on the hosting country and the time of realisation (determining the cost of labour). A discussion of other construction cost relevant factors as the size and technical quality of the building, can, however, be provided and will be presented in section 4 of this document and in Deliverable D4.7 (*layout of a prototypical NFFA-centre*). To assess the space required for labs and offices (and the need for a guesthouse) it will also be necessary to provide a good estimate of the user flow. The cost for lab space will differ according to special constructive requirements for electromagnetic and vibration shielding, requirements for clean room area and additional support labs. Current construction costs of cleanroom area are around 8 k€/m^2, building costs for 'general use area' and standard laboratories are around 4 k€/m^2 (€ value 2010). According to these numbers, the preliminary layout presented in Deliverable 4.7 (700m^2 cleanroom, total area 7300m^2) would require 35 M€ investment for construction cost, not including primary instrumental infrastructure. These needs have to be considered carefully on the basis of comparable existing reference facilities, but providing enough flexibility for later adaptations. The typical budget invested by the US Dept. of Energy (DoE) for construction of research centres with similar purpose can serve as orientation; the cost was at the time (~ 2000-2003) around 80-100 M$ (incl. primary instrumental infrastructure). The cost estimate for the French "Centre d'Intégration Nano- Innov", being currently installed at Campus Paris Saclay, was 70 M€ (for three projected buildings), two buildings for 46 M€ (9000m^2) have so far been financed.

The construction of a new facility will require more investment than the adaptation of an existing one, but also this option has several advantages:

- A new building can be designed according to the latest standards and using the best available technologies. This could provide better working conditions for staff as well as instrumentation (shielding etc.), if the means to make the necessary investment and to implement the best building practice is present. New buildings can be designed to suit best the requirements of the planned site. However, existing facilities may already be well adapted to those requirements.
- Equipment that should be present at all sites as part of the common metrology and standards strategy (see WP3) can be bought at the latest state of technology and can be procured in bulk.
- The hosting countries could provide funding for the implementation of 'low- or zero energy' or 'low CO_2' technologies, which, besides the obvious consistency with the dedication of NFFA to research issues of Environment, Energy & Health, would also reduce the long term operation costs

substantially. Such funding will also be available for existing buildings, a newly constructed building might, however, provide more flexibility for the implementation.

The time evolution of investment costs and personnel requirement during implementation of a newly constructed centre will be different than for the adaptation of an existing one. A new centre will initially have high investment costs and a low need for personnel; the staff numbers will increase according to the development of user traffic and scientific funding. Adaptation of an existing facility will require initially additional staff for technical user support and administration, the need for investment in infrastructure will be delayed and increase gradually.

3.3 User community and dimensions

The dimensioning of laboratory and office infrastructure has to be based on a careful assessment of the expected user flow and a definition of the users' needs. For dimensioning of the instrumentation, it will also be important to assess the time/year needed for maintenance and inhouse research, which will be typically 30-40% (in average, instrumentation specific, based on empirical values of user dedicated LSF infrastructure).

Cost relevant factors for the construction are not only the size but also the research field of the user community - which will differ among the centres - and the related expected preferential access modes (hands on, hands off, remote access), described in Work Packages 2 and 4. Structural biology experiments will, for example, be to a large extent requested as remote access, requiring additional staff and instrumentation for the experiments. This field currently accounts for about 40% of the user shifts at LSFs. Experiments associated with the actual presence of users and user groups (preparing and characterising samples or fabricating devices) will require additional lab and office space and associated infrastructure. Depending on the experiment, this will have to be available either for a long or short term, flexibly or coinciding with LSF experiments.

