Project No. FP7 – 212348

NFFA

Nanoscience Foundries and Fine Analysis

D4.7

Cost Analysis of the Operation of the NFFA-RI and of a Prototypical Reference Centre

Work Package	**No.4**
Work Package Title	**Management structure & format of user access for NFFA-RI Centres, Data Repository, IP issues**
Activity Type	**RTD**
Lead Beneficiary	**5 OEAW**
Estimated P/Ms	**6**
Nature	**Report**
Dissemination level	**Public**
Delivery Date	**Contractual M 30 Actual M 32**
Task Leader	**H. Amenitsch (OEAW)**
Major Contributors	**K. Jungnikl, B. Sartori (OEAW), C. Africh (CNR-IOM)**
Other Contributors	**G. Rossi (CNR-IOM), M. Rappolt, B. Marmiroli, F. Cacho-Nerin (OEAW)**

Delivery Slip

	Partner/Activity	Date	Signature
From	IBN-ÖAW	30/10/10	H. Amenitsch
Reviewed by	AC&SP Panelists	18/01/11	All
Approved by	COORDINATION BOARD	31/01/11	All

Document Log

Issue	Date	Comment	Author
1-0	30/10/10	Deliverable first version	K. Jungnikl, B. Sartori, H. Amenitsch
1-1	31/01/11	Consistency check and final version	B. Sartori, H. Amenitsch, C. Africh, G. Rossi

Document Change Record

Issue	Item	Reason Change

TABLE OF CONTENTS

Deliverable D4.7: Cost Analysis of the Operation of the NFFA-RI and of a Prototypical Reference Centre

1. INTRODUCTION

1.1. Purpose of the document

The purpose of this document is an assessment of the costs of the operation of the NFFA-RI and of a prototypical reference centre located nearby a LSF. The running costs will be compared with those of existing similar centres.

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 available from DoE reference facilities, candidate facilities as well as values provided from 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 D4.7 describes the financial issues related to the operation of the NFFA-RI and of a prototypical reference centre located nearby a Large Scale Facility (LSF). The running costs are compared with those of existing similar centres.

A tentative layout of a *Prototypical Reference Centre* will be used as basis for discussion of running costs specific to the operation of the NFFA infrastructure without taking into account possible cost relevant synergies with existing institutions or facilities. Therefore the *Prototypical Reference Centre* is introduced as a newly constructed facility *on a green-field* including all basic infrastructure and equipped with instrumentation for basic activities as well as advanced instrumentation in the specialised research areas as described in Work Package 3 - Metrology and Advanced Analysis Facility, Nanolithography, Material synthesis, Molecular and nano-particle manipulation, Nano-bio laboratory, Computing, but not including general urban services.

Provisional costs for the employed staff were estimated to be about 5.1 M€ for ~ 65 people. An annual budget of ~1M€ for the renewal of the centre's equipment was estimated; additional costs directly related to the number of users and the users' activity were also considered. These costs are actually very variable since the wages and taxes are not at all uniform in Europe. A reference value has nevertheless been taken.

The total running costs for basic instrumentation were estimated in about 3.4 M€; additionally, 1.24 M€ for advanced equipment were considered.

In this exercise we do not take into account the travel expenditures of users to come to the NFFA centers. In the current framework programme (FP7) I3-type contracts support the users access to European research infrastructures. Our general hypothesis is that in FP8 a direct support of the UE towards the running costs of the facilities enabling the open access will be in place. Accordingly the issue of users travelling costs will be redefined.

Overall a yearly budget of 13 M€ has been estimated, which also contains the sufficient provisions for maintaining the state-of-the-art level of the nanofoundry (Figure 1).