The number of users per site and year required to operate an NFFA-infrastructure successfully and efficiently is in the range of 300 (minimum) to 1000 users/year (looking 10 years ahead). Europe has more scientists but with less equipment than the US – therefore the expected demand for the NFFA-RI should be higher than at comparable DoE - facilities. The addressed user community of NFFA consists of two groups:

1) **LSF users (in Europe currently 12 000 - 15 000):** The share of LSF users interested in using the NFFA-RI with background in the scientific fields considered in WP3 was estimated to be about 20-40% corresponding to 2000-6000 users or ~ 5000 user shifts.
   At the ESRF, comparable specialised facilities can be found that provide user support for LSF based experiments and complementary infrastructure (**Minatec, The Partnership for Structural Biology, The Partnership for Soft Condensed Matter**). Those facilities are not operated as part of a distributed facility but as a central European infrastructure, therefore the dimensions can only serve as orientation.
2) **Users interested in the common metrology, in advance characterisation and in using the cleanroom facilities:** particularly an assessment of this 'extra community' interested in using the cleanroom facilities is vital for a successful design and dimensioning of newly built facilities. Existing cleanroom facilities that provide user support could serve as model and as basis for estimating the expected demand: the Nanotechnology Research Centre at Giorgia Tech., Marcus Nanotechnology Building, with ca. 2800 m² cleanroom area and additionally the same amount of Lab space on three floors, reported nearly 600 users in 2009, in the third year of operation. 2/3 of the clean room area are dedicated to electronics and 1/3 to biology, the investment for construction was ca. 90 M€ (for construction of the total 17.650m² facility), for instrumentation 53 M€.

An example for a European cleanroom facility is the Swedish network **MYFAB**, consisting of three cleanroom facilities (each consisting of several departments) for academic and commercial clients. The total cleanroom area of the participating institutes is several thousand m².

The participation in the survey (D2.1) may reflect the potential composition of the NFFA user community only to some extent: 57% were large scale facility users, 16% were scientists working at a large scale facility, 27% belonged to the nanoscience research community but are not currently LSF users. Considering the dynamic development of the nanoscience and -technology community (including small companies, spin offs, start ups without extensive own infrastructure) and its need for standardisation and metrology - particularly in the light of commercialisation and impact assessment (HSE) - this group might actually be the larger one and needs to be assessed carefully for a successful dimensioning of the NFFA centres.

4. FINANCIAL ISSUES RELATED TO THE REQUIRED INFRASTRUCTURE

The overall structure of the NFFA centres and the required infrastructure was described in detail in Work Package 3 "Design Study of the NFFA infrastructure". The estimated costs were summarised in tables and are attached as Annex I. The sites will each have a common metrology infrastructure with dedicated space, but well connected to the other NFFA facilities. Cleanroom area will be present at all sites, shared between the metrology facility and the other facilities. The proximity and connectedness of metrology, cleanroom and other facilities will play a fundamental role, providing the basis for speed and environmental control of experimental processes and providing a fast characterisation between fabrication or preparation procedures and LSF experiments. Size and layout of common metrology and cleanroom infrastructure will be similar to some extent, but - depending on the scientific and methodical specialisation at the centres - advanced instrumentation, required support labs and additionally needed facilities will be different. The costs of construction and instrumentation will therefore vary between the sites.

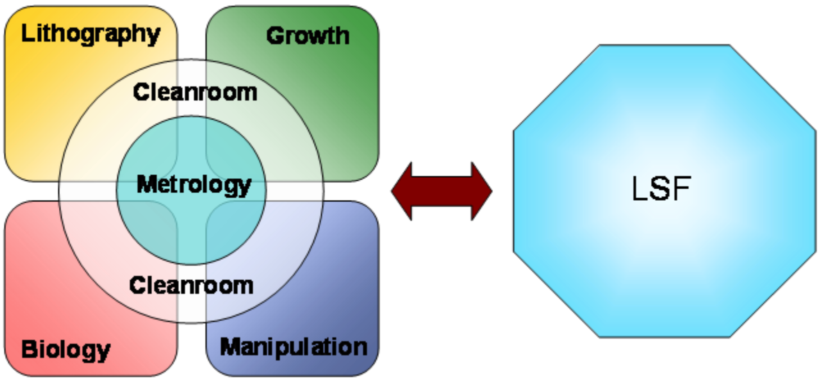

Fig.2: Scheme of the synergies between Metrology facility and other facilities in an NFFA centre and the nearby LSF (see D3.4)

4.1 Required laboratories & infrastructure

At the design study level, it is not practical to anticipate decisions on the actual research focuses of the first NFFA-centres and on which complementary facilities to combine. This will depend to a large extent on which (existing) facilities and which Large Scale Facilities will participate. For the overall NFFA infrastructure, the respective Deliverables of Work Package 3 have found the following as generally required laboratories (common infrastructure as well as specialised Labs)

Support labs: Chemical lab, Microfluidics lab, Bio-lab (basic infrastructure at all facilities), Low temperature facility (at a specialised NFFA site)

Estimated total investment cost: ca. 2.8 M€ (for a detailed listing see Table 2 of the Annex)

IT Infrastructure (supporting IT for Metrology, Simulation and Modelling, Data Repository)

Estimated total investment cost: ca. 2.2 M€ (the Data Repository is described in Deliverable 4.9)

Basic and advanced metrology and analysis tools (Deliverable D3.4), standardised Metrology and tools for Characterisation and Analysis

Estimated total investment cost per centre: ca. 12 M€ (for a detailed listing see Table 1 and 5 of the Annex)

Nanolithography facility (D3.2)

Material synthesis facility (D3.3)

Molecular and nano-particle manipulation laboratory (D3.5)

Nano-bio laboratory (D3.6)

Theory facility (D3.1)

Estimated average investment cost for advanced instrumentation: 6 – 8 M€ (for a detailed listing see Tables 5-9 of the Annex; the calculation is based on the assumption that only half of the research areas will receive advanced instrumentation), 1 M€ estimated cost for the Theory facility (this facility is discussed in deliverable D3.1).

Waste Disposal (disposal of biohazardous materials located at a specialised NFFA facility)

Stable energy supply, Emergency Power supply (EPS) (depending on the specific needs and regulations at the site)

4.1.1 Instrumentation

Frequently used characterisation equipment and support labs that are necessary for basic research purposes, will be available at all NFFA-centres. Additionally, each NFFA centre will provide advanced equipment and specialised expertise for applications in the framework of the research focus of the respective NFFA site. The cost for instrumentation includes:

1) Choice and procurement: For the choice of equipment, the knowledge and experience of staff and user experts will be vital for identifying the best option. Generally (but particularly for 'bulk procurement' of common metrology as described in detail in Deliverable D3.4), it will be necessary to develop a robust scheme to guarantee transparency and fair competition and to protect the scientists and administrative staff responsible for the procurement. Under a legal status as ERIC, the respective procurement regulations will be applied (see Deliverable D4.2).
2) Installation and adaptation: Also for installation and adaptation of the equipment, experienced technical and scientific staff will be necessary. These costs will also include work by external infrastructures and companies such as electronic- and metal workshops, installation of cooling water, shielding, UHV-environment and other instrument-related necessities.

A detailed list of basic and advanced instrumentation required for all NFFA facilities and the estimated costs was collected during Work Package 3 and are summarised in Annex I.

4.1.2 Environmental impact & Energy efficiency

A direct relation exists between environmental impact / energy efficiency and running costs. It will be important to emphasise the importance of these issues during the planning phase and to apply the best possible technical solutions for the construction. The exploitation of state-of-the-art 'zero-CO_2' (or 'low-/zero energy') options for the construction of the buildings may reduce the energy costs significantly, particularly the energy needed for general convenience as lighting, heating and warm water for general use and office space.

4.1.3 Working environment & Aesthetics

Providing a healthy, stimulating and representative working environment will result in construction costs e.g. for reasonably noise shielding office walls, non toxic interiors or space required for social interaction. This investment is justified by the positive impact on the scientific output (time spent productively at the working place, enhanced knowledge transfer (regarding e.g. use of instrumentation), attraction of high class scientists and industrial users) and secondary also on the running cost (productive working time, health, better use of instrumentation).

5. CONCLUSION

Aim of Deliverable 4.6 is to present an analysis of the construction cost to be expected for an NFFA-centre. The preliminary layout presented in Deliverable 4.7 (700m² cleanroom, total area 7300m²) would require 35 M€ investment for construction of the facility (incl. ~900 k€ cost of ~3000m² ground area), plus 22 M€ for basic instrumentation infrastructure (as presented in Work Package 3 "*Design Study*") including support labs, technical infrastructure, basic and advanced scientific equipment for one or more focus areas. Figure 3 shows the cost of construction and (primary) infrastructure according to the numbers given in the Annex. Figure 3 shows the expected evolution of investment costs during the first five years, for development, construction and investment for primary infrastructure (cost value 2010; no contingency, no escalation was considered).