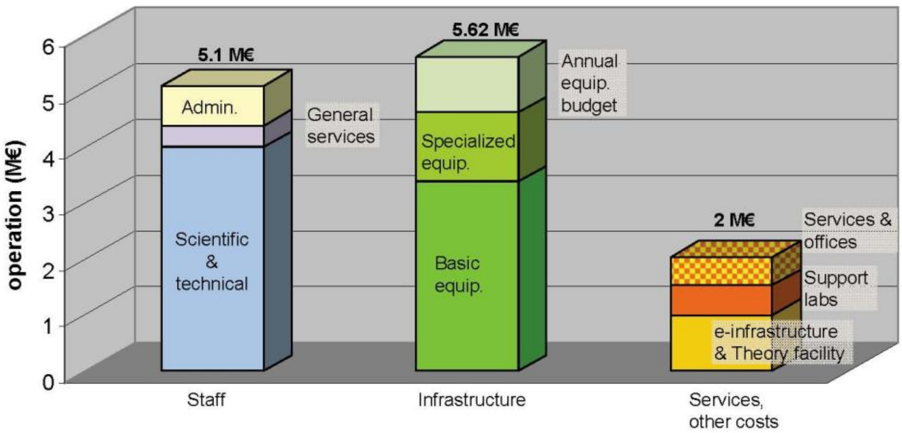

Fig. 1. Yearly operation costs split in staff, infrastructure and services / other costs for a prototypical NFFA centre.

3. THE PROTOTYPICAL REFERENCE CENTRE

The findings of Work Package 3 (*Design study of the NFFA infrastructure*) will be used as basis for discussion of the factors relevant for the running costs of a prototypical NFFA centre. The general layout is based on the discussion in Deliverable D3.1; the specific needs of the facilities are described in the Deliverables D3.2-D3.6. The estimated running costs collected in Work Package 3 are listed in Annex I.

3.1 General layout of a prototypical NFFA centre

Purpose of the NFFA centres will be to provide an open access distributed research infrastructure that is closely connected and complementary with the possibilities for fine analysis available at co-located LSFs. The aim is to take advantage of the concept of a European distributed facility and to install diverse centres with different research focuses that provide complementary instrumentation and expertise at each site. The first estimate of running costs collected in Work Package 3 considers that all NFFA centres will provide a high standard of common infrastructure and a selection of advanced equipment. As generally required laboratories (providing basic as well as advanced instrumentation) for the overall NFFA infrastructure, the respective deliverables of Work Package 3 describe the following facilities:

Nanolithography facility (D3.2)
Material synthesis facility (D3.3)
Metrology and Advanced Analysis facility (D3.4),
Molecular and nano-particle manipulation laboratory (D3.5)
Nano-bio laboratory (D3.6)
Theoretical facility (D3.1)

Support labs (such as Chemical synthesis lab, Microfluidics lab, Bio-lab, low temperature facility) will also be available.

The general layout of an NFFA centre will be strongly shaped by the need for clean-room environment and vibration damping of a major part of the instrumentation for nanomaterials fabrication/synthesis and -characterisation. The total effective area necessary to house all functions was estimated to be around 7000m^2 (see Table 1 *adapted from Deliverable D3.1*), of which around 1500-2000 m² lab area will have to be located either on the ground floor or in the basement (vibration shielded). The cleanroom area will contain the laboratories for nanolithography and part of material synthesis and of the metrology infrastructure that either requires a clean, vibration shielded environment itself or is frequently needed by these research sections. The molecule- and nano-manipulation facility may also partly need such an environment, but will also have strong methodical links with the NanoBio facility and the co-located LSF. Table 1 gives a list of estimated space required for labs, offices and infrastructure.

The legal framework (regarding safety), demands that infrastructures as a guesthouse, but also technical infrastructure like housing of process gases, nitrogen, (toxic- etc.) waste rooms etc. have to be located in separate buildings with defined safety standards. Considerations of vibration shielding would suggest that also basic building services as air conditioning units, an optional water purification plant, waste treatment/ neutralisation, emergency power supply (EPS) (anything involving pumps) and optionally the warehouse and mechanical workshop should be located in a separate building, or in a part of the building that is not statically connected to the part housing the sensitive instrumentation. A clever arrangement of disconnected constructive units (according to cleanroom- or environmental specifications, *house-in-house* concept) within one compact building envelope could provide advantages for energy consumption, building services (tubing, pumps, ventilation etc), person path length between labs and offices and for interdisciplinary communication, but also attractive architectural options for open, daylight flooded shared areas (user area, library, reception, coffee corner, kitchen) between or outside the controlled environments.

Laboratories	**Total Area (m²)**
Nanolithography	400
Material synthesis	350
Metrology	350
Molecule & nanoparticle manipulation	150
NanoBio	400
Wetlab	300
Total characterization line	150
Theory facility	60
Offices	
for technical and scientific staff	750
for users (computer and internet access)	250
Administration	
User office, Technical liaison office	60
Office for administrations	240
Archive	50

General services	
Entrance hall, reception, corridors and stairs	1000
Library	150
Seminar and meeting rooms, kitchen, coffee corner (at least one per floor)	400
Computation center	50
Mechanical workshop	250
Electronics Workshop	150
Advanced equipment development & test laboratory	150
Rest rooms	100
first aid/resting rooms	30
External utilities:	
Bunker for process gases	35
Nitrogen tank enclosure	25
Waste storage	40
Warehouse	200
Emergency Power supply (EPS)	50
Guesthouse	
Separate building with 30 rooms.	1000
Total area:	>7100m²

Table 1: Estimated area needed for the sections of a prototypical NFFA centre (*adapted from D3.1*).

A direct relation exists between environmental impact / energy efficiency and running costs. 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.

3.2 NFFA Facilities - technical specifications of the different laboratories.

A detailed description of the specific needs of the NFFA laboratories can be found in Deliverable D3.1 and in the respective design studies (D3.2 - D3.6), particularly with respect to clean room specifications and environmental requirements (temperature and humidity control, vibration- and electromagnetic shielding, *see also* Annex I).

Flexibility, ease of equipment relocation and sufficient space for technical upgrades are important factors for long term running costs. State-of-the-art construction for maximum flexibility would include 50 cm easily accessible technical space below the floor to distribute services and fluid facilities, allowing a fast and clean repositioning of outlets. The higher construction cost (<10%) is justified if reconfigurations during the prospected 20 years of operation are expected. The laboratories should also be organised to enable the development and implementation of robotics and automated solutions for sample handling and sequences of nanofabrication / characterisation steps in the future (see issues of a Total Characterisation Line for automated metrologyin D3.1).

Nanolithography: Considering the different specifications and access regulations of the equipment (see Deliverable 3.4), the cleanroom should be divided in two main areas, Nanolith I, with tight specifications for cleanliness (ISO4) and thermal control (21± 0.1 °C), and Nanolith II (ISO 5, 21±0.5 °C).

Material synthesis: part of the processing will be located in dedicated ISO6 cleanroom (21±3°C) (Material Synthesis I); an additional area with no special requirements will be provided for general processing (Material synthesis II).

Metrology and Advanced Analysis: This facility will be very closely connected to the other NFFA facilities and the LSFs. The instrumentation may be partly located in the labs/cleanrooms with the most frequent use or in labs that provide technical synergies such as shielding, cooling water, UHV. The standard specifications of the clean room areas should be min. ISO 7, 21±1 °C.

Manipulation: Techniques for assembling nanosystems and for manipulation for fine analysis experiments at LSFs (e.g. optical tweezers, single particle chemistry on biological macromolecules) will be developed in close cooperation with other facilities, the conditions need to be adapted to the specific needs.

NanoBio: S1 biological safety standard will be provided for the basic support Biolab. Biological research often involves genetically engineered tissue; therefore a classification according to genetics safety law will be necessary for a specialised NanoBio facility. Instruments that are most frequently used by this facility will be installed inside the BioNano lab area, duplication will only be necessary if the danger of (mutual) contamination or other conflicts related to kind or frequency of use make sharing unpractical. A specialised NanoBio facility could also be installed to do research at the S3 safety level, requiring infrastructure for storage, handling and disposal of highly infectious or biohazardous material.

Wetlab: an area for testing of chemicals, drugs, or other material or biological matter will be provided. The environment conditions will be adapted to the specific needs.

Chemical synthesis facility / support lab: a chemistry lab with standard equipment and a chemical synthesis facility will be available at every NFFA site.

Microfluidics lab: This support lab will need to have access to a clean area for microdevices assembly.

4. RUNNING COSTS COMPARED TO THOSE OF EXISTING FACILITIES

The operating cost of an NFFA centre after the construction phase includes the salaries of the employed staff, the infrastructure, an annual budget allowing for the renewal of the centre's equipment and costs that will be directly related to the number of users and the users' actvity (production of samples for LSF experiments, micro-/nanodevices, material costs, user offices/guest house).

4.1 Cost Analysis of Operation and Maintenance of Buildings and Infrastructure

4.1.1 e-Infrastructure:

The concept and design study of the **NFFA Theoretical Facility** and the **Data Repository** have been described in the respective deliverables (D3.1 and D4.9). These infrastructures will be unique in their concept as open access European distributed e-infrastructure, but a preliminary reference value of maintenance costs could be deduced from the already existing "European Theoretical Spectroscopy Facility" (http://www.etsf.eu).