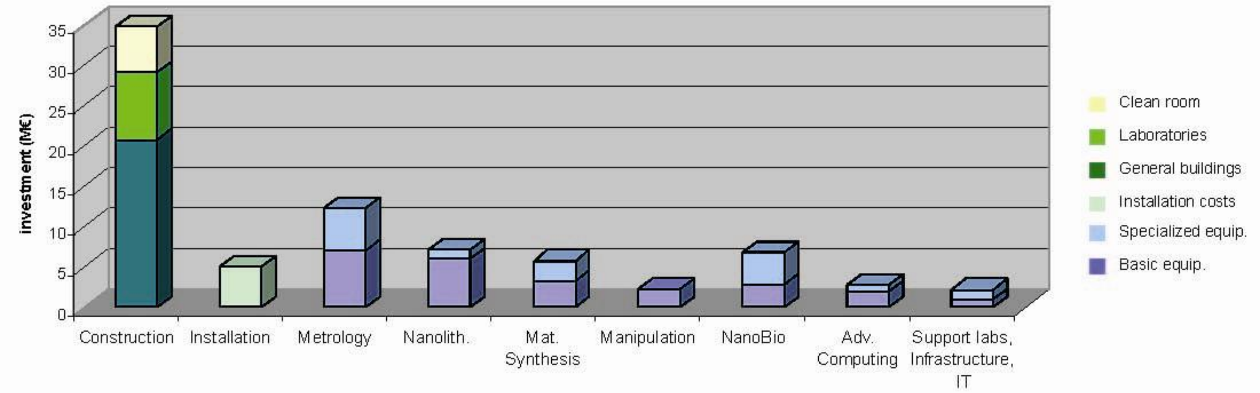

Fig.3: Graphical representation of the investment averaged costs for facilities and supplementary infrastructure for.one NFFA centre.

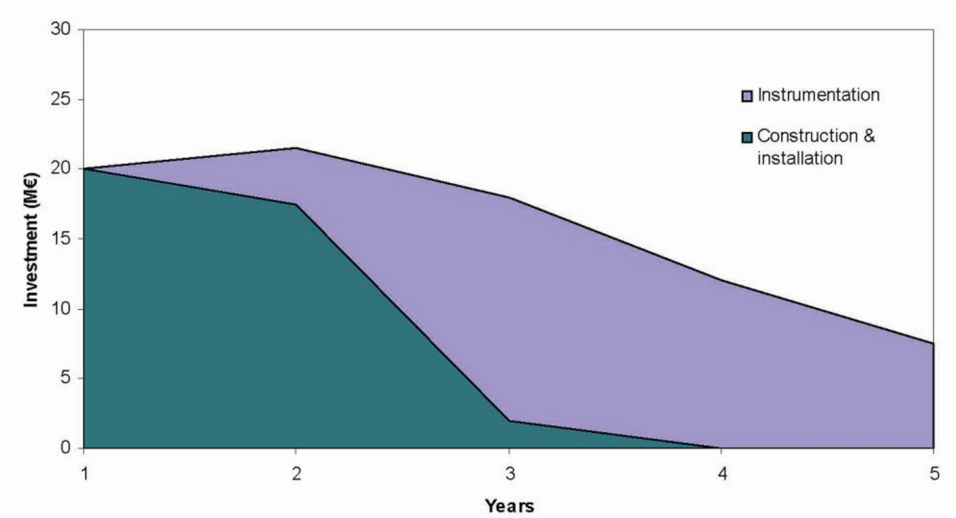

Fig.4: Development of investment costs for one NFFA centre during the first five years (Development/Construction/ Investment for primary infrastructure).

ANNEX I

Estimate of investment costs for instrumentation (*based on WP 3*)

The numbers for required instrumentation were estimated considering possible overlaps and synergies between the facilities.

Basic iinstrumentation necessary for the core activities:

Metrology basic equipment	Equipments	Access mode	Environment	Units	Cost per unit (M€)	Running costs/unit/year (M€)	Infrastructure total Costs/year (M€)	Running total Costs/year (M€)
Microscopy	SEM+EDS	open	Lab	4	0.5	0.05	2	0.2
	TEM/STEM	limited	Lab with specific requirements	3	2	0.2	6	0.6
	FIB	open	Lab or cleanroom	4	1	0.1	4	0.4
	AFM in air/large sample	open	Lab or cleanroom/air	4	0.25	0.02	1	0.08
	AFM in air/High res	limited	Lab or cleanroom/air	4	0.2	0.02	0.8	0.08
	RT STM/AFM in UHV	limited	Lab/UHV	4	0.3	0.03	1.2	0.12
	RT STM in air	open	Lab or cleanroom/air	4	0.1	0.01	0.4	0.04
	VT STM	limited	Lab/UHV	4	0.4	0.04	1.6	0.16
Structural. Optical & Compositional Analysis	Four circles XRD	open	Lab	4	0.2	0.02	0.8	0.08
	powder XRD	open	Lab	4	0.1	0.01	0.4	0.04
	basic SAXS/GISAXS	limited	Lab	4	0.2	0.02	0.8	0.08
	Profilometry	open	cleanroom	4	0.12	0.05	0.48	0.2
	Electroluminescence	open	Lab	4	0.05	0.005	0.2	0.02
	Photoluminescence	open	Lab	4	0.06	0.006	0.24	0.024
	Ellipsometry/SE	open	Lab/air	4	0.1	0.01	0.4	0.04
	DLS	limited	Lab	4	0.12	0.05	0.48	0.2
	FTIR	open	Lab/Vacuum&air	4	0.08	0.01	0.32	0.04
	µ-Raman	open	Lab/air	4	0.15	0.06	0.6	0.24
	Fluorescence	open	Lab	4	0.15	0.06	0.6	0.24
	UV-Vis	open	Lab	4	0.2	0.08	0.8	0.32
	TCSPC	limited	cleanroom	4	0.25	0.1	1	0.4
	LEEM/PEEM	limited/ hands off	Lab/UHV	3	0.5	0.05	1.5	0.15
	XPS + AES	open/ limited	Lab/UHV	4	0.35-0.40	0.04	1.6	0.16

Magnetic Characterisation	SQUID	hands off	Lab	4	0.25	0.02	1	0.08
	VSM	limited	Lab	4	0.15	0.01	0.6	0.04
	basic MOKE	open	Lab	3	0.03	0.003	0.09	0.009
Thermal & Mechanical Characterisation	TG	limited	Lab	4	0.06	0.01	0.24	0.04
	DSC	limited	Lab	4	0.06	0.01	0.24	0.04
Transport Properties	AC/DC probe station	open	Lab	4	0.035	0.005	0.14	0.02
	Cryostats (closed circuit cryo-cooler w external low field magnet. PPMS with high field magnet)	open	Lab	4	0.1	0.01	0.4	0.04

Table 1: Estimated equipment cost for NFFA-Metrology and Advanced Analysis facilities (*Deliverable 3.4*) required for the basic core activities and common metrology (cost estimation for 4 centres)

Nano-Bio lab	Basic Equipment	Access mode	Environment	Units	Infrastructure total Costs/year (M€)	Running total Costs/year (M€)
Support labs (standard equipment)	Chemistry lab	open	lab	4	3.2	0.1
	Biolab (safety cabinet, laminar-flow box, CO2-Incubator, PCR)	open	lab with specific requirements	8	1.2	0.2
	Microfluidics lab (stopped-flow, rapid mixing)	limited hands on	lab	4	0.4	0.4
Characterisation labs	Spectroscopy UV-VIS spectrometer	limited hands on	lab	4	0.14	0.4
	(Near-field-) optical microscopy,	limited hands on	lab	8	2	0.2
NanoBio*	Confocal (fluorescence) microscopy,	hands off	lab	4	1	0.1
	In-vivo fluorescence imaging,	hands off	lab	4	1	0.1
	STED super-resolution microscope	limited hands on	lab	4	1	0.1
	Protein separation, Protein purification Chromatography	open	lab	8	0.4	0.2
	Surface-enhanced laser desorption/ionization (SELDI),	hands off	lab	4	0.07	0.05
	2D gel electrophoresis	open	lab	16	0.28	0.2
	Mass spectrometry	limited hands on	lab	4	0.6	0.05
	HPLC	limited hands on	lab	4	0.34	0.05
	(Environmental-)SEM	hands off	lab	4	1.8	0.1