Synergies in the basic and advanced computing infrastructure will also be attractive for the co-located LSF, if additional capacities for data storage and safety, manipulation, visualisation and modelling can be achieved. Costs for the basic NFFA e-infrastructure will include personnel (3-5 persons), hardware and software for instrumentation, data services and the related energy consumption, and will be in the order of 1 M€/a.

4.1.2 General maintenance and infrastructure

The cost for general services will include personnel and external contracts for cleaning, safety, security, telephone, data services, library, canteen and guesthouse. Those costs will strongly depend on the hosting country of the facility.

4.1.3 Instrumentation

A detailed list of basic and advanced instrumentation for each single facility was collected in Work Package 3 and is attached as Annex I. The given total numbers for maintenance costs of a specific type of instrumentation are a direct sum of maintenance costs per unit.

The maintenance costs were estimated on the basis of empirical data obtained from partner institutions and from already established facilities maintaining similar equipment. It can be assumed that those institutions have optimised the maintenance costs according to their own infrastructure and usage. Differences between those costs and costs actually arising at an NFFA-facility could therefore depend on several factors:

1) number of external users of the equipment,
2) number of the responsible technical personnel,
3) availability of workshops (electrical engineering, metal workshop,…)
4) expertise for in-house maintenance, and

5) influence of the number of instruments on the conditions for commercial maintenance contracts (s. 'bulk procurement' issue in Deliverables D2.3 & D4.6).

4.1.4 Consumption

Energy: Energy (electricity and heat) consumption will be a substantial part of the costs and can be provided by local production (co-/trigeneration with the nearby LSF or computing facilities, direct use of waste heat, solar power) or by purchase from external providers (utilities). In any case, an additional uninterruptible power supply (UPS) will be needed. The major part of the energy consumption will be needed for running the instrumentation, including cooling and UHV-environment, and for air conditioning of clean room and lab area. Myfab (Sweden), as a comparable existing facility, can serve as orientation for an estimate of the energy costs, with ~ 3 M€/a for a 1000m² cleanroom facility.

Fluids and gasses: The consumption of fluids and gasses includes standard lab infrastructure (e.g. N_2, deionised & tab water), cryogenic fluids, liquid N_2 for synthesis labs, liquid He for Low Temperature measurements and instrumentation.

Chemicals and lab consumables: The consumption of chemicals and lab consumables for clean room, support labs (synthesis labs and bio labs), and specialised micro-/nanofabrication facilities are directly user flow dependent, the estimates given in Annex I (Table 2) are empirical values of labs with comparable function.

4.2 Staff

Staff numbers necessary for providing state-of-the-art scientific standard of user support, acquisition and execution of third party funded research projects and good lab practice of the respective facilities were described in Work Package 3. A discussion of management and governance of NFFA is presented in Deliverables D4.2 and D4.3. The staff numbers will depend strongly on the actual user flow and mode of operation: *Hands on*: Expert staff will be required for proper maintenance of the equipment and training of the users. *Hands off*, *Remote access*: Dedicated additional staff is needed to operate the equipment and to perform the measurements. The long-term target will be a total number of 60-80 permanent employees, to guarantee the continuity of operation at high-quality. We adopted a reference average costs per person (average over all functions, varying strongly between European countries) are 50-60 k€/a. This voice can vary largely from location to location within European member and associated states.

The US (DoE) NSRCs, that are reference institutions of the NFFA project with respect to purpose and size range, published typical staff numbers of about 60 permanent staff with a duty of user support of 50-85%-100% of the work time. As discussed above, the expected user flow (and therefore the corresponding need of permanent staff) for a similar European facility might be larger.

4.2.1 Operation and maintenance

The given staff numbers represent estimates for the critical minimum, these numbers will, however, be directly related to the size and actual user flow of the facilities and the mode of operation and access. Shifts may be organised as 7-8 hrs each, with assistance by technical and scientific staff during the day (regular working hrs). Specialised *direct access* users will be allowed to use certain instruments according to their own schedule, as this might be necessary for LSF co-operation related activities or long term experiments.

Staff necessary for general maintenance of the building infrastructure, additional services as security, canteen, library and the guesthouse was not included in these numbers and will not be user flow dependent to the same extent.

4.2.2 Administration

The number of staff for administration will to some degree depend on the number of scientific staff and on the user flow, but also on the administrative difference between the hosting countries, the implementation of a central management and the legal status as ERIC (*see Deliverable D4.2 on Governance*). Typical administrative costs per user shift at LSFs or existing comparable facilities can serve as orientation.