Table 2: Estimate of the investment for Support labs including a basic Biolab Infrastructure present at all NFFA-centres (*from Deliverable 3.6*). (cost estimation for 4 centres)

Pattern Transfer techniques		Basic equipment	Access mode	Required environment	Required units	Cost per unit (M€)	Running Costs per unit/year (M€)	Infrastructure total Costs/year (M€)	Running total Costs/year (M€)
Etching Techniques	Wet etching	Isotropic Chemical wet etching	open hands on	Lab or clean-room	8	0.05	0.001	0.4	0.008
		Anisotropic Si etching	limited hands on	clean-room	3	0.1		0.3	
	Dry etching	Sputter etching	limited hands on/hands off	Lab or clean-room	3	0.3	0.01	0.9	0.03
		Reactive ion etching	limited hands on/hands off	Clean-room	8	0.3	0.01	2.4	0.08
		DRIE	hands off	clean-room	3	0.8	0.015	2.4	0.045
Pattern transfer by deposition		Lift-off by PVD	limited hands on/hands off	Lab or clean-room	4	0.4	0.015	1.6	0.06
		Electroplating	limited hands on/hands off	Lab or clean-room	2	0.2	0.015	0.4	0.03
		Implantation	limited hands on/hands off	Lab or clean-room	0	1	0.015	0	0
Lithography techniques		**Basic equipment**	**Access mode**	**Required environment**	**Required units**	**Cost per unit (M€)**	**Running Costs per unit/year (M€)**	**Infrastructure total Costs/year (M€)**	**Running total Costs/year (M€)**
Pattern origination lithography	Electron beam lithography	Shaped beam	hands off	Clean-room	0	5	0.1	0	0
		Focused IonBeam lith.	limited hands on/hands off	Lab or clean-room	2	1	0.03	2	0.06
		Scanning Probe lith.	limited hands on/hands off	Lab or in-situ at LSF	2	0.4	0.015	0.8	0.03
Mask based / replication lithography	Photo lithography	Photo stepper	hands off	Clean-room	0	10-20	0.01	0	0
		EUV-IL	limited hands on/hands off	in-situ at LSF	1	0.5	0.1	0.5	0.1
		X-ray lit.	hands off	in-situ at LSF	1	1	0.1	1	0.1
Replication		Injection moulding	hands off	Lab or clean-room	1	0.5	0.02	0.5	0.02

Table 3: Estimated equipment cost for NFFA-Nanolithography and Pattern Transfer facilities (*Deliverable 3.2*) required for the basic core activities (cost estimation for 4 centres)

Material Synthesis basic equipment	Access mode	Required Environment	units	Cost/unit (M€)	Running Cost/unit/year (M€)	Infrastructure total Costs/year (M€)	Running total Costs/year (M€)
Thin film evaporators	hands on	Lab or clean-room	12	0.2	0.03	2.4	0.36
Molecular Beam Epitaxy (MBE)	hands off	Lab or clean-room	6	0.4	0.6	2.4	3.6
Sputtering	hands on	Lab or clean-room	8	0.3	0.04	2.4	0.32
CVD, PECVD, RTCVD	hands off	Lab or clean-room	12	0.5	0.03	6	0.36

Table 4: Estimated equipment cost for NFFA-Material Synthesis facilities (*Deliverable 3.3*) required for the basic core activities (cost estimation for 4 centres)

Optical Manipulation techniques	Access mode	Required Environment	Required units	Cost per unit (M€)	Running Costs per unit/year (M€)	Infrastructure total Costs/year (M€)	Running total Costs/year (M€)
Optical Tweezers	open hands on	Lab or clean room	4	0.4	0.05	1.6	0.2
Optical Levitation	limited hands on		4	0.2	0.05	0.8	0.2
Magnetic Tweezers	open hands on		4	0.2	0.03	0.8	0.12
Dielectrophoretic Tweezers	limited hands on		4	0.2	0.03	0.8	0.12
STM	limited hands on	Lab or clean room	4	0.5	0.06	2	0.24
AFM	limited hands on		4	0.5	0.06	2	0.24
Microgripper	limited hands on		4	0.25	0.04	1	0.16

Table 5: Estimated equipment cost for NFFA-Manipulation facilities (cost estimation for 4 centres)(*Deliverable 3.5*).