4.3 Costs at existing comparable Facilities

The Molecular Foundry: The dimensions of this facility are in the range expected for a typical NFFA-centre as described in WP3: Six facilities dedicated to specific research areas (*Organic and Macromolecular Synthesis / Biological Nanostructures / Inorganic Nanostructures / Theory / Nanofabrication / Imaging and Manipulation*) á 9-14 (permanent) staff members (director, staff scientists, 'scientific engineering associates', postdocs) - two or three researchers per experiment/tool, for some instruments additionally one engineer/technician. In general, the overall research activity consists of 50%-70% users activity and 50%-30% in-house research. Free access is provided for users, excluding very expensive, uncommon material and/or special instrumentation. Operational costs are 232 k€ per facility per year (in average) *plus* guarantees and maintenance. 1-1.5 (0.77-1.16) M€ per year are projected as investments for durable equipment and new instruments.

STFC – Micro and Nanotechnology Centre at RAL, UK: MNTC has 25-30 members (full-time staff, visiting researchers, students) and operates in three modes; (i) in support of the local LSFs, (ii) with universities on grant-funded research, and (iii) with commercial companies. It operates 1200 m² cleanroom (Class 100 ISO 5 classification), several other labs and semi-clean areas equipped for micro- and nanofabrication and patterning and metrology.

The National Microelectronics Center (CNM) Barcelona: CNM has a staff number of around 200 people and consists of several different Laboratories and scientific /technical infrastructures, among them the Clean Room (Class 100-10.000) with a total surface area of 1.500 m², in a *house in house* structure.

The Paul Scherrer Institut (PSI): PSI has about 1200 employees, including staff at SLS and SINQ. The Laboratory for Micro- and Nanotechnology (LMN) has 45-50 members running class 100 clean room laboratories with a total size of about 500 m^2 in addition to several other labs.

Nano INNOV - Centre d'Intégration du Campus Paris Saclay: France has announced to invest 350 M€ into a Nanotechnology initiative focused at three centres (Grenoble, Toulouse, Saclay), funding projects, the development of local nanofabrication centres, and building integration centres with research and characterisation infrastructure. The centre at Campus Paris Saclay will function as platform for Nanomedicine research, in cooperation with CEA (Commissariat à l'énergie atomique), CNRS (LPN) and the Université Paris XI (IEF) (Dept. of Pharmacy). The centre will consist of three buildings with total area of 27 900 m² and an intended staff number of ~900 people.

5. CONCLUSION

Aim of D4.7 is the description of a *Prototypical NFFA Centre* and an analysis of the expected operation cost. The costs for construction and primary infrastructure (ca. 35-45 M€) are discussed in D4.6. The running cost (Figure 2) includes the employed staff (5.1 M€ for ca. 65-70 people), infrastructure, an annual budget allowing the renewal of the centre's equipment (~1M€/a) and costs that will be directly related to the number of users and the users' activity. The total running cost of an NFFA centre will be in the range of 13 M€/year. Figure 3 shows the composition of the expected running cost, based on the numbers given in the Annex. These costs do not contain any provisions for contingency nor escalation and are based on the price level of 2010.

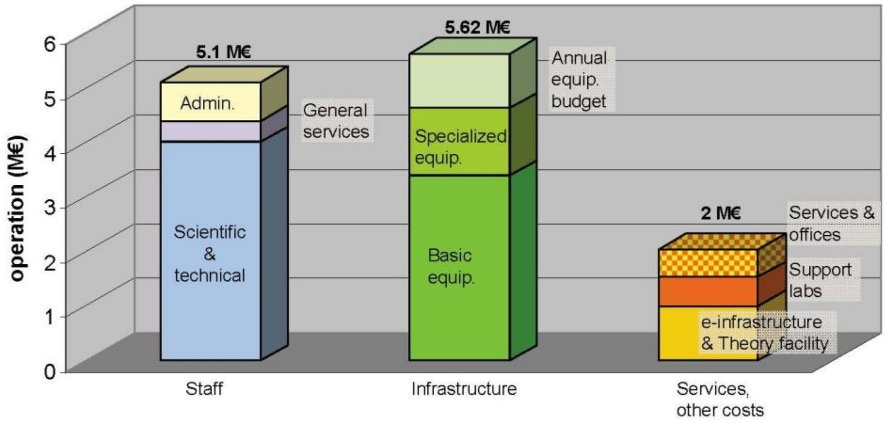

Fig.2. Composition of the expected running cost for personnel, scientific and general infrastructure for one NFFA centre.

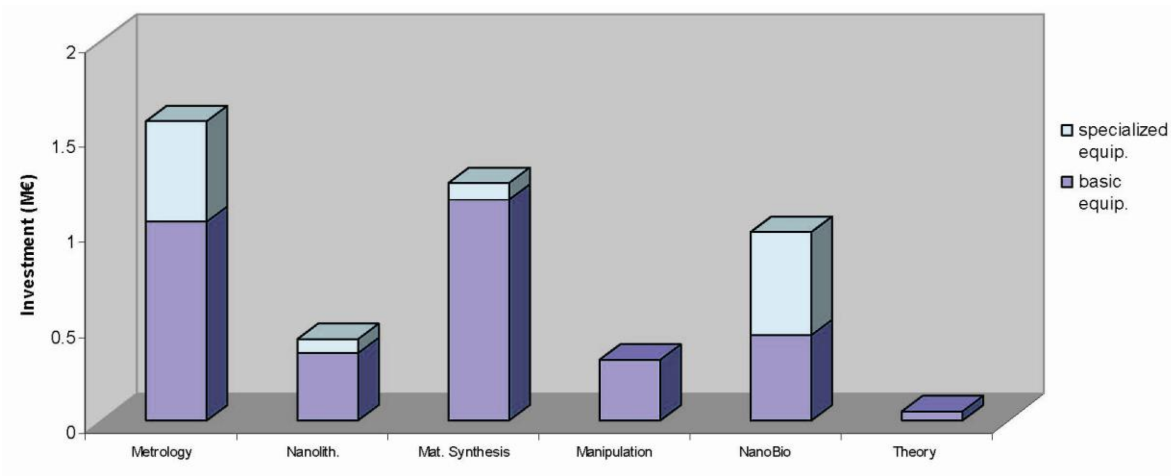

Fig.3. Expected running cost for each facility of a prototypical NFFA centre. Costs for basic and specialized instrumentation are shown.

ANNEX I

Summary of cost estimates from WP 3 "Design study of the NFFA Infrastructure"

The numbers for required instrumentation and running costs were estimated on basis of information from partner facilities and DOE visits. Staff is not included in the running cost.

Basic instrumentation necessary for the core activities:

Metrology basic equipment	Equipments	Access mode	Environment	Units	Running costs/unit/year (M€)	Running total Costs/year (M€)
Microscopy	SEM+EDS	open	Lab	4	0.05	0.2
	TEM/STEM	limited	Lab with specific requirements	3	0.2	0.6
	FIB	open	Lab or cleanroom	4	0.1	0.4
	AFM in air/large sample	open	Lab or cleanroom/air	4	0.02	0.08
	AFM in air/High res	limited	Lab or cleanroom/air	4	0.02	0.08
	RT STM/AFM in UHV	limited	Lab/UHV	4	0.03	0.12
	RT STM in air	open	Lab or cleanroom/air	4	0.01	0.04
	VT STM	limited	Lab/UHV	4	0.04	0.16
Structural. Optical & Compositional Analysis	Four circles XRD	open	Lab	4	0.02	0.08
	powder XRD	open	Lab	4	0.01	0.04
	basic SAXS/GISAXS	limited	Lab	4	0.02	0.08
	Profilometry	open	cleanroom	4	0.05	0.2
	Electroluminescence	open	Lab	4	0.005	0.02
	Photoluminescence	open	Lab	4	0.006	0.024
	Ellipsometry/SE	open	Lab/air	4	0.01	0.04
	DLS	limited	Lab	4	0.05	0.2
	FTIR	open	Lab/Vacuum&air	4	0.01	0.04
	µ-Raman	open	Lab/air	4	0.06	0.24
	Fluorescence	open	Lab	4	0.06	0.24
	UV-Vis	open	Lab	4	0.08	0.32
	TCSPC	limited	cleanroom	4	0.1	0.4
	LEEM/PEEM	limited/ hands off	Lab/UHV	3	0.05	0.15
	XPS + AES	open/ limited	Lab/UHV	4	0.04	0.16
Magnetic Characterisation	SQUID	hands off	Lab	4	0.02	0.08
	VSM	limited	Lab	4	0.01	0.04
	basic MOKE	open	Lab	3	0.003	0.009
Thermal & Mechanical Characterisation	TG	limited	Lab	4	0.01	0.04
	DSC	limited	Lab	4	0.01	0.04
Transport Properties	AC/DC probe station	open	Lab	4	0.005	0.02
	Cryostats (closed circuit cryo-cooler w external low field magnet. PPMS with high field magnet)	open	Lab	4	0.01	0.04