Advanced instrumentation necessary for specialised activities:

Metrology – specialized equipment	Techniques	Access mode	Environment	Units	Cost per unit (M€)	Running costs/unit/year (M€)	Infrastructure total Costs/year (M€)	Running total Costs/year (M€)
Advanced Microscopy	SEM+WDS+EBSD	limited/hands off	Lab	1	0.8	0.08	0.8	0.08
	TEM Cs corrected	limited/hands off	Lab with specific requirements	1	5	0.5	5	0.5
	3D Atom Probe	limited/hands off	Lab	1	2		2	
	LT-STM/AFM	limited/hands off	Lab/UHV	1	0.45	0.06	0.45	0.06
	LT-STM High Magn. Field	limited/hands off	Lab/UHV	1	0.6	0.075	0.6	0.075
	HP-STM	limited/hands off	Lab/UHV	1	0.5	0.05	0.5	0.05
	ECSTM	limited	Lab/liquids	1	0.2	0.02	0.2	0.02
	SNOM	open/limited	Lab	1	0.05	0.005	0.05	0.005
	Cryo-SNOM	limited	Lab/air	2	0.15-0.2	0.02	0.3-0.6	0.04
	HeIM	limited	Lab/HV	1	0.25	0.035	0.25	0.035
	TERS	limited/hands off	Lab	1	1	0.1	1	0.1
	Brillouin Microscope	hands off	Lab	1	0.3	0.03	0.3	0.03
Structural. Optical & Compositional Analysis	SAXS/WAXS/GISAXS	limited	Lab	1	0.3-0.6	0.06	0.3-0.6	0.06
	UFTA	limited	cleanroom	2	0.25	0.1	0.5	0.2
	TRPES	limited	cleanroom	2	0.25	0.1	0.5	0.2
	CA LEEM/PEEM	limited/hands off	Lab/UHV	1	1	0.1	1	0.1
	GC and GC/MS	open	Lab	2	0.075	0.03	0.15	0.06
	Microreactors	open	Lab	2	0.03	0.003	0.06	0.006
	HP-XPS	limited	Lab/UHV with HP cell	1	0.5	0.05	0.5	0.05
	XPS in liquids	limited	Lab/UHV	1	0.5	0.05	0.5	0.05
	SIMS	limited/hands off	Lab with specific requirements	1	1.5	0.15	1.5	0.15
	NMR	hands off	Lab	1	1	0.1	1	0.1
Magnetic Characterisation	MOKE	hands off	Lab	1	0.17	0.02	0.17	0.02
	AC-SUSCEPTIBILITY	limited	Lab	1	0.25	0.02	0.25	0.02
Thermal & Mechanical Characterisation	Nanoindentation	hands off	Lab	1	0.1	0.01	0.1	0.01
	Acoustic measurements	open	lab	1	0.02	0.002	0.02	0.002

Transport Properties	Electronic and Probe station	Limited	Lab	1	0.25	0.03	0.25	0.03
	10mK Cryostat	Limited	Lab with specific requirements	1	0.25	0.05	0.25	0.05
	300mK Cryostat	Limited	Lab	1	0.05	0.02	0.05	0.02
Additional resources required	LSF Located Section			4				0
Total Characterization Line				1*/4	3	0.3	3*/12	0.3*

Table 6: Estimated cost for advanced equipment at Metrology and Advanced Analysis Facilities (*Deliverable 3.4*)

Lithography techniques – specialized equipment			**Access mode**	**Required environment**	**Required units**	**Cost per unit (M€)**	**Running Costs per unit/year (M€)**	**Infrastructure total Costs/year (M€)**	**Running total Costs/year (M€)**
Pattern origination lithography	Electron beam lithography	SEM based	open hands on	Lab or clean-room	3	0.8	0.05	2.4	0.15
		High-end Gaussian	limited hands on/hands off	Clean-room	3	3	0.25	9	0.75
Mask based / replication lithography	Photo lithography	Mask aligner	open hands on	Clean-room	6	0.4	0.015	2.4	0.09
	Replication	NIL	open hands on	Clean-room	3	0.5	0.03	1.5	0.09
		Other replication	open hands on	Lab	4	0.05	0.02	0.2	0.08

Table 7: Additionally required equipment for Nanolithography facilities (cost estimation for 4 centres).

Material Synthesis Specialized equipment	Access mode	Required Environment	units	Cost/unit (M€)	Running Cost/unit/year (M€)	Infrastructure total Costs/year (M€)	Running total Costs/year (M€)
Pulsed Laser Deposition (PLD)	hands off	Lab or clean-room	2	0.7	0.015	1.4	0.03
Cluster Beam Deposition (CBD)	hands on	Lab or clean-room	2	0.2	0.02	0.4	0.04
Ion Implantation	hands off	Lab or clean-room	2	1.5	0.015	3	0.03
Atomic Layer Deposition (ALD)	hands off	Lab or clean-room	2	0.4	0.03	0.8	0.06
SAMs, LB, spin coating	hands on	Lab or clean-room	4	0.2	0.02	0.8	0.08
Single crystal growth	hands off	Lab or clean-room	2	1	0.03	2	0.06
Sol-gel	hands on	Lab or clean-room	3	0.5	0.02	1.5	0.06

Table 8: Additionally required equipment for Material synthesis facilities (cost estimation for 4 centres)

<table>
<tr><th colspan="2">Specialized Nano-bio facility</th><th>Investment (M€)</th></tr>
<tr><td rowspan="7">Characterisation NanoBio*</td><td>Spectroscopy, UV-VIS spectrometer</td><td>0,035</td></tr>
<tr><td>In-vivo fluorescence imaging,</td><td>1</td></tr>
<tr><td>STED super-resolution microscope</td><td>1</td></tr>
<tr><td>Protein separation, Protein purification Chromatography</td><td>0,025</td></tr>
<tr><td>Surface-enhanced laser desorption/ionization (SELDI),
2D gel electrophoresis</td><td>0,025</td></tr>
<tr><td>Mass spectrometry
HPLC</td><td>0,15
0,085</td></tr>
<tr><td>(Environmental-)SEM</td><td>0,45</td></tr>
<tr><td rowspan="4">Characterisation Metrology**</td><td>TEM</td><td>1</td></tr>
<tr><td>X-ray lab (SAXS/WAXS/GISAXS)</td><td>0,6</td></tr>
<tr><td>AFM, Surface characterisation</td><td>0,25</td></tr>
<tr><td>Brewster-angle microscopy, Ellipsometry</td><td>0,175</td></tr>
<tr><td colspan="3">* Nanobio Metrology (used frequently for Bio-purposes) that should be best located (physically) inside a Nanobio facility and can be accessed by other users if no conflicts arise from mutual contamination or similar reasons.
** shared Metrology that will also be used extensively by other Labs and could be located in the Metrology facility, but considering the restrictions given above.</td></tr>
<tr><th colspan="3">Specialised Characterisation/Support labs with shared Metrology:</th></tr>
<tr><td colspan="2">Cryo lab (CryoEM, plunge freezing, Cryo microtome)</td><td>0,6 - 4</td></tr>
<tr><td colspan="2">Single particle chemistry on biological macromolecules</td><td>0,1 – 0,5</td></tr>
<tr><td colspan="2">NMR-Spectroscopy lab</td><td>0,8 - 1</td></tr>
</table>

Table 9: Infrastructure at a specialised Nano-Bio facility, including equipment that will be shared in the framework of common Metrology (Table 1) and such that might have to be duplicated due to biospecific requirements and eventual conflicts of shared usage (*Deliverable 3.6*).