Table 1: Estimated running cost for NFFA-Metrology and Advanced Analysis facilities (*from Deliverable 3.4*) for the basic core activities and common metrology.

		Maintenance (k€/a)
Support labs	Chemistry lab, Chemical synthesis facility	25
	Biolab (safety cabinet, laminar-flow box, CO_2-Incubator, PCR)	25
	Microfluidics lab (stopped-flow, rapid mixing)	100
Additional equipment*	Spectroscopy UV-VIS spectrometer	100
	(Near-field-) optical microscopy, Confocal (fluorescence) microscopy, In-vivo fluorescence imaging,	100
	Protein separation, Protein purification Chromatography	25
	Surface-enhanced laser desorption/ionization (SELDI), 2D gel electrophoresis	25
	Mass spectrometry HPLC	25
* Examples for equipment used frequently for Bio-purposes. Some of the tools are included as common Metrology (Table 1). The actual equipment must be decided according to the needs of the site / the respective research program.		
Support lab in cooperation with Nanomanipulation facilities:		
Optical tweezers, Single particle chemistry on biological macromolecules		100

Table 2: Estimate of running cost for Support labs and the basic Nano-Bio Infrastructure present at all NFFA-centres (*from Deliverable 3.6.*)

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

Table 3: Estimated running 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	Running Cost/unit/year (M€)
Thin film evaporators	hands on	Lab or clean-room	12	0.03
Molecular Beam Epitaxy (MBE)	hands off	Lab or clean-room	6	0.6
Sputtering	hands on	Lab or clean-room	8	0.04
CVD, PECVD, RTCVD	hands off	Lab or clean-room	12	0.03

Table 4: Estimated running 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	Running Costs per unit/year (M€)
Optical Tweezers	open hands on	Lab or clean room	4	0.05
Optical Levitation	limited hands on		4	0.05
Magnetic Tweezers	open hands on		4	0.03
Dielectrophoretic Tweezers	limited hands on		4	0.03
STM	limited hands on	Lab or clean room	4	0.06
AFM	limited hands on		4	0.06
Microgripper	limited hands on		4	0.04

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

Instrumentation necessary for specialised activities:

Metrology – specialized equipment	Techniques	Access mode	Environment	Units	Running costs/unit/year (M€)	Running total Costs/year (M€)
Advanced Microscopy	SEM+WDS+EBSD	limited/hands off	Lab	1	0.08	0.08
	TEM Cs corrected	limited/hands off	Lab with specific requirements	1	0.5	0.5
	3D Atom Probe	limited/hands off	Lab	1		
	LT-STM/AFM	limited/hands off	Lab/UHV	1	0.06	0.06
	LT-STM High Magn. Field	limited/hands off	Lab/UHV	1	0.075	0.075
	HP-STM	limited/hands off	Lab/UHV	1	0.05	0.05
	ECSTM	limited	Lab/liquids	1	0.02	0.02
	SNOM	open/limited	Lab	1	0.005	0.005
	Cryo-SNOM	limited	Lab/air	2	0.02	0.04
	HeIM	limited	Lab/HV	1	0.035	0.035
	TERS	limited/hands off	Lab	1	0.1	0.1
	Brillouin Microscope	hands off	Lab	1	0.03	0.03
Structural. Optical & Compositional Analysis	SAXS/WAXS/GISAXS	limited	Lab	1	0.06	0.06
	UFTA	limited	cleanroom	2	0.1	0.2
	TRPES	limited	cleanroom	2	0.1	0.2
	CA LEEM/PEEM	limited/hands off	Lab/UHV	1	0.1	0.1
	GC and GC/MS	open	Lab	2	0.03	0.06
	Microreactors	open	Lab	2	0.003	0.006
	HP-XPS	limited	Lab/UHV with HP cell	1	0.05	0.05
	XPS in liquids	limited	Lab/UHV	1	0.05	0.05
	SIMS	limited/hands off	Lab with specific requirements	1	0.15	0.15
	NMR	hands off	Lab	1	0.1	0.1
Magnetic Characterisation	MOKE	hands off	Lab	1	0.02	0.02
	AC-SUSCEPTIBILITY	limited	Lab	1	0.02	0.02
Thermal & Mechanical Characterisation	Nanoindentation	hands off	Lab	1	0.01	0.01
	Acoustic measurements	open	lab	1	0.002	0.002
Transport Properties	Electronic and Probe station	Limited	Lab	1	0.03	0.03
	10mK Cryostat	Limited	Lab with specific requirements	1	0.05	0.05
	300mK Cryostat	Limited	Lab	1	0.02	0.02
Additional resources required	LSF Located Section			4		0
Total Characterization Line				1*/4	0.3	0.3*

Table 6: Estimate of running cost of advanced equipment for Metrology and Advanced Analysis facilities (*from Deliverable 3.4*)

Lithography techniques – specialized equipment			Access mode	Required environment	Required units	Running Costs per unit/year (M€)
Pattern origination lithography	Electron beam lithography	SEM based	open hands on	Lab or clean-room	3	0.05
		High-end Gaussian	limited hands on/hands off	Clean-room	3	0.25
Mask based / replication lithography	Photo lithography	Mask aligner	open hands on	Clean-room	6	0.015
	Replication	NIL	open hands on	Clean-room	3	0.03
		Other replication	open hands on	Lab	4	0.02

Table 7: Additional running costs for advanced equipment for Nanolithography facilities (cost estimation for 4 centres (*from Deliverable 3.2*).

Material Synthesis Specialized equipment	Access mode	Required Environment	units	Running Cost/unit/year (M€)
Pulsed Laser Deposition (PLD)	hands off	Lab or clean-room	2	0.015
Cluster Beam Deposition (CBD)	hands on	Lab or clean-room	2	0.02
Ion Implantation	hands off	Lab or clean-room	2	0.015
Atomic Layer Deposition (ALD)	hands off	Lab or clean-room	2	0.03
SAMs, LB, spin coating	hands on	Lab or clean-room	4	0.02
Single crystal growth	hands off	Lab or clean-room	2	0.03
Sol-gel	hands on	Lab or clean-room	3	0.02

Table 8: Additional running costs for advanced equipment for Material synthesis facilities (cost estimation for 4 centres - *from Deliverable 3.3*)

	Nanobiolab – specialized equipment	Maintenance (k€/a)
Support labs (standard equipment)	Chemistry lab, Chemical synthesis facility	25
	Biolab (safety cabinet, laminar-flow box, CO2-Incubator, PCR)	25
	Microfluidics lab (stopped-flow, rapid mixing)	100
Characterisation labs **NanoBio***	Spectroscopy, UV-VIS spectrometer	100
	(Near-field-) optical microscopy, Confocal (fluorescence) microscopy, In-vivo fluorescence imaging, STED super-resolution microscope	100
	Protein separation, Protein purification Chromatography	25
	Surface-enhanced laser desorption/ionization (SELDI), 2D gel electrophoresis	25
	Mass spectrometry, HPLC	25
	(Environmental-)SEM	25
Characterisation labs **shared Metrology****	TEM	200
	X-ray lab (SAXS/WAXS/GISAXS)	40 - 70 (10-20/unit)
	AFM, Surface characterisation	20
	Brewster-angle microscopy, Ellipsometry	10
NanoBio Labs - In-house research sections		
Biointerfaces, Biomimetics		75
Biosensors, Thin film technology		75
Nanomedicine, Toxicology		75
Proteomics, Protein crystallography		75
Specialised Characterisation / Support labs with shared Metrology:		
Cryo lab (CryoEM, plunge freezing, Cryo microtome)		50 - 100
Single particle chemistry on biological macromolecules, Optical tweezers		100
NMR-Spectroscopy lab		100
* Nanobio Metrology (used frequently for Bio-purposes) that should be best located (physically) inside the Nanobio facility and could 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 included in a Metrology facility, but considering the restrictions given above.		

Table 9: Running cost of a specialised Nano-Bio facility, co-located with a Metrology facility and a complementary Nanofabrication/-manipulation facility that will have a comparable number of staff and equipment that will be shared in the framework of joint research (in addition to costs of the basic support biolab) (*from Deiverable. 3.6*).